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GRADUATE COLLEGE

ROBERT CHAMBERS AND THE SUCCESSIVE REVISIONS OF THE VESTIGES OF THE NATURAL HISTORY OF CREATION

A DISSERTATION

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MARILYN BAILEY OGILVIE

Norman, Oklahoma

1973

ROBERT CHAMBERS AND THE SUCCESSIVE REVISIONS OF THE

VESTIGES OF THE NATURAL HISTORY OF CREATION

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PREFACE

Robert Chambers' Vestiges of the Natural History of Creation while containing little "hard-core science" is nevertheless important to the history of science. As the subject of many drawing room debates, it reflects the contemporary interest in the subject of transmutation. If evolutionary ideas had been novel it is doubtful whether Chambers would ever have undertaken to write a book designed to appeal to the interests of the general reading public. The effect of Vestiges was to accelerate the already present Victorian interest in transmutation.

Chambers was only in part a scientist. He understood the value of theorizing but was unable to develop a satisfying theory. He realized the necessity of observational and experimental evidence but could not select appropriate demonstrations. Since he did not possess the intellectual tools of the scientist, his scientific judgment was often faulty. But this is not to detract from the significance of Chambers or of Vestiges, since by popularizing concepts of transmutation he helped prepare the climate of opinion for the acceptance of the work of those who did possess the intellectual requisites.

Although historians concerned with the evolution of transmutationist ideas mention Vestiges as an important station in this process, they do not offer a detailed analysis of the content of the book. An excellent bibliography as well as the best textual information available is found in Milton Millhauser's account of Vestiges. However, his emphasis is on the climate of opinion which induced the spawning of

evolutionary ideas rather than on a detailed analysis of the text itself. Therefore, a study to remedy this omission was undertaken.

Most of the source materials for this dissertation on Vestiges were provided by the History of Science Collection of the University of Oklahoma library; supplementary material was available through the libraries of the University of Minnesota and Portland State University.

I want to express my especial appreciation to Professor Kenneth Taylor, my advisor. Without his appraisals and suggestions as well as his encouragement this work would not have been possible. I also want to thank the other members of my committee, Professor Duane H. D. Roller, Professor Thomas M. Smith, Professor David Kitts, and Professor David Levy for their help in supplying me the necessary research materials and for their advice on the manuscript.

ROBERT CHAMBERS AND THE SUCCESSIVE REVISIONS OF THE VESTIGES OF THE NATURAL HISTORY OF CREATION

INTRODUCTION

The Vestiges of the Natural History of Creation is exactly the kind of book that one would expect Robert Chambers to have produced. Although he had an inquiring mind, literary talent, a keen interest in his surroundings, and exposure to many respected men of science and literature, he lacked the formal education which would have provided him with the tools to make his ideas acceptable to the scientific intelligentsia.

The background of the author of the Vestiges typifies a traditional nineteenth-century success story. Robert Chambers was born July 10, 1802, the son of a cotton manufacturer in Peebles, Scotland. Because of the interests of his intellectually alert father, he was exposed early and often to the pleasures of reading. But the comfortable circumstances of the Chambers' household were soon to change. The power loom had revolutionized the cotton manufacturing trade and the elder Chambers, being no longer able to earn a living in this field, bought a draper's shop, was unable to operate it successfully, and became bankrupt. Thus the children were unable to remain in school. Robert's older brother, William, was apprenticed to a bookseller and, although Robert remained in school for a longer time, he too soon dropped out.[1]

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[1] Milton Millhauser, Just Before Darwin. Robert Chambers and Vestiges (Middletown, Conn.: Wesleyan University Press, 1959), pp. 11-21.

After attempting several jobs, Robert, with very little capital, finally established himself as a bookseller.[1] William finished his apprenticeship and he too opened a bookshop, became successful, and expanded his business to include printing and publishing.[2] In the meantime, Robert, in addition to running his shop, was writing about the local life around Edinburgh. He was successful enough to receive commissions to write a history of the Scottish rebellions and a biography of James I. As his bookshop prospered, Robert wrote more and more.[3]

William Chambers developed the idea of a well-written journal which would be informative to the masses. The Chambers Edinburgh Journal resulted and was an immediate success. Robert, who had previously been skeptical, became a joint editor after the Journal had gone through fourteen numbers. With this publication began the life-long partnership between Robert and William Chambers.[4]

During the 1830's, Robert became interested in geology and became reasonably proficient in it, even publishing some scientific papers. Since his home was a meeting place for both scientific and literary intellectuals from Edinburgh, he was able to keep abreast of current advances in both areas, a necessity when composing a book such as Vestiges.[5]

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[1]William Chambers, Memoir of William and Robert Chambers, (Edinburgh and London: W. & R. Chambers, Limited, 1893), pp. 267-69.

[2]Ibid., pp. 139-62.

[3]Ibid., pp. 190-219.

[4]Ibid., pp. 228-40.

[5]Millhauser, Just Before Darwin, pp. 26-29.

Chambers left Edinburgh for St. Andrews in 1841 and, significantly, this man who had previously published so many books published nothing between 1840 and 1844. He claimed to leave Edinburgh for "family reasons," but actually he was completing his theory and composing his book.[1] The results of his isolation appeared anonymously in 1844 in the form of the first edition of the Vestiges. In the "Note Conclusory" of this edition, Chambers vowed to let the work speak for itself, writing

> I do not expect that any word of praise which the work may elicit shall ever be responded to by me; or that any word of censure shall ever be parried or depreciated. It goest forth to take its chance of instant oblivion, or of a long and active course of usefulness in the world.[2]

However, the reviews were, in Chambers' opinion, so devastating that he did not want to let the matter stand, for "the author should have to regret seeing it in a great measure misapprehended in its general scope, and also so much excepted to, justly and unjustly, on particular points, that ordinary readers might be ready to suppose its whole indications disproved."[3] This decision resulted in the publication of Explanations in 1845 in which Chambers stressed the importance of viewing his entire theory rather than judging it by fragments. Some of the technical mistakes of the early editions of Vestiges were corrected in the Explanations.[4]

Vestiges occupied much of Chambers' time between 1844 and 1860,

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[1] Ibid., pp. 29-32.

[2] [Robert Chambers], Vestiges of the Natural History of Creation, with an Introduction by Gavin de Beer (New York: Humanities Press, 1969), p. 387.

[3] [Robert Chambers], Explanations: a Sequel to Vestiges of the Natural History of Creation (New York: Wiley and Putnam, 1846), p. 1.

[4] Millhauser, Just Before Darwin, pp. 142-43.

for he was constantly revising it. Even so, after 1846 he resumed some of his former occupations. He carried out field expeditions in geology and wrote technical pamphlets on them, wrote a four volume Life and Work of Burns (1851), became Director of the Scottish Life Assurance Society, worked on the Chambers' Encyclopaedia, and spent his last efforts in the British Museum working on the Book of Days (1863).[1]

After the death of his first wife in 1863, Chambers became more interested in religion, an interest which eventually involved him in spiritualism. During this period he wrote little. However, he remarried and wrote again during his last years until his second wife died in 1870. His failing health culminated in his death in 1871.[2]

Almost immediately upon publication of his book Chambers broke his resolution to let Vestiges stand unaltered upon its merits. The challenges of the critics were so compelling that he began modifying the book as soon as the reviews began to appear. Certain changes were made in the third edition published in 1845, and others appeared in subsequent editions through the tenth published in 1853. Although many of the changes are direct responses to the statements of the critics, others are recognized to be so only by inference. However, there is little doubt about Chambers' sensitivity to his critics. The publication of a direct answer to them in the Explanations as well as the inclusion of an appended section in the tenth edition of Vestiges entitled "Proofs and Illustrations" indicate this awareness. The latter contains evidence from prominent

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[1] Ibid., pp. 165-72.

[2] Ibid., pp. 174-89. See Millhauser, Just Before Darwin, pp. 212-14 for a bibliography of the works of Chambers.

authorities rationalizing the parts of the hypothesis that had been most harshly criticized, including specific answers to three critics, Hugh Miller, Adam Sedgwick, and Edward Hitchcock.[1]

The revisions differ in thoroughness in different editions. The third and fourth editions, both published in 1845, were in most respects identical to the first and to each other, but in some significant instances the third edition was changed from the first, and in others the fourth was changed from the third. The fifth edition (1846) was a transitional edition bridging the fourth with the much revised sixth edition. In the fifth edition certain inclusions resembled those of the early editions, others resembled those of the later, and certain passages were unique to this edition. The sixth edition (1847) possessed a new format and was quite significantly different from the earlier editions. The seventh, eighth (1850), and ninth (1851) editions were cheap productions probably intended to appeal to the low income reader, but the tenth (1853) represented another major reworking and was an attractively packaged edition.[2] Even with some changes and emendations and with the addition of illustrations it resembled the sixth edition. The last English edition published during Chambers' lifetime was the eleventh, published in 1860.

The eight American editions published from 1845 through 1858

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[1] [Robert Chambers], Vestiges of the Natural History of Creation (10th ed.; London: John Churchill, Princes Street, Soho, 1853), p. i-lxvii.

[2] Millhauser, Just Before Darwin, pp. 146-47.

[3] Ibid. An explicit reference to the seventh edition was unavailable.

were in essence reprints of their British counterparts with Americanization of spelling and other minor changes. A twelfth edition was published in 1884 with a preface by Alexander Ireland. The last production, a reprint of the first edition, was published in 1969 by the Humanities Press with an introduction by Sir Gavin de Beer. Vestiges did not become very influential abroad, but three translations were produced, two German and one Dutch.[1]

Since the Vestiges was so sharply criticized from so many different quarters and since new revised editions continued to appear with such regularity, for the purposes of this study it was decided to correlate the changes made in the successive English editions of the book with specific criticisms brought forth by the reviewers. The method used to compare and evaluate the changes in the different editions was determined after an examination of the methods used in Morse Peckham's The Origin of Species . . . a Variorum Text (1959). Peckham had indicated the desirability of a variorum edition of Vestiges when he stated that it was his hope "that other scholars will follow with editions of equally important works, such as Lyell's Principles of Geology, or Mill's Logic, or the quasi-scientific Vestiges of Creation."[2]

After examining several editions of Vestiges, the conclusion was reached that a variorum text would only be instructive as a tool for determining what changes were made and the reasons for the changes. The variorum edition approach was a useful method, for many of the changes

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[1] Ibid., pp. 145-46.

[2] Morse Peckham, ed., The Origin of Species by Charles Darwin. A Variorum Text (Philadelphia: Univ. of Pennsylvania Press, 1959), p. 11.

between editions were subtle and others were confusing because of the ways in which Chambers rearranged the material.

In preparing this preliminary variorum text, two editions, the first and the tenth, were considered as representative of the two most diverse patterns into which the other editions fell. Each sentence in each of these two editions was given a tripartite number, composed of a Roman numeral representing the chapter number, an Arabic numeral representing the sentence number within the chapter, and a third Arabic numeral representing the edition number. Footnotes were designated by lower case letters following the appropriate sentence designation.

After each sentence was numbered, it was cut out and pasted on to a sheet of notebook paper. The individual sentences of the first edition were placed next to their correlative sentences in the tenth edition. Then a sentence by sentence comparison followed with notations of changes made on the sheets of notebook paper. The other English editions, with the exception of the second and seventh (which were unavailable) and the eleventh (which was ignored because it contained few new ideas and was published after On the Origin of Species (1859) when Vestiges was no longer taken seriously), were subjected to a sentence by sentence comparison to the two pattern editions, with differences and similarities marked on the sheets of paper.

At this point it was known exactly what changes Chambers had made. The next step was a careful reading of the reviews to determine specific criticisms of the book and then to correlate these criticisms with the changes made in the different editions.

Some of the changes bore no relationship to the reviews. These were usually changes in form. For example, Chambers changed his policy

with regard to capitalization in different editions. In the first, third, and fourth editions the words "astral systems" were initiated by lower case letters, whereas in the fifth edition both words began with a capital letter, "Astral Systems."[1] Changes in spelling were also noted, such as the appearance of the archaic form "shews" in the first edition but its replacement by "shows" in the third and subsequent editions.[2] Word order was frequently rearranged; for example, a portion of a first through fifth edition sentence read "he would only as yet have accomplished half his journey," whereas in the sixth through tenth editions it read "he would as yet have accomplished only half his journey."[3] In other examples, entire passages were removed and placed in different locations within the book.[4]

Even the footnote style varied; the superscripts were asterisks in the first through fourth editions but were numerals in subsequent ones. In the sixth through ninth editions there were no footnotes, but, rather, notes at the end of the text.[5]

Punctuation varied among the editions; for example, commas

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[1]For footnotes involving comparison of subsequent editions of Vestiges a shortened form has been adopted. The author (Chambers) and title (Vestiges) are abbreviated CV, the edition by a Roman numeral, and the page by an Arabic numeral. Ibid will not be used to refer to succeeding editions of Vestiges, because of the possibility of making the citation unclear. CV I:4; V:4.

[2]CV I:8; III:8.

[3]CV I:2; III:2; IV:2; V:2; VI:2; VIII:1; IX:1; X:1.

[4]CV V:251-52; VI:263-64.

[5]CV I:3; III:3; IV:3; V:3; VI:489; VIII:295; IX:293; X:2.

are present in certain editions but deleted in others.[1] These changes in form were usually significant only in indicating the care with which Chambers had revised each subsequent edition. Thus, only if a change in form also affected a nuance of meaning and thereby altered the content was it considered in this study; otherwise, it was ignored.

The second class of changes, changes in content, are those considered in detail in the body of this paper. One way in which the content was altered was by the insertion of new examples and additional information. For example, the planet Neptune was discovered in 1846, and whereas this fact was noted in the sixth through tenth editions, it could not have been included in the earlier forms.[2] The new telescope of William Parsons, third Earl of Rosse, which was an important obstacle to Chambers' interpretation of the Nebular Hypothesis, was mentioned in the eighth and subsequent editions but not in the earlier.[3]

Although Chambers was more likely to add than to delete material, in the chapter concerned with affinities and geographical relationships between organisms he began a series of deletions from the third through eighth editions, in which the credence placed on the Macleay system of classification diminished regularly. New material was added to replace that which had been discredited.[4] In the case of the actual theory of development, Chambers changed his mind as to how the process occurred,

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[1] CV I:3; III:3.

[2] CV VI:490; VIII:295; IX:293; X:9.

[3] CV VIII:4-5; IX:4-5; X:4-5.

[4] CV I:236-76; III:245; IV:274-78; V:no mention; VI:346-50; VIII:211-13; IX:208-10; X:245-47.

and in response to this, similar chapters in subsequent editions reflected these modifications.[1] In other cases errors in fact were corrected. For example, in the first edition he stated that "the distance of Sirius might be assumed in that instance as not less than 19,200 millions of miles!" but in the third edition changed this figure to "19,200,000 miles!"[2]

Chambers began his work on a grand scale, by attempting to demonstrate that God probably had created the celestial bodies according to the general ideas expressed by Pierre Simon, Marquis de Laplace (1749-1827) and Sir William Herschel (1738-1822) on the subject, and known contemporaneously as the Nebular Hypothesis. Although Chambers insisted that the accuracy of this hypothesis would not affect the Developmental Hypothesis, it was important as confirmatory evidence that development did occur at every level, from macrocosm to microcosm. By the fifth edition of Vestiges and the 1845 edition of Explanations, it became apparent that Chambers was aware of serious problems in the Nebular Hypothesis. The Earl of Rosse had invented a new telescope which had resolved much of the diffuse nebulous material into definite stars. This application stimulated a rethinking of the postulates presented in the earlier editions. Nevertheless, in later editions, Chambers continued to regard the hypothesis as probable although he duly noted the new evidence before continuing with his preconceived ideas.[3]

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[1] CV I:203-205; III:208-10; IV:208-10; V:211-13; VI:209-12; VIII:131; IX:128-29; X:157.

[2] CV I:2; III:2.

[3] The developmental thesis of Chambers presumes the universality of the gradual evolution of every constituent of the cosmos. For a discussion of this hypothesis see Chapter IV, "The Developmental Hypothesis."

The swirling homogeneous masses of gasses were required to undergo a considerable transformation before they would be recognizable as the present day objects of our solar system. As the rotating bodies cooled, differentiation occurred and the familiar elements and compounds emerged. Chambers postulated that the same substances would be found on all of the spheres since they were all produced by the same cause.

The cooling earth then entered the part of its history that interests geologists. Chambers interpreted the fossil data as indicating a primary formation devoid of fossils followed by formations including fossils of increasing complexity. Although accused of ignoring the contradictory evidence, he was insistent about this postulate.

Having established to his own satisfaction the progression of life forms in the fossil formations, Chambers turned to the question of the origin of the first living organism. Since living things were made of constituents similar to non-living things, he was convinced that through a little added impetus such as an electrical stimulation a primordial living globule could be created from the non-living. Although he insisted that it was unnecessary to his theory that such a globule-creating activity occur currently, it was most likely that, although spontaneous generation had diminished in scope, it still occurred in a few isolated instances. After discussing how life was created, Chambers outlined how it had developed according to his hypothesis of development.

After demonstrating the origin of current forms, Chambers undertook to discuss their interrelationships. In the early editions, he accepted the Macleay system of classification as representing a truly natural system, but his scepticism regarding its reliability grew in subsequent editions until he finally despaired of arriving at a natural

system of relationships and compromised on a system of parallel relationships.

Vestiges moved from the other animals to man. It was inconceivable to Chambers that man would be exempt from the laws of the Creator to which the rest of the creation was subject. Such an inconsistent God would not be worthy of worship. Thus he showed mankind as subject to the same kind of development as the rest of the organic world; man passed successively in both race history and embryological history through various phases culminating in the adult male Caucasian. Chambers argued that mind and matter were inseparable; mind, being a result of the nervous systems of animals, was subject to the same progressive development as was the physical system.

Robert Chambers was cast in a Platonic-Pythagorean mold. Relying on the experiments and observations of others for corroboration, he constructed a universe in his mind. By means of his intellect he was able to glimpse the way in which the "Almighty Author," by necessity, would have formed the cosmos--by devising immutable preconceived natural laws operating uniformly throughout the whole of creation.[1] Chambers marvelled, "it is remarkable of physical laws, that we see them operating on every scale as to magnitude with the same regularity and perseverance."[2] To think otherwise, he argued, would be absurd. It would rob "that great being, who shall say where is his dwelling place, . . ." of his omnipotence and replace him with a whimsical anthropomorphic deity subject to the same kind of frailities found in his human creations.[3]

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[1] CV I:359.

[2] CV I:24.

[3] CV I:26

Platonic Pythagoreanism may be characterized for the purposes of this dissertation as a philosophy in which the ideal represents the highest reality--a reality perceivable in numerical relationships in natural phenomena. This outlook is characterized in methodology by a tendency to first establish hypotheses and then to seek corroborating facts. In retrospect Chambers recognized this tendency in his own thought, for in the first through fourth editions a footnote was included linking his theory to Platonic thought. He stated that "when I formed this idea, I was not aware of one which seems faintly to foreshadow it--namely, Socrates's doctrine, afterwards dilated on by Plato, that previous to the existence of the world, and beyond its present limits, there existed certain archetypes, the embodiment (if we may use such a word) of general ideas; and that these archetypes were models in imitation of which all particular beings were created."[1]

But Chambers lived in a world that professed to follow Bacon more than Plato. The great majority of scientific papers published in the Britain of Chambers' time honored the observational and experimental ideals. To be taken seriously Chambers therefore found it necessary to corroborate speculations with "facts." This he tried to do. Since he was a voracious reader, he was familiar generally with what was occurring in the contemporary scientific world.[2] Thus when it seemed appropriate for the purpose of making his speculations more credible, he was able to insert relevant "facts." His avid reading habits also exposed him to the speculations of others. If these corroborated his own, he eagerly

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[1] CV I:204; III:209; IV:209.

[2] Millhauser, Just Before Darwin, pp. 13-14; p. 31.

assimilated them into his own framework, often uncritically.

Knowing that God operated reasonably by means of established natural laws, Chambers the Pythagorean assumed that the basis of these laws was mathematical,

> nor should it escape our careful notice that the regulations on which all the laws of matter operate, are established on a rigidly accurate mathematical basis. Proportions and geometrical figures rest at the bottom of the whole.[1]

Chambers' numeralogical bias was evident as he considered the creation of the cosmos by natural law. He found numbers to establish that the primary planets showed a progressive increase of bulk and diminution of density from the one nearest the sun to the one most distant.[2] Fascinated by the relative distances of the planets to the sun, he found that these numbers supported what he already knew, for "surely there is here a most surprising proof of the unity which I am claiming for the solar system."[3] Also appealing to Chambers was Kepler's third law. Here was authority stating that the distances of the planets bore an interesting "mathematical relation to the times of the revolutions round the sun."[4]

Throughout the Vestiges, Chambers' preoccupation with numeralogy recurs. His pleasure in discovering the quinary basis for the relationships between organisms and his elation with the type of numerical relationships indicated by Mr. Babbage's calculating machine

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[1] CV I:25.

[2] CV I:10.

[3] CV I:10.

[4] CV I:11.

illustrate this bias.[1]

The greatest strength of the Vestiges, the production of a plausible hypothesis of an ideal world operating according to a principle of historical development, is probably also its most sharply criticized weakness. After Chambers had decided in a thoroughly Platonic manner how the world must have been created according to his mind's image of an ideal world, he conveniently ignored certain facts threatening to his favorite theories. At the same time, he assimilated to his argument, almost indiscriminately, a great many facts which would appeal to the sensibilities of an empirically minded society. Unfortunately for Chambers, many of these "facts" were found to be in error, causing his scientific contemporaries to reject his entire effort as a preposterous fabrication.

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[1]CV I:206-11; III:210-15; IV:210-15; V:213-19; VI:212-16; VIII:132-35; IX:129-32; X:158-61.

CHAPTER I

THE RECEPTION OF *VESTIGES*

The first edition of the *Vestiges of the Natural History of Creation*, later acknowledged to be the work of Robert Chambers of Edinburgh, appeared anonymously in 1844, provoking reactions of alarm from churchmen, scientists, and scholars.[1] But the general reader found the book attractive and book sales soared, with a second English edition appearing in 1844, followed by two more in 1845.[2] By 1860, eleven British and eight American editions had appeared. The book's popularity alarmed both the religious and scientific communities, for each feared that the public would be seduced by the smooth, pseudo-logical style of the *Vestiges* into believing dangerous and erroneous doctrines.

The *Vestiges* appealed to a wide audience and the religious community found it threatening. Perhaps if it had been a book attracting only the intellectual elite, the cause for ecclesiastical concern would have been less. But as it was, organized religion feared the contamination

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[1] Robert Chambers' authorship of *Vestiges* has been ascertained. He will be referred to by name as the author even when his reviewers write of "the author of *Vestiges*." See Millhauser's discussion in *Just Before Darwin*, pp. 30, 32, and 194.

[2] Millhauser, *Ibid.*, pp. 153-59, discussed the appearance of references to the *Vestiges* in contemporary literary works such as Disraeli's *Tancred*, Robert Hunt's *Panthea*, William Henry Smith's *Thorndale*, sections of Tennyson's *In Memoriam*, Samuel Butler's *The Way of All Flesh*, and Elizabeth Lynn's *Autobiography of Christopher Kirkland*. These works were either based on or referred to the *Vestiges*.

of those who represented its very backbone with ideas subversive to the institutional church. This intolerable situation resulted in vocal denunciations from church leaders.

At best the relationship between revealed religion and geology regarding the history of the earth had been a delicate one, and a de facto truce had resulted in which a tacit understanding had prevailed that neither side would initiate hostile actions. The nature of this tacit understanding is described by both C. C. Gillispie in Genesis and Geology and Milton Millhauser in Just Before Darwin. Both working geologists and practicing theologians realized that controversy was not to their mutual benefit. Although the days of the difficulties of a Galileo or a Bruno were past, neither side coveted a lesser martyrdom. The acrimonious attacks of the scriptural geologists threatened to disturb the serenity of a scientific community steeped in a Newtonian tradition of a universe governed by law. Therefore, it was to the advantage of science not to alter this working environment. It was also important to the Church not to appear ridiculous. Thus, a truce was in order which was to the advantage of scientists and theologians alike. Influential scientists were loath to upset the truce by giving the so-called scriptural geologists, those who were opposed to any kind of reconciliation of the scriptures with the naturalistic explanation of geology, any kind of ammunition.[1] Vestiges was replete with this

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[1] Ibid., pp. 53-56. See also Charles Coulston Gillispie, Genesis and Geology. A Study in the Relations of Scientific Thought, Natural Theology and Social Opinion in Great Britain, 1790-1850 (Cambridge: Harvard Univ. Press, 1951), p. 3; pp. 30-32. According to Gillispie, Ibid., p. 209. the "message" of natural theology is epitomized in the eight Bridgewater Treatises. Four clergymen and four physicians were chosen to author the texts in order to illustrate, according to Thomas Chalmers in the First Bridgewater Treatise, On the Power, Wisdom, and Goodness of

ammunition, and for this reason many respectable scientists considered themselves obliged to censure the work--a work which they might well have ignored in other times.

One of these respectable scientists was Sir David Brewster (1781-1868) who, in reviewing the Vestiges, noted the current agreement between "science and religion" and deplored this book for upsetting that "holy alliance." He commented that the Vestiges was "prophetic of infidel times and . . ." indicated "the unsoundness of our general education, . . ." and feared that "it had started into public favour with a fair chance of poisoning the fountains of science, and sapping the foundations of religion."[1] Brewster admitted the popularity of the work, but maintained that it had only been received well by those who were untrained in detecting flaws of reason. This lack of perspicacity was not limited to those in the lower social strata, he noted, but extended to those readers "among the influential classes of society." But, among those trained in detecting fallacies of reason, philosophers, naturalists, and divines alike, there had been concurrence "in branding it with their severest censure."[2] Brewster stressed the faults of Vestiges apparently

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God as Manifested in the Adaptation of External Nature to the Moral and Intellectual Constitution of Man, I (London, 1833), ix, "the power, wisdom and goodness of God, as manifested in the Creation; . . ." by "illustrating such works by all reasonable arguments as for instance, the variety and formation of God's creatures in the animal, vegetable, and mineral kingdoms; the effect of digestion, . . . the construction of the hand of man, . . . as also by discoveries ancient and modern, in arts, sciences, and the whole extent of literature."

[1]David Brewster, Review of Vestiges of the Natural History of Creation, by [Robert Chambers], in the North British Review, III (1845), 470-71.

[2]Ibid., p. 471.

because of his fear that science would be stifled in what should be an unfettered search for truth, for if people became sufficiently disturbed over a book such as Vestiges, the comfortable working arrangement that prevailed between science and religion might be severed. Although Chambers had not necessarily deliberately undermined religion, the result was just as devastating as if this subversion had been deliberate, Brewster contended.[1]

Brewster was representative of a class of reviewers of Vestiges who enjoyed a respectable contemporary scientific reputation. Entering the University of Edinburgh at the age of twelve to prepare for a position in the Church of Scotland, he was exposed during the course of his studies to the lectures of John Playfair (1748-1819) and other prominent scientists. Although he did become a minister and apparently established a creditable reputation, his constant fear of failure in the pulpit prompted him to give up the church as a career. After making several unsuccessful attempts to obtain chairs at the universities of Edinburgh and St. Andrews, he eventually attained one at the latter. Soon thereafter, Brewster's scientific accomplishments began to accumulate; he was elected a Fellow of the Royal Society of Edinburgh and of the Royal Society of London, received the Copley Medal, the Rumford Medal, and a prize from the French Institute in 1816 for what was considered to have been one of the two most important inventions of the year, the kaleidoscope. Editing the Edinburgh Encyclopaedia and the Edinburgh Philosophical Journal, the latter in conjunction with Robert Jameson (1774-1854), and writing seventy-five articles for the North British Review, twenty-eight for the Edinburgh

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[1] Ibid., pp. 472-73.

Review, and five for the Quarterly Review, he still found time to be active in the foundation of the British Association.[1]

During his lifetime, Brewster produced numerous technical monographs in the field of optics as well as general works such as biographies of Sir Isaac Newton, Galileo Galilei, and Johannes Kepler. In 1860, he was appointed Vice-Chancellor at the University of Edinburgh.[2]

Brewster, the eminently respectable scientist, was involved in several conflicts during his lifetime. One of these involved a confrontation with William Whewell as to whether or not other planets were inhabited. Opposing Whewell's insistence that the earth was uniquely endowed, Brewster observed that to declare this uniqueness would deny that the universe in its entirety had any intelligible purpose.[3] Another of these controversies surfaced in 1844, the year before Brewster's published review of the fourth edition of the Vestiges in the North British Review. A schism had occurred within the established church of Scotland in which 474 ministers retired to protest church patronage. Brewster took a prominent stand, siding with the protestors and almost losing his chair at St. Andrews in the process. The next year he reviewed Vestiges, stressing the dangers of upsetting the tenuous balance between the church and science.[4]

Like Brewster, Edward Newman (1801-1876), known for his

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[1]Edgar W. Morse, "Brewster, David," Dictionary of Scientific Biography, 1970, II:451-54; Robert Hunt, "Brewster, David," DNB, 1949-50, II, 1207-11; Gillispie, Genesis and Geology, p. 206.

[2]Hunt, "Brewster," II, 1207-11.

[3]Gillispie, Genesis and Geology, pp. 206-207.

[4]Hunt, "Brewster," II, 1207-11.

contributions to the scientific literature of his time, was concerned that Vestiges would cause the dissolution of the truce between the scientific and religious communities. He was apprehensive lest the readers of Vestiges conclude that the entire study of natural history was opposed to religion and, therefore, evil. According to Newman, it was his responsibility "to show that the evil forms no integral part of Natural History, but is of extraneous origin, and introduced, most unskilfully--by the hand of the sophist."[1]

Newman represented a type of nineteenth-century critic of the Vestiges rather different from Brewster. Unlike Brewster, he had not been educated at a university and was a scientific dilletante, pursuing his studies in natural history during his leisure time while engaged primarily in business. However, through his diligence he became a knowledgable naturalist, using his skills to organize scientific societies and sponsor new publications; he wrote for the Magazine of Natural History, founded the Entomological Club, began a journal in 1840, The Entomologist, which merged with The Zoologist in 1843, and initiated another journal in 1854, The Phytologist. He even attempted a theoretical work, a pamphlet published in 1832, "Sphinx vespiformis, an Essay," which was an unsuccesful attempt to develop a new system of classification.[2] It was in The Zoologist that Newman reviewed the Vestiges, expressing his concern that readers would reject what was valid in natural history because of the sophistry of Vestiges, explaining that "a man on detecting poison mixed with food

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[1]Edward Newman, "Notice of the Natural History of Creation," review of Vestiges of the Natural History of Creation, by [Robert Chambers], in The Zoologist: A Popular Miscellany of Natural History, III (1845), 954.

[2]Benjamin Daydon Jackson, "Newman, Edward," DNB, 1949-50, XIV, 338.

previously agreeable to the palate, and nutritious to the body, very sensibly rejects the food from a dread of the poison. . . ."[1]

The second American edition of Vestiges was reviewed by W. H. Allen (1808-1882) in the Methodist Quarterly Review. Although Allen was ostensibly a scientist, occupying the chair of chemistry and natural history at Dickinson College during the time the review was written, he identified himself more closely with religious than scientific work.[2] Therefore, he was concerned with the atheism of Vestiges which he assumed was an integral part of its theory. The author of Vestiges, he concluded, was a hypocrite refusing to acknowledge his atheism from fear of unfavorable criticism.[3] After abandoning chemistry and natural history at Dickinson for philosophy and English literature, Allen later became acting president of the college. Still later he became president of Girard College and Pennsylvania Agricultural College, and acquired a considerable reputation as a lecturer and orator.[4] In Allen's view, the chief danger posed by Vestiges was not to the reasoning man, who would be able logically to dismiss its fallacious arguments, but to those "whose faith in divine revelation is not settled and firm, and who will conclude that if the author has erected his edifice on the truths of nature, we may well hesitate to believe the Bible, for nature and the Bible tell

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[1]Newman, Review of Vestiges, p. 954.

[2]Thomas Woody, "Allen, William Henry," DAB, 1928, I:213.

[3]William Henry Allen, Review of the Vestiges of the Natural History of Creation, 2d ed., and Explanations: a Sequel to Vestiges of the Natural History of Creation, by [Robert Chambers], in the Methodist Quarterly Review, 1846, pp. 292-95.

[4]Woody, "Allen, William Henry," p. 213.

different stories."[1]

Unlike Brewster and Newman, Allen feared the effect of Vestiges on religion rather than upon science. Allen admitted the plausible nature of Vestiges' arguments even upon "right-minded persons, who have knowledge to expose its assumptions and detect its fallacies."[2] Therefore, in his review he attempted to show Vestiges' errors, a task for which his teaching of chemistry and natural history had prepared him reasonably well.

Not all of the reviewers with ecclesiastical connections were as vituperative in their denunciations as W. H. Allen. Joseph Henry Allen (1820-1888) exemplified the liberal clergyman who was generally sympathetic to the findings of science but who, nonetheless, did not find the Vestiges entirely acceptable either from a scientific or an ethical point of view. Educated for the Unitarian clergy, Allen became a teacher after he found the social demands of the parish not to his liking. His Latin manuals and contributions to Unitarian literature made him well-known among his contemporaries. After contributing to the Christian Examiner since 1844, two years before his review of Vestiges appeared in that publication, Allen became its editor.[3]

J. H. Allen's review, written in an unusually restrained tone, indicated that previous reviewers had already called attention to Vestiges' literary execution and its scientific claims, "both of which have been singularly overrated on the one hand, and disparaged on the

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[1] W. H. Allen, Review of Vestiges and Explanations, p. 296.

[2] Ibid.

[3] Charles Graves, "Allen, Joseph Henry," DAB, 1928, I, 200.

other." But, he claimed, there is nothing heretical about a universe of law. In fact, Allen asserted that Vestiges served an important function in presenting a clear and connected statement of a common tendency of thought.[1] Vestiges' fatalism, however, he found intolerable, and asserted that it was this tendency which made the book immoral, not the doctrine of a progression of forms.[2]

Reviewers were often critical of Chambers for the sensational quality of his writing. One of his best known critics, Adam Sedgwick (1785-1873), writing in the Edinburgh Review, complained that "we have no softer words to explain our meaning, when we call this kind of language the raving madness of hypothetical extravagance."[3] Both the Quarterly Review and the Edinburgh Review had searched for a reviewer who would demolish Vestiges once and for all. The Quarterly Review finally dropped the project after being unable to find a sufficiently qualified man to review it; Roderick Murchison (1792-1871), Gideon Mantell (1790-1852), and Richard Owen (1804-1892) all declined. But the Edinburgh Review was able to obtain the services of Sedgwick, a committed opponent of the Vestiges.[4] Besides condemning Vestiges in the Edinburgh Review, Sedgwick continued his opposition in the Discourse

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[1]Joseph Henry Allen, Review of Vestiges of the Natural History of Creation and Explanations; a Sequel to 'Vestiges of the Natural History of Creation,' by [Robert Chambers], in the Christian Examiner, XL (May, 1846), 333-34.

[2]Ibid., pp. 346-47.

[3]Adam Sedgwick, Review of Vestiges of the Natural History of Creation by [Robert Chambers], in The Edinburgh Review or Critical Journal, LXXXII (July, 1845), 25.

[4]Millhauser, Just Before Darwin, pp. 122-23.

on the Studies at the University of Cambridge.[1]

The historians of geology, Geikie and Zittel, as well as the compiler of the biographical sketch for the DNB, agreed that Sedgwick was popular among his contemporaries, "quick in temper but sympathetic, generous and openhanded. . . ." Chance and his pleasing personality, they acknowledged, played a large role in Sedgwick's emergence as one of England's best-known geologists. In 1818 while he was engaged as a tutor at Cambridge, the Woodwardian professorship of geology became vacant. Although he was almost unversed in geology, he made such a favorable impression that he was elected over an opponent who was a student of geology. Moreover, he quickly began to study to rectify his geological ignorance. In 1818 he was elected to the Geological Society and was made a Fellow of the Royal Society in 1830. He received awards in both societies, becoming president of the Geological Society in 1831 and receiving its Wollaston Medal in 1851 as well as winning the Copley Medal of the Royal Society in 1863. He was president of the British Association for the year 1833 and president of the geological section for 1845, 1847, 1853, and 1860.[2] Although Sedgwick never published a complete book on any geological subject, he established his reputation by publishing a large number of papers.[3] Thus he was considered a responsible and productive member of the scientific community and thereby

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[1]Adam Sedgwick, Discourse on the Studies at the University of Cambridge (5th ed.; London: 1850).

[2]Thomas George Bonney, "Sedgwick, Adam," DNB, 1949-50, XVII, 1117; Archibald Geikie, The Founders of Geology (2d ed.; New York: Dover, 1962), p. 421; Karl von Zittel, History of Geology and Paleontology, to the End of the Nineteenth Century, trans. by Maria M. Ogilvie-Gordon (New York: J. Cramer Weinheim, 1962), p. 432.

[3]Bonney, "Sedgwick, Adam," 1118-20.

admirably suited to review the Vestiges.

Sedgwick was of the opinion that Vestiges had been written by a shallow thinker for the purpose of producing a sensational book. It was his obligation, he testified, to defend scientific endeavour from the apostasy of the Vestiges. Remarking upon the superficial excellence of the book, he warned that whereas "the surface may be beautiful; . . . it is the glitter of gold-leaf without the solidity of the precious metal."[1] Sedgwick was particularly disturbed by the analogical reasoning so widely distributed throughout Vestiges, objecting that the author was "so enamoured of resemblances, that he will cheat his senses by mere similitudes of sound."[2]

One of Vestiges' most famous reviewers, Thomas Henry Huxley (1825-1895), accused its author of sensationalism amounting to "charlatanerie." Huxley, in reviewing the revised tenth edition for the British and Foreign Medico-Chirurgical Review, blamed the ignorance of the reader for making possible so many editions of a very bad book. "We doubt not that this edition--very pretty and well got up it is--will be as greedily swallowed by those to whom it is offered as any of the other nine to the great glory and no small profit of its modest and ingenious author." Huxley continued by grudging "no man either the glory or the profit to be obtained from charlatanerie, and we can hardly expect that those who are so ignorant of science as to be misled by the 'Vestiges' will read what we have to say upon the subject; but a book may, like a weed, acquire an importance by neglect, which it could have

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[1] Sedgwick, Review of Vestiges, p. 2.

[2] Ibid., p. 5.

attained in no other mode. . . ." The "whining assertions of sincerity" found throughout the book were extremely obnoxious to Huxley whether they were the results of ignorance or intention.[1]

Huxley's vicious attack upon the Vestiges was certainly not motivated by any desire to preserve a measure of peace between science and religion. On the other hand, his biases led him to condemn offhand any work which attempted to conciliate ecclesiastical feelings. Never, however, was Huxley to be free of the early influence of the Scottish Kirk. According to William Irvine, "the warfare between Huxley and religion was essentially fratricidal, for he was a born preacher and sermonized from nearly every platform but the pulpit."[2]

Huxley became interested in zoology during his medical student days at London University. After receiving his M. B. from London University and being still too young for the College of Surgeons, he applied for an appointment in the Royal Navy and was eventually appointed assistant surgeon on a surveying ship, the H. M. S. Rattlesnake.[3]" One of Huxley's principal achievements on the voyage out, . . ." according to Irvine, "was to bring some order out of the chaos of invertebrate zoology. . . ."[4]

Until On the Origin of Species was published, Huxley regarded as

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[1]Thomas Henry Huxley, Review of Vestiges of the Natural History of Creation, by [Robert Chambers], in the British and Foreign Medico-Chirurgical Review, XIII (April, 1854), 332-33.

[2]William Irvine, Apes, Angels, and Victorians. The Story of Darwin, Huxley, and Evolution (New York: McGraw-Hill Book Company, Inc., 1955), p. 10.

[3]Ibid., p. 15; Walter Frank Raphael Weldon, "Huxley, Thomas Henry," DNB, 1949-50, XXII, 894-97.

[4]Irvine, Apes, Angels, and Victorians, p. 16.

premature any hypothesis which attempted to link together animals with similar morphological characteristics. Even his energetic defense of Darwinism primarily grew out of his belief that the new system should have a fair trial.[1] But his view of Chambers' theory of transmutation was far from tolerant. In his later years he explained his earlier position, asserting that

> as for the 'Vestiges,' I confess that the book simply irritated me by the prodigious ignorance and thoroughly unscientific habit of mind manifested by the writer. If it had any influence on me at all, it set me against Evolution; and the only review I ever have qualms of conscience about, on the ground of needless savagery, is the one I wrote on the 'Vestiges' while under that influence.[2]

Francis Bowen (1811-1890) was neither a scientist nor a clergyman, but was interested in a harmonious relationship between science and religion. To this end he reviewed the Vestiges, stressing its sensational aspects. He described it as "one of the most striking and ingenious scientific romances that we have ever read," and accused its author of taking "up almost every questionable fact and startling hypothesis, that have been promulgated by proficients or pretenders in science during the present century, except animal magnetism; and for this omission we have reason to be thankful."[3]

As Alvord Professor of Natural Religion, Moral Philosophy, and Civil Polity at Harvard for thirty-six years, Bowen sought to reconcile

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[1] Weldon, "Huxley," p. 898.

[2] Francis Darwin, ed., The Life and Letters of Charles Darwin, Including an Autobiographical Chapter (3 vols.; London: John Murray, Albermarle Street, 1887), II, 188-89. Hereinafter referred to as Life and Letters.

[3] Francis Bowen, "A Theory of Creation," review of Vestiges of the Natural History of Creation, by [Robert Chambers], in the North American Review, LX (April, 1845), 426.

philosophy with Christianity. Vestiges, with its glib style and superficial familiarity with the sciences was unacceptable to him. He stressed its danger to the general reader who might be unable to recognize its incorrect conclusions.[1]

Bowen was notably conservative in his philosophy. During the visit to America of a popular Hungarian revolutionary, he sharply denounced the revolutionary cause. This unpopular position lost him the McLean Professorship of History at Harvard, a position for which he had been nominated. Bowen's conservatism was reflected in his attitude towards the Vestiges, and, as in other controversies, "in his polemics Bowen was somewhat prone to bend logic to meet the demands of argument."[2]

Another charge frequently hurled at the Vestiges was eclecticism. Reviewers asserted that there was nothing new in the book--Jean Baptiste Pierre Antoine de Monet, the Chevalier de Lamarck, Auguste de Saint-Hilaire, and others, they noted, had all said the same thing earlier and more convincingly. This was the point of view of Louis Agassiz (1807-1873). Agassiz did not review the Vestiges, explaining that "it must be owing to some particular circumstance that this work has been so much noticed, because it is not worthy of a critical examination by a serious scientific man."[3] Yet Agassiz as "a serious scientific man" apparently

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[1] Ernest Sutherland Bates, "Bowen, Francis," DAB, 1928, II, 503-504.

[2] Ibid.

[3] Louis Agassiz, Introduction to the Study of Natural History, in a Series of Lectures Delivered in the Hall of the College of Physicians and Surgeons, New-York. Illustrated with Numerous Engravings. Also, a Biographical Notice of the Author (New York: Greeley & McElrath, Tribune Buildings, 1847), p. 25.

was unable to ignore its impact, since it was discussed in his series of lectures "An Introduction to the Study of Natural History." He explained that he disagreed with the views expressed in Vestiges "because it is made up of old-fashioned views which have been brought before the notice of the public for half a century, by the French school, and are supported only by antiquated assertions, and by no means by facts scientifically ascertained."[1] However, Agassiz was highly regarded by Chambers who did not hesitate to use him as an authority when he needed support for a controversial position.

The first edition of Vestiges appeared two years before Agassiz left Europe for the United States. By this time his reputation had been firmly established through such publications as Fishes of Brazil (1829), Recherches sur les poissons fossiles (1833-44), History of the Fresh Water Fishes of Central Europe (1839-42), Études critiques sur les Mollusques fossiles (1840-45), Nomenclator Zoologicus (1842-46), and Monograph on the Fossil Fishes of the Old Red or Devonian of the British Isles and Russia (1844-45).[2] Agassiz remained hostile to evolution until his death in 1873, claiming that since his research on fish convinced him that higher fishes appeared in the fossil record before lower ones, progression could not have occurred. Sharks were higher fish, he postulated, because of their large brains and specialized teeth and muscular systems in spite of certain primitive characteristics. Agassiz's last published article appeared in the Atlantic Monthly and was a justification of his attitude toward evolution, an attitude which,

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[1] Ibid.

[2] David Starr Jordan and Jessie Knight Jordan, "Agassiz, Jean Louis Rodolphe," DAB, 1928, I, 114-22.

because of "the tone of finality and the consciousness of ultimate and permanent evaluation," made it appear as if "Agassiz were submitting his scientific will and testament to the world."[1]

Another scathing review accusing Chambers of eclecticism, among other things, was written by Samuel Richard Bosanquet (1800-1882). Bosanquet's chief qualification to review Vestiges appeared to be that he had something to write on most contemporary controversies. Educated at Eton and Oxford and a member of the Bar, Bosanquet wrote many lead articles for the Times and contributed frequently to the British Critic. The year before the publication of the first edition of the Vestiges, Bosanquet had published his Principia, a series of essays denouncing contemporary liberalism.[2] The appearance of Vestiges gave him another cause to oppose. Complaining that Vestiges did not contain a single original discovery, proof, experiment, or verification of experiments, he noted that the information contained therein could be obtained from "easy and popular treatises. . . ."[3] Bosanquet asserted that the reason he had written his denunciation was to emphasize the danger of Vestiges in the hands of the uneducated masses, for "we readily attribute to it all the graces of the accomplished harlot."[4]

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[1] Ibid.; Edward Lurie, Louis Agassiz, A Life in Science (Chicago: Univ. of Chicago Press, 1960), p. 387.

[2] Francis Espinasse, "Bosanquet, Samuel Richard," DNB, 1949-50, II, 874-75.

[3] Samuel Richard Bosanquet, "Vestiges of the Natural History of Creation:" Its Argument Examined and Exposed (2d ed.; London: John Hatchard and Son, Piccadilly, 1845), pp. 10-11. Hereinafter referred to as Vestiges, Its Argument Examined and Exposed.

[4] Ibid., pp. 1-3.

Hugh Miller (1802-1856) found Vestiges lacking both in original observation and abstract thought. Because Chambers relied on analogy but was undiscerning in its use, the result, accused Miller, was "an ingenious but very unsolid work. . . ."[1] Miller was another self-taught geologist. His profession, that of a stone-mason, stimulated his interest in rocks, and he began collecting materials for his work on the Old Red Sandstone while carrying on a correspondence with Murchison and Agassiz. He became a devoted churchman and was involved in the patronage reforms in Scotland. This combination of religiosity and self-taught geology made Miller an implacable foe of Vestiges. According to Gillispie, he was "a more damaging critic even than Sedgwick, . . ." because he "knew exactly why he stood where he did."[2]

Footprints of the Creator, or the Asterolepis of Stromness (1847), Miller's reply to Vestiges, was both a contribution to Christian apologetics and to paleontology.[3] By presenting a case study of asterolepis, "the oldest, largest, and--Miller held--most advanced of the ganoid fish," he demonstrated that the Developmental Hypothesis was insufficient to explain the facts of the case.[4] Miller's last book, published a year after his suicide, The Testimony of the Rocks (1857), was also concerned with the interrelationships between religion and science.[5] In this book,

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[1]Hugh Miller, The Footprints of the Creator: or, the Asterolepis of Stromness (From the 3d London Edition; Cincinnati: Am. H. Moore & Co., 1851), p. 259.

[2]Gillispie, Genesis and Geology, p. 170.

[3]Hugh Miller, "Miller, Hugh," DNB, 1949-50, XIII, 408-409.

[4]Gillispie, Genesis and Geology, p. 175.

[5]Ibid., pp. 409-10.

although Miller did not mention the Vestiges by name, he wrote disparagingly of the Developmental Hypothesis.[1]

It was a source of pleasure to Robert's brother, William, that Miller had been a frequent contributor to the Chambers's Journal. He wrote, "it is one of the things to look back upon with gratification, that Hugh Miller had been, not only an early reader of, but a contributor of interesting papers to, Chambers's Journal."[2]

Although Chambers' incompetence as a scientist was stressed by most of the reviewers who relished enumerating his errors in fact, it is notable that most of the leading scientists of the period had something to say about the Vestiges. Alfred Russel Wallace (1823-1913) wrote after the death of Chambers that the Vestiges, although it had little effect upon naturalists "because it made no attempt to grapple with the problem in detail, or to show in any single case how the allied species of a genus could have arisen, . . ." had a"considerable effect in influencing public opinion as to the extreme improbability of the doctrine of the independent special creation of each species. . . ."[3]

The paths of Wallace and Chambers crossed in another field. In his later years, Wallace had become a convert to spiritualism and wrote a pamphlet entitled The Scientific Aspect of the Supernatural. Whereas many to whom he sent copies were unconvinced or even dismayed by his

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[1]Hugh Miller, The Testimony of the Rocks; or, Geology in its Bearings on the Two Theologies, Natural and Revealed (Edinburgh: Thomas Constable & Co., 1857), pp. 111-12, 198.

[2]William Chambers, Memoir of William and Robert Chambers, pp. 267-69

[3]Alfred Russel Wallace, Darwinism. An Exposition of the Theory of Natural Selection with Some of Its Applications (London: Macmillan and Co., 1890), pp. 3-4.

acceptance of such a spurious doctrine, Robert Chambers was delighted, explaining that he had been convinced for years that spiritualistic phenomena were genuine.[1]

Charles Darwin, in the historical sketch appended to the first and third editions of Origin, discussed the tenth edition of the Vestiges. Whereas Darwin was certain that Chambers' mechanisms for change were impossible, he was convinced that Chambers argued "with more force on general grounds that species are not immutable productions."[2] Because of its beneficial results in preparing the public for a more reasonable theory of transmutation, Darwin was gentle in his criticism. A "powerful and brilliant style, . . ." characterized it, he asserted, although in the earlier editions it displayed "little accurate knowledge and a great want of scientific caution." Darwin's final verdict on the Vestiges was that because of its wide circulation "it had done excellent service in calling in this country attention to the subject, in removing prejudice, and in thus preparing the ground for the reception of analogous views."[3]

This assessment was offered in spite of Darwin's complaint that Chambers' theory indicated that "after a certain unknown number of generations, some bird had given birth to a woodpecker, and some plant to the missletow, and that these had been produced perfect as we now see

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[1]Wilma George, Biologist Philosopher. A Study of the Life and Writings of Alfred Russel Wallace (London: Abelard-Schuman, 1964), p. 242.

[2]Charles Darwin, On the Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life (3d ed., with Additions and Corrections: London: John Murray, Albermarle Street, 1861), xv-xvi.

[3]Ibid., pp. xvi.

them. . . ." This solution, Darwin concluded, was no explanation at all, "for it leaves the case of the coadaptations of organic beings to each other and to their physical conditions of life, untouched and unexplained."[1]

Although Darwin had not always been so gentle in his appraisal of the Vestiges, he had never entirely condemned it. In an 1844 letter to Joseph Dalton Hooker he mentioned that he had read the Vestiges "but have been somewhat less amused at it than you appear to have been: the writing and arrangement are admirable but his geology strikes me as bad, and his zoology far worse."[2] In a letter to his cousin, W. D. Fox, in February, 1845, Darwin asked, "have you read that strange, unphilosophical, but capitally written book, the 'Vestiges': it has made more talk than any work of late, and has been by some attributed to me--at which I ought to be much flattered and unflattered."[3] Francis Darwin asserted that his father's copy gave every indication of having been carefully read with a series of marked passages pinned in at the end. Charles Darwin wrote, "the idea of a fish passing into a reptile, monstrous. I will not specify any genealogies--much too little known at present."[4]

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[1] Ibid., pp. 3-4.

[2] Francis Darwin, Life and Letters, I, 333.

[3] Ibid.

[4] Ibid. Darwin was convinced of Chambers' authorship of Vestiges by 1847 when he wrote to J. D. Hooker that "I have made one new acquaintance of late, that is, R. Chambers; and I have just received a presentation of the sixth edition of the 'Vestiges.' Somehow I now feel perfectly convinced he is the author. He is in France, and has written to me thence," Ibid., pp. 323-24.

Although Sir John Herschel (1792-1871) and William Whewell (1794-1866) did not mention the Vestiges by name, both were highly critical of the Developmental Hypothesis.[1] In the Presidential Address to the British Association for the Advancement of Science (1845), Herschel said that although he was not basically opposed to the idea of transformation, seeing each transforming step to be as much of a miracle as special creation, it did not answer the question of cause. "Favourable circumstances of climate, food, and general situation, which no experience has ever shown to convert one species into another; . . ." were loose generalizations, he complained, and insufficient to explain cause.[2] Herschel, after giving up the study of law, took up his father's profession of astronomy, although he personally preferred chemistry and optics. His many publications and his awards in both the Royal Society and in the Royal Astronomical Society attest to the high repute in which he was held by his contemporaries.[3]

Herschel was a good friend of William Whewell, who produced a studied criticism of the Developmental Hypothesis in his Indications of a Creator.[4] Although Whewell had been given the opportunity to review Vestiges in the Edinburgh Review, he had declined to do so.[5]

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[1]Millhauser, Just Before Darwin, p. 124.

[2]John F. W. Herschel, "Presidential Address," Report of the Fifteenth Meeting of the British Association for the Advancement of Science, 1845 (London: 1846), pp. xlii-xliii.

[3]Agnes Mary Clerke, "Herschel, Sir John Frederick William," DNB, 1949-50, IX, 714-19; Günther Buttman, The Shadow of the Telescope: A Biography of John Herschel, trans. by B. E. J. Pagel (New York: Charles Scribner's Sons, 1970), pp. 19-20.

[4]Clerke, "Herschel," p. 714; Buttman, The Shadow of the Telescope, p. 18.

[5]Millhauser, Just Before Darwin, p. 120.

The Cambridge-educated Whewell was a widely informed general scholar with many friends among the scientific and general intellectual community of his time. In addition to his broad intellectual accomplishments, he was sufficiently known as a geologist to be elected a fellow of both the Geological Society and the Royal Society. Ordained a priest in 1825, he later wrote the third Bridgewater Treatise (1833), in which astronomy was considered in relation to natural theology. But, according to Gillispie, Whewell's treatise aroused controversy because of his contention that there is "a higher region than that of mathematical proof and physical consequence." This statement caused Charles Babbage to be concerned that "the facts of science could be opposed to the truths of religion."[1] Whewell was important as a critic and a compiler as well as an original investigator in the philosophy of science; the three large octavo volumes of Philosophy of the Inductive Sciences (1837) probably represent his most important work.[2]

The first reviews of Vestiges were found in respectable journals such as Lancet, the Examiner, the Spectator, and the Edinburgh New Philosophical Journal, and were relatively brief notices of its appearance.[3] The last-mentioned journal recommended Vestiges to its readers remarking that "although we do not agree with the ingenious author of this interesting volume in several of his speculations, yet we can safely recommend it to the attention of our readers, who will perceive from the subjoined table of Contents, that the subjects . . . are of

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[1]Leslie Stephen, "Whewell, William," DNB. 1949-50, XX, 1364-66; Gillispie, Genesis and Geology, p. 211.

[2]Stephen, "Whewell," XX, 1372, 1367.

[3]Millhauser, Just Before Darwin, pp. 119-20.

an attractive nature."[1] The reviewer for the Lancet found it "a very remarkable book, calculated to make men think." While acknowledging its scientific shortcomings, this reviewer concluded that "it is worth reading, and will be read, in spite of its defects, for it is written in earnest, and with good faith though very imperfect knowledge."[2]

But the year 1844 marked the end of most of the favorable reviews. With the exception of a review in George Holyoake's Movement and Anti Persecution Gazette and one in The Phytologist, the reviews became progressively more unfavorable. The Athenaum was the first journal to give it an adverse notice, followed by Blackwoods, and the British Quarterly Review.[3] A group of minor reviewers representing the scriptural geologists joined the battle, and denunciations were found in such books as Professor Edward Hitchcock's Religion of Geology and Its Connected Sciences (1851), Reverend David King's Geology and Religion (1849), Tayler Lewis' The Six Days of Creation (1855), and John Harris' The Pre-Adamite Earth (1847). Although he never reviewed the Vestiges, Baden Powell (1796-1860) remained one of its few favorable proponents.[4]

The authorship of the Vestiges was a well-kept secret for many years after its publication, with only Chambers' wife, his brother William (1800-1883), Alexander Ireland, and Robert Cox (1810-1872) privy to the secret. Chambers' wife transcribed the manuscript so that his handwriting would not be recognized; it was then sent on by mail

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[1] "New Publications," Edinburgh New Philosophical Journal, XXXVIII (October, 1844), p. 186.

[2] Review of Vestiges of the Natural History of Creation by [Robert Chambers], in Lancet, November 23, 1844, p. 265.

[3] Millhauser, Just Before Darwin, pp. 119-20.

[4] Ibid., pp. 131-35.

to Alexander Ireland, who forwarded it to John Churchill of London, the publisher, who in turn sent it to the printer. From the printer the proofs were returned directly to Ireland who sent them on to Chambers.[1]

Since the authorship of the book would reflect upon its credibility, there was speculation on the author's identity. For example, an article appeared in The American Review: a Whig Journal of Politics, Art and Science, suggesting that Isaac Taylor (1787-1865) was the author because of certain similarities between the Vestiges and Taylor's book The Physical Theory of Another Life.[2] Apparently by 1860 Chambers' authorship of Vestiges was strongly suspected, for there is reason to believe that he was denied the position of Lord Provost of Scotland because of that suspicion.[3]

This book which elicited almost universally unfavorable reviews was extremely popular. The salon society to whom the book especially appealed was not overly concerned with errors in fact and unsupported generalizations. A pleasant sense of wickedness experienced by Vestiges' readers in delving into a nearly forbidden area made the book exciting reading and an attractive subject for conversation. It was even more acceptable because of the smoothness of its literary style and the glibness of its pronouncements.

The same characteristics caused it to be an anathema to both scientists and clergymen. These two groups joined together to voice

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[1] Ibid., pp. 30-32.

[2] "The Author of the Vestiges of the Natural History of Creation," The American Review: a Whig Journal of Politics, Literature, Art and Science, III (February, 1846), 168-79.

[3] Millhauser, Just Before Darwin, pp. 30, 32-33, 194.

their disapproval of Vestiges. The one point on which most of the reviewers could agree was that the ideas in the Vestiges were potentially harmful to those untrained in scientific procedures and unaware of the book's inherent religious heresies.

CHAPTER II

THE COSMOS

The Formation of the Heavenly Bodies

Robert Chambers was a man with a purpose--to convince his readers of the universality of a single natural law, the law of development. Being, contended Chambers, in both its inorganic and organic forms is progressing from an undifferentiated beginning towards an ideal of increasing complexity. To support his hypothesis of the all-pervading influence of development, Chambers appropriated a popular theoretical proposition--an idea which was first called the Nebular Hypothesis by William Whewell in 1837.[1] This hypothesis postulated the evolution of the highly organized heavenly bodies from a primordial nebular mass. If development could be demonstrated on a cosmic scale, as indicated by this hypothesis, Chambers would have established a basis for its extension to more microcosmic levels. Therefore he was very interested in establishing the "truth" of this proposition.

Early Cosmogonical Theories

Although the term Nebular Hypothesis was a new one for nineteenth century investigators, seeds of the idea of the production of the universe from a primordial cloud were present in Presocratic Greece.

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[1] "Nebular," OED, 1933, VII, 59; William Whewell, History of the Inductive Sciences (London: J. W. Parker, 1857), II, 229.

Anaxagoras of Clazomenae (ca. 500-ca. 428 B. C.), according to G. S. Kirk's and J. E. Raven's account of Simplicius' version, noted that the formation of the earth resulted when

> air, which is at this stage the opposite of aither, is solidified into clouds; from clouds come water; from water comes earth; and finally from earth are solidified stones. Not only is like continuing to be attracted by like, but also, evidently, the pressure at the centre of the rotation . . . is compressing the 'seeds' into ever more solid bodies.[1]

The idea of solid bodies consolidating from a diffuse subtle substance was found much later in the highly mystical Principia rerum naturalium (1734) of Emmanuel Swedenborg (1689-1772). Although the Encyclopaedia Britannica has attributed a Nebular Hypothesis to Swedenborg, explaining that he "had arrived at the nebular hypothesis theory of the formation of the planets and the sun long before Kant and Laplace," nothing as structured as this was evident in his writings.[2] Apparently his so-called Nebular Hypothesis consisted of a suggestion that stars clustered, thus associating themselves into societies or systems.[3]

According to the Oxford English Dictionary, the Nebular Hypothesis was propounded by Emmanuel Kant (1724-1804).[4] However, Kant did not

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[1]G. S. Kirk and J. E. Raven, The Presocratic Philosophers. A Critical History with a Selection of Texts (Cambridge: University Press, 1964), p. 384.

[2]Alexander James Grieve, "Swedenborg, Emmanuel," Encyclopaedia Britannica, 11th ed., XXVI:222.

[3][Woodbury M. Fernald], Emanuel Swedenborg as a Man of Science; a Mathematician, and Philosopher of Nature; as a Civilian, Seer and Theologian, and as a Philosopher of Spirit: with a Brief Review of all His Works on Science, Philosophy and Theology. Being the Fullest Life of Him ever Published. With an Appendix (Boston: Otis Clapp, No. 3 Beacon Street, 1860), pp. 16-18.

[4]"Nebular," OED, 1933, VII, 59.

equate the original universe-forming-material with the observable nebular material; therefore, it is somewhat presumptuous to credit him with a nebular hypothesis. Nevertheless, Kant's cosmogony is such that it is possible to substitute the observable nebular material for the unnamed primordial material out of which the bodies of the universe were formed. Kant conceived of the original universe as a chaos upon which attraction and repulsion acted to construct order.

Laplace was also slow in equating the observable nebular material with the formative material of the cosmos. This postulate was added in the fourth edition of his Exposition du système du monde (1813) when he stated that

> dans l'état primitif où nous supposons le soleil, il ressemblait aux nébuleuses que le télescope nous montre composées d'un noyau plus ou moins brillant, entouré d'une nébulosité qui, en se condensant à la surface du noyau, le transforme en étoile.[1]

His use of the terms nébulosité, atmosphere du soleil, and vapeurs for the primordial substance varied in different editions, suggesting that Laplace was not necessarily supposing a nebular origin for the entire cosmos but only that he perceived an analogy between the nebular material and the raw material of the solar system. The repeated revisions of the sections concerned with the primordial substance suggest that Laplace was not certain in his own mind about the relationship between the nebular material and the solar-system-forming material.

Laplace was more explicit in his description of the latter substance than he was of the nebular material. Explaining that it once had embraced all of the planets and their satellites, he concluded

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[1] Pierre Simon Laplace, Exposition du système du monde (4th ed.; Paris: M^me^ V^e^ Courcier, Imprimeur-Lib. pour les Sciences, quai des Augustins, n^o^ 57, 1813), II:425-26.

that it had to be some kind of a fluid. This "solar atmosphere" extended beyond the orbits of all of the planets but gradually contracted to its present limits.[1] As the entire mass of the solar system rotated, occasionally centrifugal force overbalanced the gravitational force causing the separation of an outer ring from the inner mass. Although for a period of time the two forces were in balance, eventually an inequality again occurred causing another ring to be formed. This continued to occur until a series of concentric rings were formed which were abandoned in the plane of the sun's equator.[2] From these rings, explained Laplace, the planets were condensed; the satellites were formed in a similar way from the atmosphere of the planets.

Although Laplace indicated that the occurrence of the rings of Saturn added probability to the hypothesis, he made it evident that he considered it highly speculative, observing that

> Quoiqu'il en soit de cette origine du systéme planétaire, que je présente avec la défiance que doit inspirer tout ce qui n'est point un résultat de l'observation ou du calcul; il est certain que ses élémens sont ordonnés de manière qu'il doit jouir de la plus grande stabilité, si des causes étrangeres ne viennent point la troubler.[3]

But to Robert Chambers the hypothesis was highly probable because it fit into his total conception of "development" as a fundamental process. In referring to the hypothesis in the later editions of Vestiges, Chambers tended to replace the terms "Nebular Hypothesis" with "Laplacian Cosmogony," "Laplace's Hypothesis," or"Laplace's Theory," making it

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[1] Ibid., p. 425.

[2] Laplace, Exposition du système du monde (Paris: De l'Imprimerie du Cercle-Social, rue du Théâtre Français, N°. 4, [1796], II, 301-303.

[3] Ibid., p. 303.

apparent that he credited Laplace with the original nebular concept. Chambers' acknowledgment of Laplace's primary role in the development of this hypothesis was even more obvious in the tenth edition, for he entitled an entire section the "Laplacian Cosmogony."[1]

In addition to the theory of the Frenchman Laplace, some detailed observations and cautious theories produced by the Astronomer Royal, William Herschel (1738-1822), influenced Chambers. Herschel had long been interested in the observation and classification of the varieties of nebulae, but his cosmology reached maturity in two papers of 1811 and 1814. In a paper read to the Royal Society on June 20, 1811, Herschel presented a classification of nebulae indicating that although when the extremes were observed little relationship was evident, when a whole series of nebulae were placed side by side one form could be found to intergrade with the next.[2] He summarized his hypothesis as follows:

> the total dissimilitude between the appearance of a diffusion of the nebulous matter and of a star, is so striking, that an idea of the conversion of the one into the other can hardly occur to anyone who has not before him the result of the critical examination of the nebulous system which has been displayed in this paper. The end I have had in view by arranging my observations in the order in which they have been placed has been to shew, that the above mentioned extremes may be connected by such nearly allied intermediate steps, as will make it highly probable that every succeeding state of the nebulous matter is the result of the action of gravitation upon it while in a foregoing one, and by such steps the successive condensation of it has been brought up to the planetary condition. From this the transit to the stellar form,

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[1] CV X:[ii]-iii.

[2] William Herschel, "Astronomical Observations Relating to the Construction of the Heavens, Arranged for the Purpose of a Critical Examination, the Result of Which Appears to Throw Some New Light upon the Organization of the Celestial Bodies," Philosophical Transactions of the Royal Society of London, CI (1817), 271.

> it has been shown, requires but a very small additional compression of the nebulous matters, and several instances have been given which connect the planetary to the stellar appearance.[1]

Herschel's opinions were greatly respected, especially in Great Britain. Since the discussion in the Encyclopaedia Britannica on the nebulae was based to a large extent on his observations and opinions, and the fourth edition of the Britannica was possessed by the Chambers family and read by young Robert, it was probably influential in developing his interest in astronomy.[2] Although in this edition the evolutionary character of the nebulae was not specified, the report afforded a detailed description of them, discussed Herschel's method of "gauging the heavens," and described the position of the solar system within the Milky Way.[3] The universality of the law of attraction was applied to the stars which, explained the article, attracted one another and resolved themselves into clusters.[4] The nebula of which our solar system is a part is relatively young, since the stars comprising it have not yet formed clusters. Clustering, it continued, is gradual and may be eventually forthcoming in this nebula.[5] Thus Herschel's early emphasis on the involvement of gradual process in the clustering of stars was available to Chambers.

The Influence of the Earl of Rosse's Telescope on the Credibility of the Nebular Hypothesis

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[1] Ibid., pp. 330-31.

[2] Millhauser, Just Before Darwin, pp. 12-13.

[3] "Astronomy," Encyclopaedia Britannica, 4th ed., III, 73-74.

[4] Ibid., p. 75.

[5] Ibid., p. 78.

After Herschel's two papers of 1811 and 1814, the Nebular Hypothesis became a scientifically respectable speculation. But shortly afterwards a discovery by the Earl of Rosse made astronomers question the reliability of the hypothesis. Lord Rosse reported to the British Association in 1844 that he had constructed a reflecting telescope which he hoped would be more effective in examining the nebulae than were the refracting ones currently in use.[1]

This proved to be the case, for many of the nebulae formerly thought to be irresolvable were resolved into their component stars. But in 1844, the year of the first edition of Vestiges, Lord Rosse was still unwilling to postulate that all of these nebulae were resolvable, as he explained that

> it is also perhaps important to observe, that now, as has always been the case, an increase of instrumental power has added to the number of the clusters at the expense of the nebulae, properly so called; still it would be very unsafe to conclude that such will always be the case, and thence to draw the obvious inference that all nebulosity is but the glare of stars too remote to be separated by the utmost power of our instruments.[2]

By 1845, in a paper presented to the Royal Irish Academy, Thomas Romney Robinson (1792-1882), the astronomer in charge of Armagh Observatory who was closely associated with the experiments of Rosse, argued that every additional nebula resolved was evidence against the existence of unresolvable nebulae, for

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[1] William Parsons, Third Earl of Rosse, "On the Construction of Large Reflecting Telescopes," Report of the Fourteenth Meeting of the British Association for the Advancement of Science; Held at York in September, 1844 (London: John Murray, Albermarle Street, 1845), p. 79.

[2] Rosse, "Observations on Some of the Nebulae," Philosophical Transactions of the Royal Society of London, CXXXIV (1844), 324.

> there must always be a very great number of clusters, which from mere distance will be irresolvable in any instrument; and if it prove to be the case that all the brighter nebulae yield to this telescope, it appears unphilosophical not to make universal Sir J. Herschel's proposition that 'a nebula, at least in the generality of cases, is nothing more than a cluster of discrete stars.'[1]

In 1848, in another paper to the Royal Irish Academy, Robinson cited the case of the resolution of the great nebula of Orion to support his previous opinion, for this nebula had formerly been classified as one composed of irresolvable nebulous material.[2]

This new scepticism made its way into the seventh edition of the Britannica. Herschel's nebular speculations as developed in his paper of 1811 to the Royal Society were presented, but with the postscript by the author of the article that the views were mere speculations and not of the slightest value to astronomy.[3]

Chambers' Reaction to New Discoveries

Into this controversy stepped Chambers. Since he had no way of learning about the new scepticism resulting from the use of the Earl of Rosse's telescope before the first edition of Vestiges was published, he was at a decided disadvantage, for his critics did have access to this information and duly used it to chastize him. However, this excuse vanished in subsequent editions. It becomes important to note how Chambers reacted to this information and to other new data in order

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[1] T. R. Robinson, "On Lord Rosse's Telescope," from the Proceedings of the Royal Irish Academy, III (1845) 114 in The Scientific Papers of William Parsons, Third Earl of Rosse, 1800-1867 (London: Collected and Republished by the Hon. Sir Charles Parsons, K. C. B., F. R. S., 1926), p. 29.

[2] Robinson, "On Lord Rosse's Telescope," Ibid., IV (March, 1848), in Ibid., p. 35.

[3] "Astronomy," Encyclopaedia Britannica, 7th ed., III, 48.

to understand how he handled new material once he had been exposed to it.

This opportunity arose in the first sentence of Vestiges. In the first through fifth editions, Chambers had described the earth as "one of a series of eleven" spheres rotating around the sun.[1] But on September 23, 1846, Johann Gottfried Galle (1812-1910) had observed the planet Neptune whose presence had previously been predicted by John Couch Adams (1819-1892) and Urbain Jean Joseph Leverrier (1811-1877). Chambers modified his text in the sixth through tenth editions to acknowledge the discovery of Neptune by omitting the word "eleven" from the sentence. The earth was described in these editions as "being one of a series" of globes rotating around the sun.[2]

In a subsequent portion of the sixth through tenth editions, Chambers explicitly mentioned in a footnote the discovery of Neptune but resolved to ignore the implications of this discovery until more was known about it.[3] That Chambers considered this material in a footnote rather than in the text is significant, for it illustrates the caution with which he reacted to new material which might alter one of his preconceptions.

Chambers, seeking pleasing numerical relationships, noted in all of the editions the "curiously relative" distances of the planets, in which he ascertained a "most surprising proof of the unity which I am claiming for the solar system."[4] Since the discovery of Neptune nearly

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[1]CV I:1; III:L; IV:1; V:1.

[2]CV VI:1; VIII:1; IX:1; X:1.

[3]CV VI:489-90; VIII:295; IX:293; X:9.

[4]CV I:11; III:11; IV:11; VI:14; VIII:8-9; IX:8-9; X:9.

doubled the linear extent of the solar system, it could overturn his previous conception of the relative distances of the planets as expressed by Bode's Law.[1]

Thus an element of optimism that the new discovery would not negate the law was included in the same footnote, as Chambers described a case in which it formerly had appeared that the unity of a regular gradation had been violated. But theory again took precedence over observation, for the apparent discrepancy was solved when the four small planets between Mars and Jupiter were discovered and inserted into the scheme. Therefore Chambers was determined not to allow the discovery of Neptune to alter his text until "our knowledge of this stranger is somewhat extended."[2] In this example, although Chambers acknowledged the new discovery as soon as the information became available to him, he reacted to it with a Platonic-Pythagorean bias--with an assurance that the new discovery would preserve the ideal arrangement.

Chambers Acquaints the Reader with Basic Astronomy

Before attempting to support his theoretical convictions, Chambers, in the first pages of Vestiges, endeavoured to introduce the general reader to basic descriptive astronomy. He described the earth's place in the solar system, the solar system's place in an "astral system," and the interrelationships between astral systems. In order to do this, he relied heavily on secondary sources, a fact

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[1] Bode's Law, as explained by R. J. Forbes and E. J. Dijksterhuis, in A History of Science and Technology (Baltimore, Maryland: Penguin Books, 1963), II:427, "is an empirical rule for the distances of the planets from the sun, and runs as follows $d = 0.4 + (0.3 \times 2^i)$, where $i \geq 0$."

[2] CV VI:489; VIII:295; IX:293; X:9.

which annoyed critic Bosanquet. One of the popular treatises upon which Chambers relied for source material was specifically mentioned as objectionable by Bosanquet, an article in the London, Edinburgh and Dublin Philosophical Magazine by Professor Ottaviano Fabrizio Mossotti (1791-1863), a professor of pure and applied mathematics at the University of the Ionian Islands.[1]

The similarities between Chambers' presentation and the Mossotti article, "On the Constitution of the Sidereal System of Which the Sun Forms a Part," were apparent. Both Mossotti and Chambers chose a similar subject with which to begin their discussions; they stressed the vastness of the universe. Chambers presented this concept by suggesting that "if the swiftest race-horse ever known had begun to traverse it, at full speed, at the time of the birth of Moses, he would only as yet have accomplished half his journey."[2] But, he stressed, if the solar system is vast, its extent is minuscule in comparison with the distance of the closest star for

> attempts have been made to ascertain the distance of some of the stars by calculations founded on parallax, it being previously understood that, if a parallax of so much as one second, or the 3600th of a degree, could be ascertained in any one instance, the distance might be assumed in that instance as not less than 19,200 millions of miles.[3]

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[1] Bosanquet, Vestiges Examined and Exposed, pp. 10-11; O. F. Mossotti, "On the Constitution of the Sidereal System of which the Sun forms a part," The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, 3d Ser., XXII (February, 1843), 81-92; CV I:1-7; III:1-7; IV:1-7; V:1-7; VI:1-4; VIII:1-4; IX:1-4; X:1-4.

[2] CV I:2; III:2; IV:2; VI:2; VIII:2; IX:2; X:2.

[3] CV I:2; III:2; IV:2; V:1-2; VI:2; VIII:2; IX:2; X:2. A numerical correction is found in the third through tenth editions. The first edition read "not less than 19,200 millions of miles," whereas the later editions read "not less than 19,200,000 millions of miles."

Mossotti's paper also began with a discussion of the vastness of distances in the universe. At these boundless extents, he noted, "our imagination fails, and is bewildered in the conception of such an immensity of space."[1]

In his discussion of parallax as related to sidereal distances, Chambers mentioned the work of Thomas Henderson (1798-1844) and, in the first five editions, a Lieutenant Meadows, who calculated the parallax of a double star in the constellation of the Centaur. Mossotti also used this example, suggesting either a common source or Chambers' reliance on Mossotti for this information.[2]

All of Chambers' examples to illustrate the immensity of the universe were not included by Mossotti. Chambers, but not Mossotti, used the parallax of the double star 61 Cygni as an example in all of the editions but was criticized by Sedgwick for neglecting to give Friedrich Wilhelm Bessel (1784-1846) credit for calculating its parallax. Sedgwick retorted, however, that considering the quality of the book Bessel should probably have been flattered to have been omitted.[3] Bessel, however, was not allowed oblivion, for Chambers changed his text in the sixth through tenth editions, giving Bessel credit for the discovery and adding the specific parallax of 61 Cygni.[4]

Chambers proceeded in his discussion from distances to numbers of stars, stressing that, although the known number of visible stars is enormous, as telescopes of higher magnifications are produced these

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[1] Mossotti, "On the Constitution of the Sidereal System," p. 82.

[2] Ibid., p. 89.

[3] Sedgwick, Review of Vestiges, pp. 18-19.

[4] CV VI:3; VIII:2; IX:2; X:2.

numbers can be expected to increase greatly.[1] He explained that stars are organized into solar systems belonging to greater units termed astral systems. The position of a specific star, our sun, within its astral system was described according to a hypothesis advanced by Sir John Herschel. This hypothesis, also described by Mossotti (again indicating a relationship between the two reports), insisted that our astral system was not merely a stratum, as had been proposed by William Herschel, but a ring in which the sun is situated eccentrically in the southern portion.[2]

Both Chambers and Mossotti cited a common source (although it is conceivable that Chambers relied solely on Mossotti), the work of Friedrich Wilhelm August Argelander (1799-1875) a director of the observatory at Abo, to verify William Herschel's proposal that the position of the solar system with respect to the fixed stars is changing. Both Mossotti and Chambers, in the first four editions, quoted Argelander as concluding that this movement was towards a point in the constellation Hercules "near the star 143 of the 17th hour, according to Piozzi's catalogue."[3] Although no criticism of this statement was found in the reviews, Chambers omitted mentioning, in the fifth through tenth editions, the specific star towards which the sun was moving. But since Chambers' presentation of Argelander's conclusion was so similar and in some places identical to Mossotti's account, perhaps Bosanquet's insistence that

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[1] CV I:3; III:3; IV:3; V:3; VI:3; VIII:2-3; IX:2-3; X:2-3.

[2] Mossotti, "On the Constitution of the Sidereal System," p. 85; CV I:3-5; III:3-5; IV:3-5; V:3-5; VI:4-5; VIII:3; IX:3; X:3.

[3] Mossotti, "On the Constitution of the Sidereal System," p. 88; CV I:5; III:5; IV:5; V:5; VI:5-6; VIII:3-4; IX:3-4; X:3.

Chambers relied too heavily on secondary sources prompted him to omit this from the later editions. Chambers explicitly gave Mossotti credit for his description of the motions of all of the suns of the astral system. This is the only place in the book where Mossotti's influence is acknowledged.[1]

From the general discussion of the form of the cosmos, Chambers proceeded to a discussion of William Herschel's description of the distant astral systems. Noting that these systems appear to be cloud-like when viewed with telescopes of low magnification, he stated that when observed under higher magnifications they could be resolved into distinct stars. Although in the first through fourth editions Chambers mentioned that one of these astral systems bore a striking resemblance to our own system, this description was omitted from the fifth through tenth editions. Even though no reviewer specifically denounced this comparison, perhaps observations made with the Earl of Rosse's telescope rendered it less appropriate.[2]

After concluding that the forms of the astral systems differed, Chambers observed that their distances also varied considerably. During this discussion, Chambers had, in the first edition, made a numerical error in the distance of the star Sirius. In this edition he reported that its distance was "about twenty thousand millions of miles," but in the third and all subsequent editions it was recorded as "twenty millions of millions of miles."[3]

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[1] CV I:5-6; III:5-6; IV:5-6; V:5; VI:6; VIII:4, 295; IX:4, 293; X:4.

[2] CV I:7; III:7; IV:7.

[3] CV I:7; III:7; IV:7; V:7; VI:7; VIII:4; IX:4; X:4.

Although it would not necessarily be expected that a summary-type presentation of the position of contemporary astronomy would involve a reliance upon primary sources, Chambers was vulnerable to Bosanquet's charge of relying upon the extensive superficial treatment of the material by Mossotti. But since the works are far from identical, it is apparent that Chambers used other sources, although he does not indicate which ones, to complete his summary.

Chambers Uncritical Acceptance of the Nebular Hypothesis

Although Chambers insisted that the correctness of the Nebular Hypothesis was not essential to his theory, he continued to defend it throughout all of the editions while decreasing the amount of space used in explaining it. Even though this hypothesis had received a nearly lethal blow with the publication of observations made with the Earl of Rosse's telescope, Chambers was not one to let a few questionable facts upset his preconceptions. Critic W. H. Allen remarked on this characteristic when he complained that

> our author, in his Sequel, clings to the unresolved nebulae with a tenacity which shows how well he loves his hypothesis, and how clearly he sees that it cannot survive them. As one after another disappear before the unrelenting sweep of Lord Rosse's giant reflector, he grasps the few that are left, or which he hopes may be left, with the desperation of a drowning man.[1]

The critic reviewing Vestiges in the British Quarterly Review warned that extreme caution was imperative for anybody basing anything on such a questionable theory as the Nebular Hypothesis after the new

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[1] W. H. Allen, Review of Vestiges, pp. 306-307.

observational results were analyzed.[1] Chambers' poor timing in basing

> his system of the cosmical arrangements of the universe on the nebular hypothesis, at the very moment when the discoveries made by the telescope of Lord Rosse had led astronomers to regard it with greater doubt than at any period since its promulgation, . . .[2]

was noted by the reviewer in Fraser's Magazine.

Even though Chambers, in the sixth through tenth editions, admitted that Rosse's invention resolved many nebulae which William Herschel had seen as "filmy matter" into aggregations of stars, he ignored the impact of this revelation upon the Nebular Hypothesis.[3] But his critics did not! Most of the reviewers who discussed Chambers' presentation of the Nebular Hypothesis mentioned the devastating effect which Rosse's telescope had on the theory. Bowen's criticism typified several reactions among reviewers. He was convinced that just as Lord Rosse's instrument had resolved many nebulae formerly considered irresolvable, higher powered instruments of the future would eventually resolve all of the remaining unresolved nebulae into their components. This would result, he asserted, in the final demise of the Nebular Hypothesis, which was, after all, a mere guess directly opposed by "an obvious induction from those nebula which are resolvable into perfect stars."[4] Sedgwick agreed with Bowen's assumption that if all of the nebulae were resolved the Nebular Hypothesis would be destroyed,

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[1]Review of Vestiges of the Natural History of Creation, by [Robert Chambers], in the British Quarterly Review, I (May, 1845), 493.

[2]"Geology Versus Development," review of Vestiges of the Natural History of Creation, 8th ed., by [Robert Chambers], in Fraser's Magazine, XLII (October, 1950), 359.

[3]CV VI:7-8; VIII:4-5; IX:4-5; X:4-5.

[4]Bowen, Review of Vestiges, pp. 441-42.

a position also accepted by John Wallis.[1]

Sir David Brewster was even more intolerant of an attempt to use the Nebular Hypothesis to demonstrate anything. He considered Rosse's telescope a signal of its impending death. Brewster rationalized that his only reason for discussing Chambers' errors in the interpretation of this worthless theory was to counteract "the heresy, and the use which has been made of it as a basis for other errors. . . ."[2]

Sir John Herschel perhaps best summed up the effect of the new discovery on the Nebular Hypothesis when he wrote

> should the powers of an instrument such as Lord Rosse's succeed in resolving these [unresolved nebulae] also into stars, and, moreover, in demonstrating the starry nature of the regular elliptic nebulae, which have hitherto resisted such decomposition, the idea of a nebulous matter in the nature of a shining fluid, or condensible gas, must, of course, cease to rest on any support derived from actual observation in the sidereal heavens, whatever countenance it may still receive in the minds of cosmogonists from the tails and atmospheres of comets, and the zodiacal light in our own system.[3]

Herschel still allowed the Nebular Hypothesis an existence as pure speculation, a position which Sedgwick also found acceptable.[4]

The effect of the discoveries made with the new telescope upon Chambers' acceptance of the Nebular Hypothesis as "development" upon a cosmic scale, can best be seen from examining the amount of emphasis placed on it in the first five and the last five editions. In the

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[1] Sedgwick, Review of Vestiges, p. 19; John Wallis, Brief Examination of the Nebulous Hypothesis, with Strictures on a Work Entitled Vestiges of the Natural History of Creation (London: R. Groombridge & Sons, 5, Paternoster Row, 1845), pp. 22-23.

[2] Brewster, Review of Vestiges, p. 479.

[3] John Herschel, "Presidential Address," pp. xxxvii-xxxviii.

[4] Ibid.; Sedgwick, Review of Vestiges, p. 19-20.

earlier editions, the hypothesis was presented as an accepted truth with a major emphasis upon explaining its mechanisms to the reader, whereas in the later editions less emphasis was placed on the mechanics of the system with more consequence placed upon the philosophical legitimacy of searching for cause.

The Rationale for the Nebular Hypothesis

In the sixth through tenth editions, Chambers delayed the discussion of the Nebular Hypothesis itself by presenting a preparatory section, not included in the earlier editions, upon the nature of knowledge. He noted that modern philosophy revealed a universe

> different indeed from that of our forefathers, who did not know the bounds even of this little world, and beheld in the sun, moon, and stars, only a set of menial lights, ordained, usefully or not, to attend it.[1]

His optimistic view stressed that not only had mankind progressed to a remarkable degree in its concepts of the universe, it had the potential to advance much further, for "where our perceptive faculties are baffled, we dream; where they compass their object we inquire after cause."[2]

Since the use of the mind presents a "direct means of improving our condition on earth, and to advance in the scale of moral as well as intellectual being," mankind's ability to be creative must be good, Chambers asserted.[3] These idealistic concepts are justification for the Nebular Hypothesis as well as for the Developmental Hypothesis, and may

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[1] CV VI:8; VIII:5; IX:5; X:5.

[2] CV VI:9; VIII:5; IX:5; X:5.

[3] CV VI:9; VIII:5; IX:5; X:5-6.

explain their inclusion in the later editions at this point, for since the veracity of the Nebular Hypothesis had been so frequently questioned, Chambers sought to establish the legitimacy of this kind of theoretical inquiry.

It is unnecessary for inquiry to have any foreseeable practical result, continued Chambers. Pure science, entirely divorced from pragmatic considerations is a legitimate activity. Such a pursuit may even yield unexpected practical results, as "from Napier's discovery of the logarithms, or, to take an opposite instance, from Smith's ascertainment of the order of rocks."[1] Thus, he concluded, no field of inquiry should be closed to the investigations of the mind, as any form of inquiry which might lead man closer to truth is good.[2] Again, Chambers had established a rationale for concerning himself with suspect fields of inquiry such as the origin of the universe through the auspices of natural law.

The Nebular Hypothesis as Vital to Chambers' Concept of the Universality of Law

From his Platonic preconceptions, Chambers knew that God would have created the universe as simply as possible. And simplicity, from Chambers' point of view, involved universal law acting at every level of being, from the origin of the cosmos to the operation of the most minute of terrestrial phenomena. The problem was, he explained in the sixth through tenth editions, "in bringing down the mind to sufficiently simple conceptions."[3] This concept of universal law explains why the

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[1] CV VI:9; VIII:6; IX:6; X:6.

[2] CV VI:9; VIII:6; IX:6; X:6.

[3] CV VI:10-11; VIII:6-7; X:6-7.

Nebular Hypothesis or a comparable developmental theory as to the origin of the cosmos was so necessary to Chambers' hypothesis, in spite of his assertions to the contrary.

In order to convince the reader of the validity of his assumption, Chambers claimed that geometers had recently established universal law as a "fact," asserting that it was now "fully ascertained" that the globular form of the planets was established by means of the same laws that determine the spherical shape of the dew drop. The reference here is to a series of experiments by Professor Plateau of Ghent noted in a subsequent section of this chapter. Since analogies between the microcosm and macrocosm could also be applied to the forces which controlled each, the same forces, gravitation and centrifugal force, operate to keep the planets in stable orbits around a central mass as operate "when we see a stone which has been thrown from a boy's hand brought in a curve to the ground."[1]

It should not be assumed that the idea of natural law working at every level of organization and of simplicity as the ordering principle of the Creator were new ideas found in the sixth through tenth editions. On the contrary, the ideas were present in the Vestiges from the commencement of the first edition. But both the form in which these concepts were presented and their position in the text, before the discussion of the particulars of the Nebular Hypothesis, were new in these editions. The discussion of law was at the conclusion of the earlier editions. In the first five editions, Chambers also concluded that simplicity and uniformity are primary characteristics of the universe but in different

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[1]CV VI:10-11; VIII:6-7; IX:6-7; X:6-7.

words from those used in the later editions as he explained that

> the regulations on which all the laws of matter operate, are established on a rigidly accurate mathematical basis. Proportions of numbers and geometrical figures rest at the bottom of the whole.[1]

The fifth edition exhibited characteristics of both the first through fourth editions and the sixth through tenth. Although the order of presentation was similar to that of the earlier editions, the content resembled that of the later attempts. As in the first four editions, the general discussion of a uniformly acting natural law was included near the conclusion of the chapter, although the actual discussion of the microcosmic-macrocosmic analogies more resembled that found in the sixth through tenth editions. In this case, the fifth edition apparently represented a "developmental" stage in Chambers' thought, in which he was rewriting and reorganizing but was not yet satisfied with the result.

The fifth edition continued along these intermediate lines in its introduction of the experiments of Plateau of Ghent. These experiments were not described in the first four editions but were inserted in the fifth edition after a description of the Nebular Hypothesis--a description similar in all five of these editions. However, in the sixth through tenth editions, the Ghentian experiments were summarized at the conclusion of the chapter.

The Ghentian experiments were prime evidence, making it difficult for the reader not to accept the Nebular Hypothesis. For Chambers concluded that whereas the nebular proposition was not completely proved, these experiments virtually left no doubt as to its credibility,

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[1] CV I:25; III:25; IV:25; V:27.

advancing it "by experiment to a point at which we may almost be said to see it passing into the region of ascertained truths." This quotation exemplified Chambers' use of essentially the same sentence to illustrate different propositions in different editions. A similar sentence was used in the third and fourth editions where Chambers also mentioned, without the evidence of the Ghentian experiments, that he considered the Nebular Hypothesis to be "verging upon the region of our ascertained truths."[1]

Sedgwick had taken particular exception to Chambers' consideration of the Nebular Hypothesis as essentially proved. He described the hypothesis as "a splendid vision, and may vanish in mid air. . . ." It certainly was not, as Chambers had stated, "verging on the region of ascertained truths."[2]

In the sixth through tenth editions, Chambers was more cautious in extolling the virtues of the Ghentian experiments as proof of the Nebular Hypothesis than he was in the fifth edition, possibly reflecting Sedgwick's consternation. The positive "passing into the region of ascertained truths" of the fifth edition was excised from these later editions and replaced by the more moderate statement that "a remarkable approximation had also been made to what may be called an experimental verification of this cosmogony, by a living professor, M. Plateau of Ghent."[3]

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[1] CV III:19-20; IV:19-20; V:17-21.

[2] Sedgwick, Review of Vestiges, p. 23.

[3] CV VI:23; VIII:14; IX:15; X:15.

The Ghentian Experiments as Illustrative of Universal Law

These experiments as described in the fifth through tenth editions demonstrated that oil relieved from the effects of gravity would assume a globular form. If an oil sphere was caused to rotate it soon flattened at the poles and swelled out at the equator. As the rotation quickened the globule became more oblately spheroidal. After a maximum of flattening was reached, a ring was formed which became disengaged. If the rotation was continued after the separation of the ring, it divided itself into several masses which immediately took spherical forms and began to rotate in the same direction as the ring.

Chambers concluded that "the experiment presents, as we see, an image in miniature of the formation of the planets, according to the hypothesis of Laplace, by the rupture of the cosmical rings attributable to the condensation of the solar atmosphere."[1] However, W. H. Allen objected to the Ghentian experiments as proof of the Nebular Hypothesis because he did not consider the experimental situation analogous to the cosmic arrangement. For in the experiment, although the oil collected into a sphere, a revolving sphere was not produced by the collection of materials at a common center as would have occurred in the cosmos if the Nebular Hypothesis were correct.[2]

Gravitation as Illustrative of Universal Law

Gravitation as a universal phenomenon was emphasized more in

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[1] CV V:17-21; VI:23-25; VIII:14-16; IX:15-16; X:15-17.

[2] W. H. Allen, Review of Vestiges, p. 306.

the sixth through tenth editions than it was in the first through fifth. In the early editions, this discussion was included as a part of the general description of the cosmos, and, although Chambers mentioned that the laws of gravity are as applicable in stellar space as they are within our solar system, he did not expand upon this concept. But in the sixth through tenth editions, an expanded description appeared after the discussion of the universality of natural law. Chambers in these editions considered the extension of Newton's gravitational laws to explain perturbations in planetary motions as well as the proper motion of stars. Everything, he concluded, depends "upon those simple physical laws which preside over every particle of tangible matter in our own sphere."[1]

Chambers' Presentation of the Endangered Nebular Hypothesis

The way in which Chambers presented the Nebular Hypothesis in the different editions illustrates how he obtained knowledge of the universe and how he reacted when this knowledge was threatened. As a Platonist, he had accepted the Nebular Hypothesis as the way in which God would have formed the universe. Granted this postulate, he searched for, and found, confirmatory evidence from both observation and calculation. When conflicting evidence arose, he was in a dilemma. He solved the problem by revising his discussion of the Nebular Hypothesis and presenting it as a tentative statement while alluding to the difficulties in its acceptance. Still he did not allow this new tentativeness of approach to materially alter his conclusions, for he

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[1]CV I:7; III:7; IV:7; V:7; VI:11-12; VIII:7; IX:7; X:7-8.

left no doubt in the mind of the reader that the Nebular Hypothesis did, in fact, represent truth. A truth which, although he denied it, was necessary in order for his own Developmental Hypothesis to be valid. Thus Chambers after having conceived of how God would have created the universe was not inclined to allow new facts to alter that conception, but yet was unable to entirely ignore their existence.

Chambers' recognition of the new data collected from observations from Lord Rosse's telescope was implicitly evidenced by his omission in the sixth through tenth editions of the detailed discussion of evolving nebulae found in the first five editions. In the earlier editions, Chambers had presented the observational evidence to support a view of the evolution of the globes from a primitive nebular material. Included in these editions was William Herschel's classification of nebulae. Herschel had explained that nebulae ranged from irresolvable ones "as that in the sword of Orion," to those "in which small bright nuclei appear here and there over the surface," to an ultimate stage wherein "we see only a common star with a slight bur around it."[1]

Chambers described the nebular situation by analogy, noting that "it may be presumed that all these are but stages in a progress, just as if, seeing a child, a boy, a youth, a middle-aged, and an old man together, we might presume that the whole were only variations of one being."[2] This analogy appeared to be an expanded version of one used by William Herschel in his paper of 1811 when he compared the nebular

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[1] CV I:7-8; III:7-8; IV:8; V:8.

[2] CV I:8; III:8; IV:8; V:8.

gradations by writing "that there is perhaps not so much difference between them if I may use the comparison, as there would be in an annual description of the human figure, were it given from the birth of a child till he comes to be a man in his prime."[1]

The Ability of the Nebular Hypothesis to Save the Phenomena

Whereas only in the earlier editions did Chambers discuss the observational bases for the Nebular Hypothesis, he noted in all of the editions the general characteristics of the solar system which would make it susceptible to having been created by such a method.[2] The uniformity of the planetary motions made him reject chance as a formative cause. As had Laplace earlier, he observed both that the planets all moved nearly in one plane--a plane passing through the center of the sun's mass--and that the motions of the planets and their satellites were all in one direction, from west to east.[3]

But John Wallis complained that this was not the case, for although, according to the hypothesis, the planes of the planetary orbits should correspond with that of the sun's equator he claimed that they did not.[4] W. H. Allen was also critical of the Nebular Hypothesis for failing to explain the inclination of the axes of rotation to the planes of revolution or for the great inclination of some of the

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[1]William Herschel, "Astronomical Observations Relating to the Construction of the Heavens," p. 271.

[2]CV I:9-12; III:9-12; IV:9-12; V:8-12; VI:12-15; VIII:7-9; IX:7-9; X:8-10.

[3]CV CV I:9; III:9; IV:9; V:9; VI:13; VIII:8; IX:8; X:8.

[4]Wallis, Brief Examination of the Nebulous Hypothesis, p. 21.

planetary orbits to the plane of the sun's equator.[1] However, William Whewell interpreted the facts as allowing the hypothesis to explain the nearly circular motion because it was almost in the plane of the original solar rotation and in the direction of that rotation.[2] For whereas Whewell saw the motion as nearly circular, Wallis stressed its non-circularity, thus finding the hypothesis wanting. Since when the planets were expelled the centrifugal force was only slightly ascendant over the gravitational, the orbits should be quite circular, claimed Wallis.[3]

The Nebular Hypothesis itself, exclusive of the observational evidence countering it, received other criticisms for failing to save the phenomena from several of the reviewers of Vestiges. One general criticism which continually reappeared in the reviews was its inability to explain comets. Sir David Brewster found it impossible to find an explanation for comets, "moving in all directions, and in planes of every possible inclination, launched across systems in which no material for their production can be found," in this hypothesis.[4] The writer of the review in the Expository Outline as well as W. H. Allen noted also that the hypothesis had no explanation for either the existence of comets or for their anomalous motion.[5] John Wallis was

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[1] W. H. Allen, Review of Vestiges, pp. 297-98.

[2] William Whewell, Indications of a Creator. Extracts Bearing upon Theology from the History and the Philosophy of the Inductive Sciences (London: John W. Parker, West Strand, 1845), p. 11.

[3] Wallis, Brief Examination of the Nebulous Hypothesis, pp. 21-22.

[4] Brewster, Review of Vestiges, p. 480.

[5] An Expository Outline of the "Vestiges of the Natural History of Creation;" with a Comprehensive and Critical Analysis of the Arguments by

similarly critical and added that the hypothesis would not explain why the comets are luminescent and gaseous rather than opaque and solid like the planets.[1]

The reviewers continued with adverse criticisms. Brewster was unable to understand how this hypothesis could explain the motion of "the whole of our system round a point in the constellation Hercules." He noted that Chambers had failed to conjecture about this lack and volunteered that "were he to make the attempt, he might learn, better than by any other process, the true character of his own speculations."[2] Wallis thought that the sun was the wrong shape for the Nebular Hypothesis to be correct. If this hypothesis were valid, he assumed that the sun should be an oblate spheroid of enormous eccentricity because a centrifugal force strong enough to overcome the centripetal force of gravity would result in an oblately flattened nebula.[3] W. H. Allen objected that the hypothesis could not explain why the rotatory motions of Jupiter and Saturn were more rapid than those of the smaller and denser planets.[4]

Even Chambers recognized one instance in which uniformity of motion was violated and for which the Nebular Hypothesis had no

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Which the Extraordinary Hypotheses of the Author are Supported and Have been Impugned, with Their Bearing upon the Religious and Moral Interest of the Community. With a Notice of the Author's "Explanations: a Sequel to the Vestiges." Originally printed in a Supplement of The Atlas Newspaper of August 30 and December 20, 1845 (London: J. Vincent, 1846), p. 17.

[1] Wallis, Brief Examination of the Nebulous Hypothesis, p. 22.

[2] Brewster, Review of Vestiges, p. 480.

[3] Wallis, Brief Examination of the Nebulous Hypothesis, p. 21.

[4] W. H. Allen, Review of Vestiges, pp. 297-98.

satisfactory explanation--the apparent anomalies in the motion of the satellites of Uranus. But he attempted such an explanation in a footnote in each edition. In the first through fourth editions, Chambers stated that although the revolutions of the satellites had not yet been clearly scanned, they appeared to be retrograde. Clearly this exception to uniformly operating natural law was impossible within Chambers' framework, so he sought an explanation consistent with his preconceptions.

In the first through fourth editions, he explained the anomaly by suggesting that the problem probably stemmed from the fact that the revolutions of the satellites "have not as yet been clearly scanned." Possibly, he noted, the motions were not actually retrograde but merely appeared to be so because of a bouleversement of the primary. But Chambers conceded that "the subject is altogether so obscure, that nothing can be founded on it."[1]

Bosanquet was highly critical of Chambers for not attaching the proper significance to this exception. He wrote that the reason Chambers merely mentioned such a devastating anomaly was that to him "the theory is more worthy than the proofs, the proofs must bend to it; and it is only suggested that these satellites probably overshot themselves, 'owing to a bouleversement of the primary.'"[2] Bosanquet considered this an unjustifiable position.

The author of the Expository Outline concurred, and remarked that "what is meant by the bouleversement of a planet none of his critics

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[1]CV I:9; III:9; IV:9.

[2]Bosanquet, Vestiges Examined and Exposed, p. 15.

seems to apprehend, nor do we."[1] W. H. Allen also complained that the Nebular Hypothesis did not explain the retrograde motion of the satellites of Uranus.[2]

It was totally improbable, asserted Sedgwick, that the problem of the retrogradation of the satellites of Uranus could be solved by simply doubting the fact of retrogradation.[3] In spite of the critics' rejection, this type of approach accepted by Chambers has been historically consistent with idealism. For from the time of Parmenides who, finding inconsistencies between sensory and rational knowledge, simply denied the validity of sensory knowledge, idealists have explained inconsistencies in their theories by ignoring their existence. However, Chambers was unable to completely follow a Parmenidean path and deny that these satellites presented a difficulty, for again, in Explanations, he suggested the bouleversement idea as a possible solution although "it has been scoffed at."[4]

As the editions progressed, Chambers apparently became more convinced that the retrogradation was apparent only. By the fifth edition he wrote that "there is an exception, but I believe apparent only, in the motion of the satellites of Uranus, which, compared with

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[1] Expository Outline, p. 17. Chambers himself does not explain what he means by a "bouleversement." However, in the later editions he states that "I suggest, as the explanation of the apparent exception, that what we call the north pole of this planet is in reality the south, the axis having passed across the plane of the orbit, so that the planet may be said to be in that small measure upside down," which is apparently a description of a bouleversement; CV VIII:295; IX:293; X:8.

[2] W. H. Allen, Review of Vestiges, pp. 297-98.

[3] Sedgwick, Review of Vestiges, p. 24.

[4] [Chambers], Explanations, pp. 14-15.

the rest is retrograde." The statement was even stronger in the sixth through tenth editions in which he explained that "there is an exception, but doubtless apparent only, in the motion of the satellites of Uranus, which, compared with the rest, is retrograde."[1]

Another general characteristic of the solar system which would emphasize the order inherent in its creation was the relationship between the bulk and density of the planets nearer the sun to that of those further out. This presented Chambers with a problem which he solved in his characteristic way--holding steadfastly to the theory and ignoring the implications of the exceptions. In the first through fourth editions, he had stated that the primary planets showed a progressive increase in bulk and diminution of density from the one nearest the sun to that which was most distant. By assuming the density of water to be one, he ascribed numbers to each planet to correspond to its supposed density. But by the fifth edition he had changed his position. In this edition he wrote that "it is of little consequence that the larger planets are towards the outside of the system, since there is an absence of regularity in the gradation in this respect." The sixth through tenth editions were basically like the fifth.[2]

Unable to abandon a mathematically satisfying explanation, Chambers, after stating that there really was no regular gradation, explained that "we find something approaching to a regular gradation."[3]

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[1] CV V:9; VI:489; VIII:295; IX:293; X:8.

[2] CV I:10; III:10; IV:10; V:10; VI:13; VIII:8; IX:8; X:8.

[3] CV V:10; VI:13; VIII:8; IX:8; X:8.

He proceeded to show this gradation by using decimal comparisons, whereas in the first through fourth editions he had used fractions. Two exceptions were apparent from his figures. Venus was less dense than Earth and Uranus was more dense than either Jupiter or Saturn. But he did not let these exceptions unduly alarm him. He ignored the problem with Venus and wrote only that "the last [Uranus] . . ." was "the only very decided violation of the rule."[1]

This attitude of ignoring the exceptions made Chambers very vulnerable to criticism. Sedgwick wrote that it simply was not true as Vestiges had stated that "the planets show a progressive diminution in density, from the one nearest the sun to that which is most distant."[2] Even though Chambers was aware of his earlier mistake by the time he wrote Explanations, noting that the planets did not increase regularly in density from the outermost to the innermost and that the sizes were also not in regular procession, this realization did not stop him from ignoring the exception in subsequent editions of Vestiges.[3]

Although Bowen did not quarrel with Chambers' assertions about the relative density of the planets, he did accuse him of selecting only those numerical relationships which supported his thesis. Bowen was apparently unaware of Chambers' mistake in his conclusions. Complaining that whereas Chambers used the figures showing a progressive increase of bulk and diminution of density from the planet nearest to the sun to that most distant because it supported his hypothesis, he

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[1] CV V:10-11; VI:13-14; VIII:8-9; X:8-9.

[2] Sedgwick, Review of Vestiges, p. 23.

[3] [Chambers], Explanations, p. 13.

ignored the periods of rotation on their respective axes because they showed no correspondence. He explained that there was no indication that the revolving motion was imparted by one inflexible law. The irregularity, noted Bowen, in the number of satellites possessed by the various planets is fatal to the theory.[1]

As was the case with Bowen, neither W. H. Allen nor John Wallis was concerned with Chambers' density figures, but both considered the Nebular Hypothesis incapable of explaining the contradictions in these data. Allen stressed that the Nebular Hypothesis did not explain the greater density of Uranus over that of Saturn. According to Wallis, the Nebular Hypothesis could not account for the observational evidence as to densities. The theory dictates, noted Wallis, that the sun should be the densest body and planets progressively more diffuse towards the periphery, for condensation must have begun at the center. It is impossible to reconcile the fact that Jupiter and the sun possess close to the same densities "although the sun has shrunk to less than a one thousand three hundred and sixty millionth part . . ." of its original bulk. Wallis noted another contradiction, for Uranus is more dense than Jupiter "though nearly four times his distance."[2]

Chambers, however, found only confirmation of the Nebular Hypothesis in the data. He considered it observationally supported by the "curiously relative" distance of the planets, and theoretically by Kepler's Third Law. Sedgwick objected to Chambers finding any confirmation of the Nebular Hypothesis in this law of Kepler's. It is

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[1] Bowen, Review of Vestiges, pp. 444-45.

[2] Wallis, Brief Examination of the Nebulous Hypothesis, pp. 11-12.

impossible, he complained, to deduce this law from the condensation of nebulae as Chambers had claimed.[1] Laplace would not have made this kind of mistake, asserted Sedgwick, for he was intelligent enough to know the limitations of his hypothesis, whereas Chambers was not.[2] However, this criticism did not cause Chambers to modify his text in later editions.

The Nebular Hypothesis

Chambers appeared reluctant to present the description of the Nebular Hypothesis in the sixth through tenth editions. In these editions he prefaced the presentation of the hypothesis with an additional discussion of natural law. Stressing again that number is basic to law, he explained that although mind is necessary for the operation of these numerically perfect laws it is not identical with them, for mind is impressed upon the laws from the outside.

The Nebular Hypothesis as Described in the Sixth through Tenth Editions

In the first through fifth editions, Chambers launched boldly into a presentation of the Nebular Hypothesis without the subtle preparatory statements found in the later editions. Perhaps in the early editions he did not realize the controversial nature of the theory so he did not assume that the reader would need to be gently led into its tenets. In addition, since the incriminating observational facts had not been digested at the time of the earlier editions, he

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[1] Sedgwick, Review of Vestiges, p. 22; CV I:11; III:11; IV:11; V:11; VI:14-15; VIII:9; IX:9; X:9.

[2] Sedgwick, Review of Vestiges, p. 22.

did not anticipate any harsh criticisms of the theory. However, in the sixth through tenth editions he was aware of the controversy surrounding the hypothesis and cautious in his presentation.

Where does one begin, questioned Chambers, when describing the creation of the cosmos? In the sixth through tenth editions he accepted as his initial postulate "the clear fact of the orbs being determined in their forms by law."[1] Although he explained that this postulate inferred a previous form of matter in which the molecules were separately moveable, he did not attempt to explain the origin of motion in these particles, for in the first five editions he had attempted to do so and had been adversely criticized for this approach.

But, given motion in the individual particles, Chambers found no problem in placing the planets in their proper orbits. This "work may be said to have been done by the will of God, expressed in the form of the law of gravitation," he explained.[2] Determining just how the will of God accomplished this end resulted in Chambers' acceptance of an Aristotelian solution, as he concluded that law, acting in a non-material manner, was able to impress itself on the material in the act of creation.[3] Special creationists are open to ridicule, asserted Chambers, for it is inconceivable to imagine separate creative fiats;

> everything leads us to the belief that there was a previous form of matter, out of which were educed the present forms and motions of the bodies of space, in the manner of though certainly not by any self-dependent efficacy in, Natural Law.[4]

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[1]CV VI:17-18; VIII:10; IX:10; X:11.

[2]CV VI:17-18; VIII:10-11; IX:10-11; X:11.

[3]CV VI:18; VIII:11; IX:11; X:12.

[4]CV VI:18; VIII:11; IX:11; X:12.

In presenting the Nebular Hypothesis in the sixth through tenth editions, Chambers used the mechanism of an historical summary. By discussing the hypothesis historically, he was spared the necessity of totally endorsing or rejecting it.

Although Chambers alluded to the new evidence in a description of the nebulae in the sixth through tenth editions, explaining that although many nebulae were resolvable "others resisted the highest telescopic power which the astronomer applied, and from various considerations, he came to regard them (it has since, appeared erroneously) as masses of diffused Luminous Matter," he was not suggesting that the Nebular Hypothesis should be in any way discredited.[1] But one can detect some anxiety over the effect of the possible, although, according to Chambers unlikely, discrediting of this hypothesis on his own Developmental Hypothesis.

This discomfiture was stated in the Explanations where Chambers stressed that the disproving of the Nebular Hypothesis would not negate his developmental theory.[2] But in this book he still considered the Nebular Hypothesis to be the most likely explanation, referring the reader to a secondary source, Professor Nichol's View of the Architecture of the Heavens for confirmation.[3] He concluded that "overlooking a few minor unexplained difficulties, the objections to the nebular hypothesis are not formidable to it."[4]

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[1] CV VI:19-20; VIII:12; IX:12; IX:12; X:12.

[2] [Chambers], Explanations, pp. 4-5.

[3] Ibid., p. 5.

[4] Ibid., p. 16.

In the later editions, still in the form of an historical summary, Chambers noted William Herschel's conclusions regarding the evolutionary character of the nebulae--a discussion which had previously appeared in the earlier editions as a part of the observational evidence making the Nebular Hypothesis likely.[1] Chambers continued his historical summary with a short explanation of Laplace's concepts of the formation of the universe.[2] By discussing the Nebular Hypothesis within this historical framework, he was both able to include its concepts as a buttress for his developmental theory and spared the necessity of committing himself completely to it.

The Nebular Hypothesis as Described in the First through Fifth Editions

Although the mechanisms of the Nebular Hypothesis were considered in more detail in the first through fifth editions than in the sixth through tenth, even in these editions Chambers did not present the material identically. The fifth edition differed slightly from the first four in several places, but there were many more common features than variations. In all of the first five editions, he proposed that the preliminary stage in the creation of the planets was the establishment of formative nuclei, although he was unable to suggest how these nuclei could have been created. After the nuclei were formed, Chambers asserted that matter was attracted to them by virtue of the law of gravitation.[3]

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[1] CV VI:19-20; VIII:11-12; IX:11-12; X:12.

[2] CV VI:20-21; VIII:12-13; IX:12-13; X:12-13.

[3] CV I:12-13; III:12-13; IV:12-13; V:12-13.

W. H. Allen found it impossible to imagine how these nuclei could be formed and rejected Chambers' suggestion that an unknown law might be responsible. Deriding Chambers, Allen asserted that he "imagines he can establish a nucleus by some law which he cannot imagine!"[1] Brewster also objected to these "nuclei of agglomeration." Insisting that he had doubted their existence even before receiving the confirmatory evidence from Lord Rosse's telescope, he stated that he had found "every reason to believe from analogy as well as from observation, that the nebulae are mere collections of stars, deriving their general lustre, or the lustre of their individual parts, from the brightness and the number of the stars of which they are composed. . . ."[2] Although Chambers did not discard the nuclei in the sixth through tenth editions, by mentioning them in the historical context of Laplace's work he evaded personal responsibility for them.[3]

Chambers observed that after matter had collected around the nuclei, the next step was the initiation of the rotation. In the first four editions, he proposed that this rotation was established in accordance with "a well-known law in physics that, when fluid matter collects towards or meets in a centre, it establishes a rotatory motion."[4] But W. H. Allen denied that there was such a "well-known law in physics." Although he conceded that this error was not entirely Chambers' fault since William Herschel had made it earlier, it did reveal "his ignorance of the first principles of mechanics, . . ." a

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[1] W. H. Allen, Review of Vestiges, pp. 301-302.

[2] Brewster, Review of Vestiges, p. 481.

[3] CV VI:20-21; VIII:12-13; IX:12-13; X:12-13.

[4] CV I:12-13; III:12-13; IV:12-13.

deficit which Allen suggested be remedied by studying "the laws of nature, by the rigorous methods of analysis, before he again ventures to set himself up as their expounder."[1] A state of rest rather than of rotation would occur following "the contraction of the nebulous mass," concluded Allen.[2]

Brewster agreed with Allen that Chambers' explanation of the establishment of a rotatory motion was impossible and that instead of rotating, the mass would remain at rest. In contrast to Chambers, Laplace, insisted Brewster, had been too well-informed to try to discover a physical cause for the original rotation when it was obviously impossible, and had postulated that a Creator gave the sun with its atmosphere its prime rotation.[3] The author of the Expository Outline was also critical of Chambers' description of the establishment of a rotatory motion, concluding that Chambers' method for accounting for the rotation was "clearly erroneous." He assumed that although gravitation would compress the particles of matter, the motion would be straight towards the nucleus, not more towards one side than the other. Therefore, it would be impossible for a rotatory motion to occur.[4] Wallis was also unable to accept Chambers' explanation. He argued that theories of heat could not explain the establishment of the rotatory motion, since the upward and downward currents would always occur toward or away from the center of gravity, "for the

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[1] W. H. Allen, Review of Vestiges, pp. 301-302.

[2] Ibid., p. 302.

[3] Brewster, Review of Vestiges, p. 479.

[4] Expository Outline, p. 14.

momentum imparted by any moving body can only cause motion in the same direction as that of the previous body."[1]

Chambers himself, by the fifth edition, reflected a lack of confidence in the automatic establishment of a rotatory motion. Caution replaced surety as he tentatively explained that when fluid matter meets in a center "there are many chances against its meeting so directly as to produce rest; most frequently, the various moments are opposed in such an oblique way, as to cause a rotatory motion."[2] These ideas were credited by Chambers to Laplace in the sixth through tenth editions as well as a conclusion that "a rotatory motion would be established, wherever, as was the most likely case, there was any obliquity in the lines of direction in which the opposing currents met each other. . . ."[3]

In the first through fifth editions, Chambers considered the whirlwind, whirlpool, and water sinking through the aperture of a funnel as analogous to the meeting of nebulous flows in space, for, in each case, a rotation commences.[4] This analogy evoked a barrage of criticism. Bosanquet stated that the meeting of nebulous streams to form a star was not comparable to fluids meeting in a whirlpool, since in a whirlpool or whirlwind the gyration was caused not by the fluid passing to the center but through it and away, whereas the nebulous material would only flow towards the center and have no

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[1]Wallis, Brief Examination of the Nebulous Hypothesis, p. 14.

[2]CV V:12-13.

[3]CV VI:20-21; VIII:12-13; IX:12-13; X:12-13.

[4]CV I:13; III:13; IV:13; V:13.

exit.[1]

Wallis asserted that forces other than gravity were responsible for the rotatory motion in a funnel; an external force not directed to the center of gravity would be required to cause the rotation. Chambers' naive explanation, Wallis asserted, would cause the reader to smile "when he is told that the little, accidental, reverberating ripples, eddies and whirlpools, sometimes occuring on the surface of running water, that originate in the influence of little gusts and whirls of wind, irregularities of surfaces and other trifling contingencies, have been seriously proposed as explanatory of the source of rotation in this nebulous mass of the solar system."[2]

Bowen's criticism of the analogy related back to the general discussion of motion. He was convinced that if the sun and all of the planets had been once molded into a single mass it would have been so huge that motion within it could not have been circular but would, of necessity, have been chaotic. Since any motion generated could not be circular it could not conceivably generate vortices or whirlwinds, for "even a rotatory motion could not be established in it, except by an impulse received from without; for there is every reason to believe, that the movement of a homogeneous fluid towards its centre, if it could take place without disturbing causes, would be in radial lines, and not in a spiral."[3]

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[1] Bosanquet, Vestiges Examined and Exposed, p. 24.

[2] Wallis, Brief Examination of the Nebulous Hypothesis, pp. 15-16.

[3] W. H. Allen, Review of Vestiges, p. 303.

W. H. Allen also objected to the analogy and explained that vortices established in the whirlwind, whirlpool, and funnel were created by conditions which were not and could not be duplicated in a nebula.[1] As the writer of the Expository Outline concluded, Chambers' error in the whirlwind-whirlpool analogy illustrated his general ignorance of the laws of mechanical philosophy.[2]

After Chambers had established to his own satisfaction the rotation of the mass, he described the next steps in the formation of the solar system by summarizing his understanding of Laplace's proposition without mentioning him by name. From the similar wording it is probable that Chambers' summary was based on the rendition of Laplace's hypothesis by Nichol, indicating again his reliance upon a secondary source.[2]

The reviewers were more critical of Chambers' presentation of the hypothesis than they were of their understanding of Laplace's original propositions. Whereas Sir David Brewster criticized Vestiges' improper use of this hypothesis, he considered Laplace's original ideas to have been perfectly legitimate speculations prior to the collection of the evidence from Lord Rosse's telescope. Laplace's objectives were limited, he explained, for "the object of Laplace was merely to explain the general circumstances which characterize the constitution of our solar system,--namely, the small eccentricity of the planetary orbits--the slight deviation of their planes from that

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[1] W. H. Allen, Review of Vestiges, p. 303.

[2] Expository Outline, p. 14.

[3] J. P. Nichol, Views of the Architecture of the Heavens. In a Series of Letters to a Lady (3d ed.; Edinburgh: William Tait, 78 Prince's Street, 1839), pp. 164-179.

of the sun's equator--and the identity in the direction of all their motions. . . ."[1] But Brewster regarded William Herschel's application of this hypothesis to the entire cosmos as unwarranted by facts, and Chambers' confused presentation of both points of view inexcusable.[2]

The writer of the Expository Outline also was convinced that Chambers had distorted Laplace's original intent which was to present a mathematical possibility, by suggesting that it was a proved theory, something, he asserted, that Laplace never intended to indicate.[3] The Nebular Hypothesis as stated by Laplace and rephrased by Whewell was objectionable, according to W. H. Allen, but when it was described by Chambers it was absolutely impossible.[4]

Summarizing the remainder of the hypothesis in the first five editions, Chambers explained that as soon as a mass begins to rotate, centrifugal force comes into action to oppose gravitational force. As long as these two forces remain balanced, the mass stays intact, but if the centrifugal force gains a slight ascendancy over the gravitational force, an outer portion separates from the mass and a ring forms which continues to rotate around the parental mass. This process is repeated whenever the centrifugal force overbalances the gravitational force. The throwing off of rings continued "until the mass attained the ultimate limits of the condensation which its constitution imposed on it."[5]

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[1] Brewster, Review of Vestiges, p. 476.

[2] Ibid.

[3] Expository Outline, p. 12.

[4] W. H. Allen, Review of Vestiges, pp. 297-99.

[5] CV I:13-14; III:13-14; IV:13-14; V:13-14.

Although the cause of the periodic excess of centrifugal over gravitational force concerned Chambers in the first four editions, his explanations failed to satisfy the critics. Postulating that since the agglomeration of a nebulous mass was attended by cooling from the outside, he assumed that the exterior would present a greater resistance to gravity and eventually cause a separation.[1] But Bowen found it impossible to understand why a refrigeration and subsequent shrinking of the internal parts would occur. Cooling, he considered, would only happen at the surface and any other viewpoint would be negated by the pragmatic act of penetrating the earth and measuring its temperature at different levels. The increase in temperature at greater depths would be opposed to the view that cooling occurred in the interior as well as on the surface. Although Chambers did not answer this specific criticism in the Explanations, he acknowledged that it presented a difficulty.[2]

Apparently Chambers found omission the only way of solving this problem since the offending sentence which stated that concurrently with the cooling at the surface, "the condensation of the central mass would be going on, tending to produce a separation from what may now be determined the solidifying crust," was omitted from the fifth through tenth editions.[3]

Wallis also denied the possibility that a law of cooling operated in the detachment of rings. Because of the rarified gaseous nature of the mass, he insisted that the interior portion could not,

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[1] CV I:14; III:14; IV:14.

[2] Bowen, Review of Vestiges, p. 444; [Chambers], Explanations, p. 13.

[3] CV I:14; III:14; IV:14.

by means of any law of cooling, at any stage shrink away independently and leave a detached ring of matter. Centrifugal force was the only possible explanation for this shrinking, he concluded.[1]

Nevertheless, Chambers, as a good Platonic-Pythagorean, knew that there had to be a mathematical basis which would determine precisely the stages at which the rings would be formed and solidified, but had to plead science's ignorance of these laws.[2] Bosanquet was unsatisfied by this explanation and persisted in asking the question as to why heavenly bodies should be left behind at exact geometrical distances.[3] Chambers stressed again in the Explanations that this was one of the particular objections "which cannot now be answered" since no law is known to determine the particular stages at which rings were formed and detached.[4] Following his usual epistemology, Chambers found little difficulty in accepting that, although science was ignorant of it, such a law had to exist for it was necessary in order to confirm what his reason told him to be the case.

But this explanation so apparently aesthetically pleasing to Chambers continued to annoy his critics. Brewster refused to accept Chambers' vague assertion that some unknown law was responsible, and demanded to be shown a demonstration of this law. From such a law it would follow, he assumed, that "we might expect that satellites might not only have satellites but also rings, and that the sun

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[1]Wallis, Brief Examination of the Nebulous Hypothesis, p. 24.

[2]CV I:14; III:14; IV:14.

[3]Bosanquet, Vestiges Examined and Exposed, p. 16.

[4][Chambers], Explanations, p. 13.

himself might have had a huge ring revolving round him in the plane of his equator."[1]

W. H. Allen objected that if, in the first place, the mass of the sun were diffused throughout the orbit of Uranus, the substance would be so exceedingly rare that the solidification of a crust to form planetary rings would be impossible. Even if this extreme diffusion and later consolidation was possible, the fragments of a solid ring, he insisted, would not consolidate to form a perfect spheroid like a planet but would form an irregular mass.[2] Although Chambers omitted the discussion of the laws determining the formation of rings from the fifth and subsequent editions (perhaps, because he could not answer the critics) he hinted at solutions in these editions.[3]

Although Chambers explained Laplace's concept of planet formation in all of the editions, the description in the first five editions was in much more detail than that of the last five. The planets, noted Chambers, were formed from the extruded rings. Since the chances were minute that the rings would be uniform throughout, they would break up, with the larger particles attracting the smaller and eventually resulting in one or several spherical masses. Although in the first through fourth editions, he did not credit anyone with these ideas, in the fifth he wrote that "such were the suggestions of the elder Herschel and Laplace as to our cosmogony; the latter of whom

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[1] Brewster, Review of Vestiges, p. 479.

[2] W. H. Allen, Review of Vestiges, pp. 304-305.

[3] CV V:14-15; VI:21; VIII:13; IX:13; X:13.

proved its "dynamical possibility by well-known physical laws."[1]

Chambers illustrated the manner of planet formation by discussing two exceptions, the rings of Saturn and the four small planets between Mars and Jupiter. These exceptions were presented in all of the editions, but in addition, in the sixth through tenth editions, Chambers also mentioned as supportive the fact that the revolutionary motions of the planets are proportional to their distances from the sun and that the planets rotate more rapidly in their orbits than do their satellites.[2]

Even though the presence of the rings of Saturn appeared to oppose the law of planet formation, Chambers asserted that "the rule, if I can be allowed so to call it, receives a striking support from what appear to be its exceptions."[3] The phrasing was different in the fifth edition with less emphasis placed on planet-formation as a rule and more emphasis on the authority of "these great men" who conceived the ideas.[4] In the discussion of the rings of Saturn as an exception, the fifth edition consistently was slightly different from the earlier editions. Although Chambers in all five of these editions mentioned the rings around Saturn as a contemporary example of rings in which the consolidation had not occurred because of a rare equal distribution of its consituents, in the fifth edition he again called upon authority

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[1]CV I:15-16; III:15-16; IV:15-16; V:14-16; VI:20-21; VII:12-13; IX:12-13; X:12-13.

[2]CV VI:21; VIII:13; IX:13; X:13.

[3]CV I:15-16; III:15-16; IV:15-16.

[4]CV V:15.

and credited Laplace with this example.[1] W. H. Allen objected to Chambers' description of the rings of Saturn as an example. Chambers' declaration that the uniformity of the substance forming the ring explained why it had not broken down was impossible, he insisted, "for if it were perfectly similar in all its parts, the equilibrium would be troubled by the smallest force, such as the attraction of a comet or satellite; and the ring would finally be precipitated upon the body of Saturn."[2]

Multiple agglomerations might sometimes occur, noted Chambers in the first five editions, as observed in the presence of the four small planets between Mars and Jupiter. Unlike in the earlier editions, in the fifth edition Chambers presented this example more as speculation than as established truth.[3]

Comte's Elaborations on the Nebular Hypothesis

Although Chambers included a discussion of Comte's additions to the Nebular Hypothesis in the first four editions, including a long footnote taken from his Cours de Philosophie Positif, this discussion was omitted from the fifth through tenth editions. The omission may have been in response to the harsh criticisms of Comte voiced by Sedgwick in the Edinburgh Review. The author of Vestiges had bestowed undeserved praise on Comte, who, in reality, left the Nebular Hypothesis where he found it, asserted Sedgwick.[1] Brewster, however, was not so

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[1] CV I:16; III:16; IV:16; V:15.

[2] W. H. Allen, Review of Vestiges, p. 305.

[3] CV I:16; III:16; IV:16; V:15.

[4] CV I:17; III:17; IV:17; Sedgwick, Review of Vestiges, p. 22.

hard on Comte, stressing that he merely regarded the Nebular Hypothesis as the most plausible of the hypotheses of the origin of the solar system "when restricted to our own planetary system." Comte, according to Brewster, was content to speculate as to whether or not "the present state of our system presented any appreciable indications of a more simple anterior state, whose general character was susceptible of being determined."[1]

Chambers did not replace the omitted discussion of Comte with additional corroboration in the fifth through eighth editions, but in the ninth and tenth editions a new authority was substituted for the missing section on Comte. In this edition, Chambers credited a Mr. Kirkwood of Pennsylvania with inventing "a fourth Keplerian law" in 1850 which accorded with the Laplacian hypothesis. This new "law" which stated that in the spheres of attraction "the periods of the rotations of the several planets;--the SQUARE of the number of times that each planet rotates during one Revolution in its orbit, is proportional to the CUBE of the breadth or diameter of its Sphere of Attraction" satisfied Chambers' Pythagorean need for a mathematical support for the Nebular Hypothesis. For here again was evidence that the rotation of each planet was not independent but a product of that planet's interrelationships with the entire mathematically-oriented system, since "thus it impresses a view of that system, analogous in every important respect to that which characterizes the philosophical speculation of Laplace."[2] This new substantiation also countered

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[1] Brewster, Review of Vestiges, p. 476.

[2] CV IX:13; X:13.

Bowen's objection that Chambers ignored the periods of rotation on axes because this rotation would not indicate the operation of one inflexible law.[1] Chambers was elated with the new evidence and considered it "as a virtual confirmation of that order of speculations"--the Nebular Hypothesis.[2]

In all of the editions Chambers presented the existence of solar systems with more than one sun as an additional support for the hypothesis, although the account in the sixth through tenth editions was abbreviated. He explained in the first five editions that Herschel's observations that these double stars had a regular revolutionary motion around each other in an ellipse had been confirmed in a rudimentary state as well, i.e. nebulous stars containing two and three nuclei in near association which at a certain point in the mixing of their matter became linked in a common revolutionary motion although they might be far enough from each other to allow for each center to have its own planets.[3] Following his analogical method of reasoning, Chambers explained that on the surface of a river where there are contending currents, two or more "dimples" may be formed near each other; in the same way binary and ternary solar systems could be formed by the confluence of conflicting streams of nebulous material.[4]

The phenomenon of the zodiacal light was used in every edition to illustrate that there existed a remainder of the primitive

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[1] Bowen, Review of Vestiges, pp. 444-45; CV IX:13-14; X:13-14.

[2] CV IX:14; X:14.

[3] CV I:18-19; III:18-19; IV:18-19; V:18-19.

[4] CV I:19; III:19; IV:19; V:17; VI:22-23; VIII:13-14; IX:14-15; X:14-15.

nebulous material which had not yet been entirely condensed into the body of the planet Mercury. In the first through fifth editions this was discussed in some detail as proof of the relatively recent completion of our solar system in contrast to others. Although the detailed discussion of the four earlier editions was also found in the fifth, in addition it included the single-sentence reminder found in the sixth through tenth editions which characterized the zodiacal light as "a remnant, as has been supposed, of the diffused solar atmosphere of the nebular cosmogony."[1]

Although this phenomenon was usually used to support the nebular cosmogony, Bowen used it to refute this hypothesis.[2] He argued that if the zodiacal light was composed of primitive nebulous matter it would be thick and dense because our system was nearly completed and the process of aggregation almost finished. This is not the case, for the light is very faint when viewed from the earth and probably not visible at all from the planets further out. Thus it would be inconceivable to imagine that we could see the very diffuse nebulous material of a system very far away when we can scarcely see the compact matter around our own sun.[3]

Chambers' Evaluation of the Hypothesis

After presenting the Nebular Hypothesis and after having marshalled much of the available theoretical, observational, and

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[1] CV I:22; III:22; IV:21-22; V:23; VI:21-22; VIII:13; IX:14; X:14.

[2] Bowen, Review of Vestiges, pp. 442-43.

[3] Ibid.

analogical support for it, Chambers reached a point for evaluation. In the first four editions he was positive as to the truth of the theory. In fact, he appeared to be even more convinced in the third edition than he was in the first. In the first edition whereas he wrote that

> the nebular hypothesis is, indeed, supported by so many ascertained features of the celestial scenery, and by so many calculations of exact science, that it is impossible for a candid mind to refrain from giving it a cordial reception, if not to repose full reliance upon it, even without seeking for it support of any other kind,

by the third and fourth editions he was considering it as "verging upon the region of our ascertained truths."[1] But by the fifth edition, he had a few misgivings, for he stated that although the Nebular Hypothesis was not proved, it was still brought as close to demonstration as we can believe any hypothesis to be.[2] In the sixth through tenth editions, Chambers omitted any such evaluation at this point in the text, although his alternating doubts and assurances appeared throughout the chapter. However, he appeared to be more convinced of the truth of the hypothesis in the ninth and tenth editions than he was in the sixth through eighth, because of the new evidence from the calculations of Kirkwood.

Although Chambers in the Explanations and the later editions of Vestiges insisted that his own Developmental Hypothesis was not tied to the Nebular Hypothesis in any way, W. H. Allen was amazed at his temerity in writing that this would not affect the validity of the

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[1] CV I:19-20.

[2] CV V:22.

developmental theory.[1] Nonsense, raged Allen, insisting that Chambers

> has the hardihood to say this, when it is obvious to the most superficial reader that he has made the fact of the creation of the solar system by law--a fact which he attempts to prove in no other way than by assuming the truth of the nebular hypothesis--the basis of an argument a fortori on which he rings the changes through the remainder of his book.[2]

The Implications of the Hypothesis

Chambers, having presented this hypothesis, asked the reader to admit of its truth for the purpose of looking at the constitution of the universe. It revealed a universe in a state of progress; a universe in which many stages in the formative prccess could be seen grading into each other, from the undifferentiated to the specialized. In the first five editions, Chambers concluded that "the whole of our firmament was at one time a diffused mass of nebular matter, extending through the space which it still occupies."[3] From this diffuse material, bodies were formed in space, a process which is "still and at present in progress."[4] Perfection was defined as consisting of the completion of a series of planets, a state which had been accomplished in our solar system since there were mathematical reasons for concluding that no planet could exist nearer to the sun than Mercury. In the first four editions alone, Chambers stated that other solar systems within our astral system were in a less advanced state, whereas some were also fully formed.[5] Although he omitted this statement from the fifth and

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[1][Chambers]. Explanations, p. 4.

[2]W. H. Allen, Review of Vestiges, pp. 299-300.

[3]CV I:21-22; III:21-22; IV:20-21; V:22-23.

[4]CV I:21; III:12; IV:21.

[5]CV I:21; III:21; IV:21.

subsequent editions, in the first five editions he noted that it was reasonable to assume because of the numbers involved that some were older than ours.[1]

But Chambers was much more cautious and concise when discussing the idea of a progressive universe originating from diffuse nebulous material in the sixth through tenth editions. In these editions, he stated that it might be assumed that the constituents of the solar system had a "common origin in a soft and diffused form of matter."[2] The disrepute into which the Nebular Hypothesis had fallen elicited a cautious statement in these editions that although "such a form of matter may now, as is alleged, be no longer actually seen in the heavens; and yet there may remain good reasons for believing that it once existed."[3]

Universal Law and the Nebular Hypothesis

Chambers concluded the first chapter of Vestiges in the first through fifth editions with a description of the universality of law in the cosmos, including a summary of the Nebular Hypothesis as a means by which such law was operative in the formation of the universe.[4] In the fifth edition he reiterated that the fate of his Developmental Hypothesis was not identical with that of the Nebular Hypothesis, stating that

> we might, then entirely dismiss the nebular theory, and still in the relations of the planets, and in the calculations as to

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[1] CV I:21-22; III:21-22; IV:21-22; V:23.

[2] CV VI:21-22; VIII:13; IX:14; X:14.

[3] CV VI:21-22; VIII:13; IX:14; X:14.

[4] CV I:23-26; III:23-26; IV:23-26; V:25-28.

> their oblate spheroidality, we should have overpowering proof that the cosmical arrangements were produced in the way of natural law.[1]

The experiment of Plateau of Ghent was placed in a final position in the chapter in the sixth through tenth editions to stress the prevalence of law and the probability of the Nebular Hypothesis.[2]

The terminal discussion in all of the editions consisted of theological musings as to the cause of natural law. In the first five editions Chambers concluded that man's finite endowments were baffled when it came to the contemplation of God, leaving nothing but to "wonder and adore!"[3] After summarizing the concepts described in this chapter, he concluded the sixth through tenth editions by wondering at the wisdom of the God who created law, writing, "truly must we be in some way immediate to the august Father, who can think all this, and so come into his presence and council, albeit only to fall prostrate and mutely adore."[4]

The most significant approach in this chapter was the way in which Chambers concerned himself with a controversial subject, the Nebular Hypothesis. This hypothesis, despite his repeated protestations to the contrary, was important to his Developmental Hypothesis. Thus he wanted it to be acceptable. And when compromising evidence appeared, although he mentioned it, he either rationalized it to support the hypothesis or else ignored the implications. This was not done

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[1] CV V:26.

[2] CV VI:23-26; VIII:14-15; IX:15-16; X:15-17.

[3] CV I:26; III:26; IV:26; V:28.

[4] CV VI:27; VIII:16; IX:17; X:17.

intentionally to deceive the reader, for Chambers as a Platonist knew that when the totality of the evidence had been collected he would be proved correct. In the meantime, it was unnecessary to dwell on the little inconsistencies which would be resolved later, although in the interest of intellectual honesty and to waylay possible criticism he was obliged to mention them. It was in this chapter that Chambers laid the foundation for creation by law in increasingly more microcosmic surroundings.

The Constitution of the Earth and Other Heavenly Bodies

Chambers' second chapter, "Constituent Materials of the Earth and of the Other Bodies of Space," spans the first section of the book on the cosmos and the second part on the earth. Constantly leaping from the outer reaches of the solar system to the earth and back again, Chambers emphasized the uniformity of the action of natural law at each level. Since the uniformity of origin of the members of the entire cosmos by means of the Nebular Hypothesis assured a commonality of substance between the different spheres, a study of the chemical formation of the planet Earth would be basic to a study of the constitution of the other heavenly bodies. Although Chambers recognized that certain variations might occur from one globe to another (such as differing planetary densities due to the amount of heat contained by the primordial matter when it was expelled from the sun), he assumed that the basic principle was still uniformity.

The Chemistry of the Universe

Proceeding to describe the chemistry of the earth and, by

extrapolation, of the other heavenly bodies, in terms comprehensible to the scientific neophyte, Chambers emerged in the role of the teacher with the reader as a pupil. He provided a general textbook description of an element, the number of which he considered to be "fifty-four or fifty-five" in the first five editions, "fifty-five" in the sixth through ninth editions, and "fifty-five is, or was lately," in the tenth, indicating an awareness of the difficulty of assigning any specific numbers.[1] Asserting that the elements were as likely to be universally occurring throughout the cosmos as were the laws of gravity and centrifugal force, Chambers reinforced his assertion of a universally operating natural law.[2]

After describing the nature of a chemical element and discussing the different states of matter, Chambers informed the reader, by referring to the earth as typical, of the kinds of matter making up the other members of the solar system. In the first edition, he mentioned that there were six gases, "oxygen, hydrogen, and nitrogen being the chief," whereas in the later editions he reported that four elements, oxygen, hydrogen, nitrogen, and chlorine were permanently gaseous. Whereas in the first edition he noted forty-two metals, in the later forms he fixed the number at forty.[3]

In describing the most abundant substances comprising the earth's crust, Chambers in the first edition stated that oxygen made up a third part of water while in the subsequent editions he reported

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[1] CV I:27-28; III:27-28; IV:27-28; V:29-30; VI:28-29; VIII:17-18; IX:18-19; X:17-18.

[2] CV I:28; III:28; IV:28; V:30; VI:29; VIII:17; IX:18; X:18.

[3] CV I:33; III:33; IV:33-34; V:35-36; VI:33-35; VIII:20-21; IX:21-22; X:21-22.

that oxygen comprised "eight-ninths of the weight of water," and in the first edition that hydrogen formed two-thirds of water, whereas in the later editions that it formed "the remaining part of water."[1]

Chambers sought, in all of the editions, to educate his readers as to the nature of chemical compounds and mixtures and to the laws regulating combination and recombination of chemical substances, explaining that although there are many simple substances they are seldom found independently. An increasing sophistication in the use of the terms compound and mixture was apparent from the earlier to the later editions. Whereas in the first through fourth editions he stated that simple substances are usually found "in some compound form," in the fifth through tenth editions he was more explicit, noting that they "generally exist in combination." By the third edition, he was aware of the differences between compounds and mixtures. Whereas in the first edition he stated that "oxygen and nitrogen though in union," form the atmosphere but are never separate in nature, in the third through tenth editions he wrote, "oxygen and nitrogen, though in mixture," form most of the atmosphere.[2]

Combination and recombination were described as principles pervasive throughout nature. Although Chambers discussed the principles of the combination of gases by volume in all of the editions, the rules governing combination by weight were not discussed in the first edition but were in all subsequent editions.[3] The laws governing

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[1]CV I:33; III:33; IV:34; V:35; VI:34; VIII:20; IX:21; X:21.

[2]CV I:34; III:34-35; IV:34-35; V:36; VI:35; VIII:21; IX:22; X:22.

[3]CV I:34-35; III:35-36; IV:35-56; V:37-38; VI:35-36; VIII:21-22; IX:22-23; X:22-23.

combination and recombination appealed to his Pythagorean biases as he noted that it was "wonderful" that the elements "observe certain mathematical proportions in their unions."[1] In all of the editions but the first, Chambers indicated that he found beauty in the proportions by which gases united by both volume and weight, marvelling that "combinations by weight are also governed by fixed and unchanging laws of the greatest beauty and simplicity."[2]

Chambers' Pythagorean mind also found attractive the idea that the orbit of a satellite marked the outermost extension of its parent planet. Writing of the earth, he reported that

> at a certain point of time after it was thrown off from the sun, the earth was no less than 482,000 miles in diameter being sixty times what it has since shrunk to. At that time, the mass must have taken rather more than twenty-nine and a half days to rotate, (being the revolutionary period of the moon,) instead of as now, rather less than twenty-four hours.[3]

The Nebular Hypothesis continued to be the point of reference upon which Chambers' discussion of chemical uniformity was based. But although in each edition Chambers attempted to convince the reader of differentiation from an originally homogeneous mass, in the sixth through tenth editions he no longer credited this position to the authority of the Nebular Hypothesis. This increased caution in relying upon the authority of this theory does not indicate a change in Chambers' assessment of the importance of this hypothesis--merely a realization that it was not as critically acceptable as it had been

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[1] CV I:35; III:35; IV:35; V:37; VI:35-36; VIII:21; IX:22; X:22.

[2] CV III:35; IV:35; V:37; VI:36; VIII:21; IX:22; X:22.

[3] CV I:36-37; III:36-37; IV:36-37; V:38-39; VI:37-38; VIII:22-23; IX:23-24; X:23.

formerly. Moreover, his subsequent discussion made it even more evident that a common origin from a common material was necessary for the uniformity of constitution of all of the bodies of the universe. In all of the editions but the first, Chambers included a long footnote, a "note from a correspondent," on the constitution of "meteoric stones," This information was used to support Chambers' uniformitarian view that a similar cause, the Nebular Hypothesis, would result in all of the heavenly bodies containing the same elements although in different combinations.[1]

The Role of Heat as a Cause for Change

Since so many combinations of elemental substances were possible, innumerable variations could occur. Chambers asserted that heat was an important cause of these variations, particularly in regulating volume. With his propensity for discovering appropriate exact mathematical laws, he overextended the state of knowledge of contemporary chemistry when he stated in the first four editions that chemists were able to determine the exact amount of heat necessary to vaporize all of the water on the earth as well as determining the amount which would be required to make the whole planet vaporiform. By the fifth edition, he realized that the chemist could not really accomplish this feat, but he had great hopes for the future, writing that "the chemist will probably yet tell us what additional amount of heat would be required to vaporize all the water of our globe; . . . and, finally, how much more would be required to cause the whole to become

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[1]CV III:40-41 IV:40-41; V:42-43; VI:490-91; VIII:298; IX:296; X:25-26.

vaporiform. . . ."[1] By rendering the entire globe vaporiform, speculated Chambers, an approximation to the original nebulous state could be ideally attained. The increasingly precarious position of the Nebular Hypothesis was apparent in a difference in wording between the fifth edition, which remarked on the earth's "original nebulous state" and the sixth through tenth editions which reported on its "supposed original nebulous state."[2] Chambers theorized in all of the editions that the chemist could calculate the exact amount of shrinking which would result from a cooling earth.

The original nebulous material, explained Chambers in all of the editions, was very hot. In the first five editions, he stated that

> when, then we find that its matter and that of the associate planets was at one time diffused throughout the whole space, now circumscribed by the orbit of Uranus, we cannot doubt, after what we know of the power of heat, that the nebulous form of matter was attended by the condition of a very high temperature.[3]

But Sir David Brewster was skeptical of this statement.

Brewster doubted that it was possible for a nebulous material to diffuse as far as the orbit of Uranus, explaining that this substance would be millions of times more rare than the rarest of known gaseous bodies. He presented a second problem. Since all of the nebulous matter would be self-luminous, he found it conceivable to assume that it could aggregate to form more self-luminous suns, but he con-

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[1] CV I:29-30; III:29-30; IV:29-30; V:31; VI:30; VIII:18; IX:19; X:19.

[2] CV I:30; III:30; IV:30; V:31-32; VI:30; VIII:18; IX:19; X:19.

[3] CV I:30; III:30; IV:30; V:32; VI:30-31; VIII:18; IX:19; X:19.

sidered it most improbable that it could form dark, opaque planets.[1] How, asked Brewster, could the nebulous matter become hot and luminous in the first place? Noting that although this was not a problem for Laplace, who assumed the existence of a sun which was already revolving and already hot and luminous, Brewster reflected that it was a serious difficulty in Chambers' presentation.[2]

Although Chambers did not answer the latter criticisms, in the Explanations he discussed Brewster's first objection and conceded that the excessive diffuseness of the nebulous material did constitute a problem "which cannot now be answered." Even by glossing over Brewster's criticism as an irrelevant detail not to be accorded too much importance, Chambers was still forced to admit that "if this be the case, let it be allowed as a difficulty."[3] In the sixth through tenth editions, Chambers reflected the result of this criticism by slightly rewording the statement in the first through fifth editions to read that

> on the supposition that its matter and that of the associate planets was at one time diffused throughout the whole space, now circumscribed by the orbit of the outermost planet, we cannot doubt, after what we know of the power of heat, that the nebulous form of matter was attended by the condition of a very high temperature.[4]

The key difference in this sentence as stated in the earlier and later edition types relates to the use of the word "supposition" in the later forms. In the earlier editions the diffusion of the

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[1] Brewster, Review of Vestiges, pp. 480-81.

[2] Ibid., p. 480.

[3] [Chambers], Explanations, p. 13.

[4] CV VI:30-31; VIII:18; IX:19; X:19.

nebulous material was stated as an article of truth, whereas in the later it became a matter of supposition. Chambers also changed this statement in the later editions to admit the discovery of Neptune--the early editions read "circumscribed by the orbit of Uranus" and the later ones "circumscribed by the orbit of the outermost planet."[1] In view of Chambers' assertion that he would not include implications in his text regarding Neptune until more was known about it, this seemed a minor concession, for if the critics found it difficult to accept a nebulous material diffuse enough to reach to the orbit of Uranus, how much more difficult might they find it to accept a material extending clear to the orbit of Neptune which, according to Chambers' admission, would double the linear extent of the solar system.[2]

Chambers described this nebulous material which previously had been diffused throughout the planetary orbits as a "universal Fire Mist," an unhappy choice of terms which provoked the scorn of his critics.[3] Sedgwick in discussing this "universal Fire Mist," derisively stated that it was destined to "work all wonders." "We might laugh at it, or admire it, according to our humour, in a poem like that of Lucretius; but we ought to do neither the one nor the other when we read it in the laboured prose of an English Christian gentleman," lamented Sedgwick.[4] However, even these harsh words did not deter

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[1]CV I:30; III:30; IV:30; V:32; VI:30-31; VIII:18; IX:19; X:19.

[2]CV I:30; III:30; IV:30; V:32-33; VI:31; VIII:19; IX:19-20; X:19-20.

[3]CV I:30; III:30; IV:30; V:32; VI:31; VIII:18-19; IX:19-20; X:19.

[4]Sedgwick, Review of Vestiges, p. 26.

Chambers from including the concept in each edition.

Chambers himself noted another problem implicit in the previously described arrangement. Since the original diffusion of the nebulous material would necessitate a repulsive operative force, whereas the formation of the planets would require an agglomerative force, an explanation for the reversal would be required. Chambers proposed that a change in the condition of heat must occur to cause the consolidation but admitted ignorance of the laws of heat that would make this possible. Nevertheless, he postulated the existence of such laws and proposed to "trace some of the steps and consequences of the process."[1]

The cause of the change from a repulsive to an agglomerating force also disturbed the writer of the Expository Outline. Chambers' answer that something would be necessary in order to change the condition of the mist so that it could be resolved into planets, was insufficient for this critic.[2] Wallis was not satisfied either, and noted that gravity was not sufficient to cause the particles to aggregate towards the center. The repulsive element of heat, he asserted, would exactly counterbalance gravity, causing the system to remain in equilibrium.[3] Since, Wallis concluded, the only way the mass could cool was by condensation and the only way that it could condense was by cooling, an impossible circular situation resulted. If such cooling could occur it would begin at the surface and the transference of heat would go on in a direction from the center. Thus

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[1] CV I:30-31; III:30-31; IV:30-31; V:32-33; VI:31; VIII:18-19; IX:19-20; X:19-20.

[2] Expository Outline, p. 13.

[3] Wallis, Brief Examination of the Nebulous Hypothesis, p. 7.

as the central portions cooled they would become condensed and heat would pass more rapidly by conduction to the outer parts. If this were the case, then the sun should have the lowest temperature of any of the bodies, and the planets should be progressively hotter the further away that they were from the sun.[1]

W. H. Allen also found Chambers' lack of a mechanism to explain how a universally diffused and very hot vapor could be broken up into distinct nebulae unsatisfactory. Chambers' vague assertion that it would require a change of some kind in the condition of heat was unacceptable to him; he felt constrained to ask, "what change; . . . and by what law?" No possible law would account for this change, concluded Allen.[2]

Disagreeing with Wallis' supposition that the sun should be the densest and coolest of the bodies of the solar system, Chambers presumed that the outermost planets are the least dense since they were formed when the heat of the system was the greatest and, therefore, retained a portion of this heat. Mercury, on the contrary, the newest member of the solar system, is very dense because at the time of its formation the heat of the system was greatly reduced; "thus there may be upon the whole a nearly equal experience of heat amongst all these children of the sun."[3]

Sedgwick was indignant about these "brain-heated visions" of Chambers. The possibility "that Mercury and Saturn may have the very

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[1] Ibid., pp. 8-9.

[2] W. H. Allen, Review of Vestiges, p. 300.

[3] CV I:31; III:31; IV:31; V:33; VI:32; VIII:19; IX:20; X:20.

temperature of the earth" is ridiculous, he argued, even granting the truth of the Nebular Hypothesis which "assuredly in the present state of our knowledge is a very bold assumption."[1] Since, according to this theory, Saturn would have been thrown off from the sun before the earth, it would have had longer to cool by radiating its heat into space and would be cooler than the earth. Also,

> because it is less dense than the earth, and having on that account a greater capacity for latent heat, must have a less heat or temperature--and because it receives a less supply of heat from the emanation of the sun,

Saturn would be cooler than Earth; for the converse reasons, Mercury would be much hotter.[2] But Chambers continued to write in subsequent editions as he had in the first, ignoring this criticism, except for the trivial admission of the discovery of Neptune and a correction in the density of Mercury; in the early editions he had stated that Mercury was twice the density of the earth, but in the fifth through tenth editions that it was thrice the density of the earth.[3]

The Suitability of All Planets for Life

Since all of the planets are equally heated, any planet should be suitable for the development of life. The excess heat remaining after the planets were formed aggregated, Chambers explained, in "that luminous envelope of the sun" and was, therefore, available to sustain life on the various planets. Not only were the planets uniform in temperature, they were also similar chemically. Thus,

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[1] Sedgwick, Review of Vestiges, p. 25.

[2] Ibid.

[3] CV I:31; III:31; IV:31; V:33; VI:32; VIII:19; IX:20; X:20.

the earth does not have "any peculiarity about it which does not probably attach to multitudes of cosmical arrangements."[1] Sedgwick was unconvinced, writing that "beings organized like ourselves, could not exist on either of the planets we have named."[2]

The Moon as Illustrative of Cosmic Uniformity

After describing the ways in which satellites were thrown off from their planets according to the "nebular hypothesis" in the first five editions, "Laplace's theory" in the sixth through ninth editions and "Laplace's Hypothesis" in the tenth edition, Chambers described the topography of the moon. Although conceding that currently the moon does not support life, he suspected that it was in an earlier evolutionary state than the earth and that it might one day evolve into a more habitable environment.[3]

Chambers implied that the form of the ring mountains indicated an early developmental stage. The moon's surface, he noted, has a remarkable similarity to a "volcanic district in South America, and one illustrative of the formerly volcanic district of Auvergne, in France." This similarity between terrestrial and lunar processes of mountain formation implies a developmental cycle for lunar events.[4]

Chambers was more explicit in the fifth through tenth editions regarding the relationship of ring mountains to development on the

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[1] CV I:32-33; III:32-33; IV:32-33; V:34; VI:33; VIII:20; IX:21; X:21.

[2] Sedgwick, Review of Vestiges, p. 25.

[3] CV I:39-40; III:39-40; IV:39-40; V:41-42; VI:40; VIII:24; IX:25; X:25.

[4] CV I:39; III:39; IV:39.

moon. Although the specific examples of ring mountain Tycho and the comparison of the moon's surface to specific terrestrial volcanic areas, included in the first four editions, were omitted from the later editions they were replaced by two sentences adding support for "development" on the moon itself--a situation which might indicate that life too would eventually be developed on the lunar surface. Some of the ring mountains, Chambers explained, "even intrude upon and obliterate portions of the neighbouring circles, thus leading to the idea of date, or a succession of events on the moon's surface."[1]

Thus, Chambers saw no reason not to consider the moon as a possible future theatre for life--a point of view with which his reviewers were not in sympathy. We must not draw any rash conclusion about the moon not ever being suitable for life, explained Chambers in the first four editions, for it "may be only in an earlier stage of the progress through which the earth has already gone."[2] Impossible, observed the British Quarterly Review, for this theory would require either one of two things of the moon--either that, because it is a smaller body, it has gone through all of the changes which have taken place on the earth more rapidly, or, alternatively, by some accident, its development was halted at an early stage. Since neither possibility allowed for future developments which might make it supportive of life, this reviewer was convinced that Chambers had inadvertently trapped himself into admitting the possibility of a special creation of water and atmosphere for the moon. If an atmosphere had not appeared when

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[1]CV V:41; VI:39-40; VIII:23-24; IX:24-25; X:24.

[2]CV I:39-40; III:39-40; IV:39-40.

the moon was theoretically thrown off half fluid from the earth, a special creation was the only way in which this reviewer saw that there could be a possibility of such an atmosphere.[1]

The Edinburgh Review also challenged Chambers with regard to his theory of the moon. Criticizing the assumption that the moon might eventually become habitable, Sedgwick stated that "we think we have caught him napping here; for the progress of his worlds, on his own scheme of creation, is from gaseous to solid, and not from solid to gaseous." But Sedgwick felt that Chambers would be able to extricate himself from such a predicament, for

> a new hypothesis, like a witch's broomstick, will lift him from the mire, should the one he rode before have landed him there by accident. The moon's atmosphere may, for ought we know, be pent up in her bowels; and, being let out by some geological catastrophe, may thenceforth blow good to her inhabitants, as many an ill wind has done to the inhabitants of the earth.[2]

Chambers' omission of the sentence stating that the moon was only in an earlier stage of progress through which the earth had already gone was a concession to the critics which he made in the fifth through tenth editions. But such a concession was only minor, for he continued by suggesting in all of the editions that perhaps new combinations of elements on the moon might result in a more earth-like situation.[3]

A Final Case for the Nebular Hypothesis

Chambers made a final plea for the acceptance of the Nebular

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[1] Review of Vestiges, in the British Quarterly Review, I, 494.

[2] Sedgwick, Review of Vestiges, pp. 25-26.

[3] CV I:39-40; III:39-40; IV:39-40; V:41-42; VI:40; VIII:24; IX:25; X:25.

Hypothesis in all of the editions. Since all of the relevant phenomena supported it and since it (the Nebular Hypothesis in the earlier editions and the Laplacian Cosmogony in the sixth through tenth editions) explained facts which could not be explained by any other supposition, Chambers considered it probable. In the tenth edition, he called upon the authority of John Stuart Mill (1806-1873). Mill stated that there was

> in Laplace's theory, nothing hypothetical: it is an example of legitimate reasoning from a present effect to its past cause, according to the known laws of that cause; it assumes nothing more than objects which really exist, obey the laws which are known to be obeyed by all terrestrial objects resembling them.[1]

In his final plea for the Nebular Hypothesis, Chambers radically revised his discussion in subsequent editions. In the first four forms, he sought to use the idea of a central heat as an ultimate confirmation of this hypothesis. After summarizing the hypothesis once again, he added that the fact of the earth's equatorial bulge was proof that it had once been in a fluid state, for such a bulge would represent the form "which a soft revolving body takes, and must inevitably take, under the influence of centrifugal force."[2] He continued by remarking that this bulge would make the equatorial exceed the polar diameter as 230 to 229.[3]

Sedgwick was critical of Chambers' figures. According to him, the more accurate figures were 300 to 299 rather than 230 to 229. He explained that the latter numbers were derived by Newton

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[1] CV X:iii-iv.

[2] CV I:40-43; III:40-44; IV:42-44.

[3] CV I:40; III:42; IV:42.

theoretically from the statical condition of a revolving fluid body and not from any previous measurements whatsoever. He continued by stating that "it was from these two latter numbers, combined with the great physical blunders already pointed out, that we were first led to refer 'the Vestiges' to the science gleaned at a lady's boarding-school; but its rank materialism soon undeceived us."[1] Chambers omitted the offending sentence from the fifth through tenth editions.

The concept of a central heat was treated differently in the later editions than it was in the earlier ones. In the first through sixth editions, Chambers assumed the existence of such a heat as a fact, an assessment with which even Sedgwick concurred. But in the eighth through tenth editions, he had begun to doubt its existence and relegated it to the realm of supposition. Rather than accept it as a fact, he wrote of the "well-known hypothesis of a central heat."[2]

However, not all of the reviewers agreed that a hot central core represented evidence for the Nebular Hypothesis. Wallis, on the contrary, thought that if the Nebular Hypothesis were correct, the coldest part of the earth should be in the center since the heat would travel by conduction to the exterior.[3]

All of the editions were similar as Chambers explained the "fact" (in the early editions) of the central heat or the "postulate"

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[1]Sedgwick, Review of Vestiges, pp. 26-27.

[2]CV V:42-45; VI:40-42; VIII:24-25; IX:25-26; X:23-24.

[3]Wallis, Brief Examination of the Nebulous Hypothesis, pp. 8-10.

(in the later editions) of such a heat.[1] However, in the later editions, he corrected a factual error in the first four editions. In the early editions he had assumed the density of the earth to be four and a half times the weight of water, but in the later editions he described it as five and a half times this weight.[2]

In the first through sixth editions, Chambers assumed that the only way in which the central materials of the earth could be expanded was by the action of heat. But in the later editions he explained that he was giving the reasons which had previously caused scientists to accept the doctrine of a central heat.[3] Hesitating to reject a hypothesis which he considered supportive of the Nebular Hypothesis, yet deciding that it might be in error, Chambers attempted to capitalize on both views. From stating boldly that

> indeed, the existence of this central heat, a residuum of that which kept all matter in a vaporiform chaos at first, is amongst the most solid discoveries of modern science, and the support which it gives to Herschel's explanation of the formation of the worlds is most important,

to remarking in the later editions that this hypothesis was "losing favour, in consequence of experiments which show that substances cannot be maintained at a high temperature, which in contact with similar substances at a lower temperature," represented quite a change of opinion. Nevertheless by discussing the supports for the doctrine of an internal heat, Chambers was still able to make it appear as a support for the Nebular Hypothesis in the later editions.

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[1] CV I:41; III:43; IV:43; V:45; VI:42; VIII:25; IX:26; X:26.

[2] CV I:41; III:43; IV:43; V:45; VI:42; VIII:25; IX:26; X:26.

[3] CV I:42; III:43; IV:43; V:45; VI:42; VIII:25; IX:26; X:26.

[4] CV I:42; III:44; V:45; VI:42, 491; VIII:25; IX:26; X:27.

In the first through fourth editions, Chambers continued discussing the central heat, concluding that it had now reached a fixed point at which it would remain forever, whereas in the eighth through tenth editions he mentioned an alternative proposal to central heat to explain the phenomena. A plausible alternative contemporary view suggested that electric currents might account for the high heat of the interior.[1] As usual, he refused to allow a possibly conflicting fact shake his belief in the Nebular Hypothesis, concluding this chapter in the eighth through tenth editions by stating that "while the matter remains undetermined, it may be pointed to as one tending to support the Laplacian cosmogony; the statical fact alone, which is not questioned, appears in remarkable harmony therewith, in so far as it proves a rarity of materials in the interior."[2]

Chambers' purpose in including this chapter was to emphasize the universality of natural law. By considering the earth not as a unique body but as a typical representative of many other spheres, he was able to make a transition from the celestial to terrestrial regions--an important transition since the subsequent sections of the book were to be concerned with mundane occurrences.

The specific topics discussed in this chapter all related to this universality. In explaining the chemical constitution of the earth, Chambers stressed that because of a common origin all of the celestial bodies were chemically similar. It was important to Chambers to find a cause for the whirling nebulous material consolidating to

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[1] CV I:43; III:44; IV:44; VIII:25; IX:26; X:27.

[2] CV VI:42; VIII:25; IX:26; X:27.

form planets and much of the chapter was concerned with his article of faith that although no known law would explain the condensation of the nebulous material such a law had to exist and would some day be discovered--a solution found unsatisfactory by his critics. Since all of the planets were chemically similar, Chambers fully expected them to host living forms. Although admitting that the moon at the present did not support life, he held out future hope for this apparently barren satellite.

In this chapter Chambers made it clear just how dependent his whole theory was on the acceptability of the Nebular Hypothesis. Upon this hypothesis he based his entire concept of the universality of natural law. Without it, his theory lacked an essential foundation. Therefore, he concluded this chapter with a last desperate plea for the acceptance of this hypothesis before he continued with the more microcosmic applications of his dedication to universality of natural law.

CHAPTER III

THE EARTH AND ITS EARLY INHABITANTS

From the celestial subject of the creation and evolution of planets and stars, Chambers plummeted to the terrestrial region and considered the origin and progression of earthly phenomena. This descent enabled him to amass evidence to support the theoretical proposition of progressive development at all levels in the cosmos. By interpreting geological formations and their organic constituents with a developmental bias, he gathered the data upon which he could empirically justify his theoretical postulates. But when these empirical data--the paleontological and geological facts--proved to be contrary to his original assumption of development, he either ignored them, stated them briefly and discounted their significance, or, if circumstances made it possible, interpreted them with a developmental prejudice.

Since the interpretation of the fossil record at the time of the writing of the earlier editions of Vestiges was not favorable to a developmental interpretation, Chambers was often obliged to rationalize the appearances. A considerable amount of commitment was necessary to see progressive development in the phenomena. Although he possessed this commitment, he lacked the company of most of the distinguished geologists of his day.[1] Even Lyell, whom the

[1] "Geology Versus Development," p. 358.

reviewer of Vestiges in Fraser's Magazine suggested would be the the most likely of modern geologists to accept a theory of transmutation, claimed that the species had a real existence imparted to it at the time of creation with only a limited capacity to respond to the modifications of the environment.[1] It was possible, suggested this reviewer, that Lyell had Chambers in mind when he wrote in the 1847 edition of Principles of Geology that

> the theory of progressive development arose from a desire to ingraft the doctrines of the transmutationists on the most popular generalizations of geology. But modern geological researches have almost destroyed every appearance of that gradation in the successive groups of animated beings, which was once supposed to indicate the progress of the organic world from the more simple to the more complex forms.[2]

But when Chambers viewed the fossil record he found nothing but evidence for a doctrine of transformism. In order to illustrate the progressive fossil complexity in subsequent geological formations, he described each of the superimposed layers of the earth's crust from the primitive granite to the superficial formations. Although he followed this basic procedure in all of the editions, two distinct types of formats were discernible within the discussions. Whereas in the first five editions, he included a separate chapter for each geological formation considered, in the last six editions he discussed each formation as a subchapter under a primary chapter entitled, "The Earth Formed."[3]

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[1] Ibid., p. 357.

[2] Ibid.

[3] The organization of this section of the early editions of Vestiges, showing chapter titles, is indicated by this reproduction of a section of the table of contents of the first edition, p. [v].

The Primary Rocks

How, asked Chambers in all of the editions, is knowledge of the deeper portion of the earth's crust to be obtained? In answering this question in the first five editions he presented a lengthy description, explaining how observations on the strata of mountains could yield information so that "the kind of rock existing many miles below the surface can often be inferred with considerable confidence."[1]

Topic	Page No.
The Earth formed--Era of the Primary Rocks	44
Commencement of Organic Life--Sea Plants, Corals, & c.	54
Era of the Old Red Sandstone--Fishes abundant	66
Secondary Rocks--Era of the Carboniferous Formation --Land formed--Commencement of Land Plants	76
Era of the New Red Sandstone--Terrestrial Zoology commences with Reptiles--First traces of Birds	94
Era of the Oolite--Commencement of Mammalia	105
Era of the Cretaceous Formation	116
Era of the Tertiary Formation--Mammalia abundant	125
Era of the Superficial Formations--Commencement of present Species	134

The organization of the comparable material in the tenth edition as characteristic of the later edition types follows:

The Earth Formed--Geological Changes	28
Lower and Upper Silurian Formations--First Forms of Life	31
Upper Silurian	42
Devonian Era--Fishes Abundant	43
Carbonigenous Era--Land Plants and Animals	51
Permian Era--Reptiles	65
Era of the Trias and Oolite--Reptiles Abundant-- First Traces of Birds and Mammalia	69
Trias	70
Oolite	77
Cretaceous Era	90
Era of the Tertiary Formation--Mammalia Abundant	95
Era of the Superficial Formations--Existing Specific Forms Abundant	104

[1] CV I:44-45; III:45-46; IV:45-46; V:46-47.

However, in the sixth through tenth editions this information was condensed into a single sentence which stated that "the nature of the materials of the externe or crust of our globe is known to a greater depth than might be supposed, in consequence of the relation of position of its various masses."[1]

Although no mention of the Nebular Hypothesis was made in the first five editions, Chambers began the discussion in the later editions with a proposal to transport the reader from "the consideration of orb-filled space and the character of the universal elements, to trace the history of our own globe."[2] Even though it might have been expected that it would have been circumspect to avoid overemphasizing this hypothesis in the later editions, far from abandoning this conception, Chambers stressed its ability to explain geological phenomena. He assured the reader that his discussion of the earth would correspond "in an interesting manner with the primary order of things indicated by Laplace's Theory."[3]

Chaos, insisted Chambers in all of the editions, is apparent only, for beneath a superficially appearing disorder is an underlying order in the earth's crust. In presenting this proposition, however, he followed a different order in the first five and last five editions. A general outline of the components of the earth's crust preceded the discussion of order in the first five editions and followed it in the last five. This change in sentence placement again demonstrates that

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[1]CV VI:43; VIII:26; IX:27; X:28.

[2]CV VI:43; VIII:26; IX:27; X:28.

[3]CV VI:43; VIII:26; IX:27; X:28.

much of Chambers' revision consisted of rearrangement.

Polishing sentences without fundamentally changing the meaning, another revisionary method of Chambers, was also apparent in this passage. Whereas in the first through fifth editions Chambers wrote that "at first sight, a most confused scene [resulted]; but after some careful observation, we readily detect in it a regularity and order from which much instruction in the history of our globe is to be derived," in the last five editions he revised his sentence to explain that "confused as these [components of the earth's crust] first appear, an order of arrangement, connected with time, has been detected in them by the labours of modern geologists."[1] The major difference between the two sentences is in the greater economy of the latter. In addition, by emphasizing the authority of geologists in the later editions, Chambers enhanced the credibility of his position.

Organization of the Earth's Crust

Granite, explained Chambers, is a fundamental rock juxtaposed to the expanded inner material of the earth; resting upon this granitic root are strata of aqueous rocks, with volcanic projections of crystalline rock above these. Even though this chapter was relatively exempt from adverse criticism by reviewers, Chambers still revised the presentation from the earlier to the later editions. However, these revisions chiefly involved the form and order of presentation, not the content.

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[1] CV I:46-47; III:47-48; IV:47-48; V:48-49; VI:43; VIII:26; IX:27; X:28.

[2] CV I:45-46; III:46-47; IV:46-47; V:47-48; VI:44; VIII:26-27; IX:27-28; X:28-29.

Chambers was apparently aware of a deficiency in organization in the first five editions. In detailing the method of formation and the structure of the general layers of the earth's crust in the early editions, the discussion was disorganized with the discussion of granite both preceded and succeeded by a discussion of aqueous rock. This fault was corrected in the later editions by following a more strictly chronological order. After considering Chambers' description of the earth's crust, the reviewer for the Athenaum remarked that his conclusions were as much a matter of speculation as his description of the formation of "universe, suns, and worlds," commenting that "here again, as a matter of necessity, conjecture supplies the place of observation."[1]

Granite

Crystalline granite, stated Chambers in the first five editions, was "the condition into which the great bulk of the solids of our earth were agglomerated directly from the nebulous or vaporiform state."[2] Although this statement of origin was not found in the later editions, he referred to the chemical composition of granite in all of the editions. In the first four forms he described it as a blend of four substances--"silica, mica, quartz, and hornblende," in the fifth as "filspar, mica, quartz, and hornblende," and in the sixth through tenth as "quartz, felspar, mica, and hornblende."[3]

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[1]Review of Vestiges of the Natural History of Creation, by [Robert Chambers] in the Athenaeum, (January 4, 1845), p. 11.

[2]CV I:47; III:48; IV:48; V:49.

[3]CV I:47-48; III:48-49; IV:48-49; V:49-50; VI:44; VIII:46; IX:27; X:28.

Igneous Projections

Although Chambers described projections of igneous material from the molten center of the earth in all of the editions, he proposed two functions of this internal heat in the first five forms--to become "the scenes of volcanic operations," and to aid in the formation of the aqueous rocks. The first function only was admitted in the last five editions. Perhaps the latter function was omitted in response to his growing doubt as to the existence of an internal heat expressed in the previous chapter. But in the early editions he expressed the doctrine of an internal heat as a reality, explaining how the subterranean heat could have penetrated the thick layers of granite in order to aid in the formation of sedimentary rocks. "The process is precisely the same," he related, "as that of putting additional coats upon our own bodies; when, of course, the internal heat rises through each coat in succession, and the third (supposing there is a fourth above it) becomes as warm as perhaps the first originally was."[1]

Sedimentary Rocks

Chambers' discussion of the sedimentary rocks differed from the earlier to the later editions both in the order of presentation and in the economy of the discussion. Whereas in the first five editions, he discussed these rocks after the explanation of igneous protrusions, in the later editions he described them after the discussion of the formation and composition of granite.[2] Although in each edition he

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[1] CV I:48-49; III:49-50; IV:49; V:50-51; VI:47; VIII:28; IX:29; X:30.

[2] CV I:49-51; III:50-52; IV:50-52; V:51-52; VI:44-45; VIII: 27-29; IX:28-29; X:29-30.

explained that each subsequent deposition was formed of the components of a previous stratum, noting that there were both chemical and physical reasons for rocks being composed almost exclusively of one or more of the materials of granite, the presentation was much more detailed in the earlier editions than in the later.[1]

In only one instance did the change in wording appear to reflect a change in viewpoint. Chambers included some material in the first edition which he omitted from all subsequent editions possibly signifying a more uniformitarian outlook in his thinking in the later editions. Explaining in the first edition that "there is the clearest evidence that the seas of those days were not in some instances less than a hundred miles in depth, however much more," and that the sub-aqueous mountains "must necessarily have been of at least equal magnitude," he indicated that the processes operating in the early formative stages of the earth may have been different from present ones.[2]

Although he omitted these sentences from all of the other editions, a distinct non-uniformitarian tone was still present in the third through fifth editions as he indicated that although the same processes were involved in the earth's formative stages as are in effect today, they had been "upon a much more magnificent scale."[3] By the writing of the sixth edition the more sensational descriptions of the early earth had been excluded.

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[1] CV I:51-52; III:52-53; IV:52; V:53-54; VI:45-46; VIII:27; IX:28; X:29.

[2] CV I:50.

[3] CV I:50; III:51; IV:51; V:52.

The apparent lack of a total uniformitarian commitment in the early editions was further illustrated by their reference to the existence of "a stronger degree of heat than what operated in subsequent stages of the world," during the formation of the earliest strata. "It appears as if the seas in which these deposits were formed, had been in the troubled state of a caldron of water nearly at boiling heat," concluded Chambers.[1]

A change in terminology occurred within the editions. Although all of the forms mentioned the early stratified gneiss system, the first through fifth editions referring to it as the gneiss and mica slate system, only in the first edition did Chambers mention a next higher stratum, the one-hundred mile thick Pennsylvania grawacke.[2]

In concluding the later editions, Chambers stressed the amount of time involved in the deposition of the various strata, asserting that "dates, such as the chronologists never dreamed of--compared with which those of Egypt's dynasties are as the latter to a child's reckoning of its birthdays--have thus been presented to the now living generation, in connection with the history of our planet."[3] Summarizing what he proposed to discuss subsequently in detail and presenting a discussion of geological nomenclature, he remarked that "as we pass along through the series of strata, we find a cessation of certain specific forms of plants and animals, while others come to view, at some points, the

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[1]CV I:51; III:51-52; IV:52; V:52-53.

[2]CV I:51; III:51; IV:51; V:52; VI:45; VIII:27; IX:28; X:29.

[3]CV VI:47; VIII:28; IX:29; X:30.

change is almost complete--at others, it is very considerable."[1]

The Silurian Formations

The Lower Silurian

As Chambers proceeded from his discussion of the formation of the stratified rocks to an appraisal of the organic remains found in these rocks, he encountered many factual incongruities which appeared to be opposed to his philosophy of development. From the fossil record, it was not at all obvious when life first appeared on the planet, and if the record was to be taken at its face value a relatively late origin of life would have to be accepted. Since these later "first-forms" were not simple organisms, the developmentalist found the fossil evidence disconcerting. Therefore, he was forced either to search the literature for supposed early forms or to postulate simpler antecedents for the known fossils. Chambers did both. And in his search for evidence he was stimulated to rewrite and rearrange.

The newly acquired evidence resulted in significant changes. Even the first, third, and fourth editions which, in most sections of Vestiges are similar, underwent revisions. Hugh Miller was impressed by the progressive revisions, writing that the author of the Vestiges "has in every edition of his work been correcting, modifying, or altogether withdrawing his statements regarding both geological and zoological phenomena, and that his gradual development as a geologist and zoologist, from the sufficiently low type of acquirement to which his first edition bore witness, may be traced, in consequence, with a distinctness and certainty which we in vain seek in the cases of

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[1] CV VI:48; VIII:29; IX:30; X:30-31.

presumed development which he would so fain establish,--has in its bearing exactly the same effect."[1]

As was noted by the reviewer in the Spectator, Chambers was inconsistent in his use of taxonomic nomenclature. This critic wrote that "throughout the book, the technicalities of natural history are misunderstood, and the important terms, genus, species, tribe, and formation, are used in the loosest and most inaccurate manner."[2] Sometimes Chambers italicized the names of genera, at other times he did not. His capitalization was erratic. Therefore, with the exception of direct quotations, all scientific terminology, both biological and geological, will be presented in lower case letters and without italics in this dissertation.

Chambers encountered difficulties almost immediately as he discussed the earliest fossiliferous strata. The relatively complex nature of the first fossils disturbed the critics but he was oblivious of any problem as he wrote in the first edition, "nature is simpler than man's wit would make her, and behold, the interrogation only brings before us the unpretending forms of various zoophytes and polypes, together with a few single and double-valved shell-fish (mollusks), all of them creatures of the sea." Although this particular admission was omitted from the third edition, the idea reappeared in the fourth, was omitted from the fifth, but reemerged in a slightly modified form in

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[1]Hugh Miller, The Footprints of the Creator: or, the Asterolepis of Stromness (from the 3d London Ediction; Cincinnati: William H. Moore & Co., 1851), pp. 272-73.

[2]Review of Vestiges of the Natural History of Creation by [Robert Chambers] in the Spectator, XVII (November 9, 1844), p. 265.

the sixth through tenth editions.[1]

But Chambers was incorrect; the first organisms were not at all simple, claimed the reviewer for Fraser's Magazine. This reviewer alleged that "two of the higher molluscous orders, which rank in perfection of structure the nearest to the vertebrates," are present in these early rocks. Therefore, he concluded, in order for a theory of transmutation to be valid it would be necessary to postulate the existence of earlier forms. But to do this would remove transmutation from the realm of inductive science, for although "the transmutationists may imagine earlier as the parents of these, . . . their existence is purely conjectural."[2] Accusations such as this one were common in the reviews and Chambers' attempts to prove an earlier existence of life did not satisfy the critics.

The Limestone Hypothesis

A postulate that the beginning of the limestone found intermingled with the primary rocks "was coeval with the existence of the earliest, or all but the earliest, living creatures upon the earth," suited Chambers' purpose of locating evidence to indicate that traces of life were to be found in older strata.[3] Although Chambers considered the limestone hypothesis in all of the editions, the greatest amount of emphasis on this idea was found in the first edition, with the number of pages devoted to its presentation diminishing in each subsequent edition. Since his critics did not specifically object

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[1] CV I:58.

[2] "Geology versus Development," p. 361.

[3] CV I:58.

to this hypothesis, Chambers' lessened interest cannot be attributed to their statements, but rather to his own doubts.

In the first edition, Chambers defined the problem as consisting of the means by which carbon was converted from its atmospheric gaseous form, carbonic acid gas, into the carbonate of lime found in limestone. Since he knew that carbon was a primary constituent of living things, its appearance in the rocks led him to conclude that the carbon-containing limestone rock bore some relationship to early living creatures. He contended that if carbon could have been assimilated directly as a gas into the rocks this would have happened long previously, and limestone would have been an early rock form. Chambers, knowing that certain plants and marine polypes are capable of appropriating carbonate of lime from the ocean and manufacturing limestone, concluded that "the appearance, then, of limestone beds in the early part of the stratified series, may be presumed to be connected with the fact of the commencement of organic life upon our planet, and, indeed, a consequent and a symptom of it."[1]

Experimental evidence acquired by Thomas Delabeche (1796-1855) estimating the quantity of carbonic acid locked up in each cubic yard of limestone was cited by Chambers to corroborate observational evidence from the fossil record. From the data of Delabeche, Chambers concluded that a large portion of this gas would have been, at one time, a part of the atmosphere, making the existence of land animals impossible but favoring the growth of a luxuriant land vegetation. He found support in the fossil record for this idea, contending that

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[1] CV I:58.

"the results which we observe are perfectly consistent with, and may be said to presuppose an atmosphere highly charged with this gas, from about the close of the primary non-fossiliferous rocks to the termination of the carboniferous series, for there we see vast deposits (coal) containing carbon as a large ingredient, while at the same time the leaves of the Stone Book present no record of the contemporaneous existence of land animals."[1] Although Chambers, even in this edition, was not convinced of the truth of the limestone hypothesis, mentioning that "my hypothesis may indeed be unsound; . . ." he emphasized that observation supported his contention that there is a connection between "the first limestone beds with the commencement of organic life upon our planet."[2]

Chambers' description of the limestone hypothesis in the third edition, although more abbreviated than that of the first, was similar to it in most respects. However, rather than introducing the chapter with this hypothesis as he had done in the first edition, he presented it after an outline of the slate system and a general discussion of fossils and their preservation in the third edition. Although he had stated in the first edition that carbon was primevally found as a gas locked in the interior of the earth, this section was eliminated from the third edition.[3] Other sentences found in the first edition were also deleted from the third, resulting in a diminished emphasis on this hypothesis. However, Chambers was more positive in

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[1] CV I:57.

[2] CV I:54-55; III:56.

[3] CV I:54-55; III:56.

the third than in the first edition that many limestone strata were the result of the appropriation of carbonate of lime from the sea by certain marine polyps. "It is fully ascertained of many strata of limestone higher in the series, that they are simply reefs of that kind changed by subjection to heat and pressure," he asserted.[1] He was more tentative in the first edition, stating that "it has even been suggested, on strong grounds of probability, that a class of limestone beds are simply these reefs subjected to subsequent heat and pressure."[2]

Although Chambers argued in the third edition that the facts established "a strongly probable connexion between the time of the primary limestones and the earlier days or ages of organic creation," his conviction that the appearance of limestone was indicative of the first forms of life was not as positive as in the first edition.[3] Even though both editions described Delabeche's studies, the third edition excluded one of the conclusions of the first edition, that "the connexion of the first limestone beds with the commencement of organic life upon our planet is supported by the fact, that in these beds we find the first remains of the bodies of animated creatures."[4] The omission of this conclusion in the third edition may relate to Chambers' new awareness of the necessity for simpler fossil antecedents than those currently known to enhance the credibility of the Developmental Hypothesis.

In the fourth edition, Chambers pushed the discussion of the

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[1] CV III:57.

[2] CV I:56.

[3] CV I:56; III:57.

[4] CV I:56-57; III:57.

limestone hypothesis to a more obscure position in the chapter. As in the third edition, he began this chapter with an outline of the slate system and a general discussion of fossils and their preservation. But, in addition in this edition, a description of certain early fossils also preceded the limestone hypothesis. Until the connection of the limestone beds with the origin of life was mentioned, his presentation of this hypothesis in the fourth edition was similar to that of the third; he did not explicitly state this connection in the fourth edition nor did he mention Delabeche's work.[1]

Chambers' policy of deemphasizing the limestone hypothesis continued in the fifth edition. Far into the chapter the presence of limestone among primary rocks was mentioned. The only other allusion made to this hypothesis in the fifth edition was a brief discussion of the use of carbon by plants and its appropriation from the ocean by marine polyps. But neither the supposition of the equation of the origin of life with this limestone nor the Delabeche studies were included.[2]

Although Chambers still was unwilling to discard this theory entirely in the sixth through tenth editions, only one sentence remained of it. Expressing the idea in the tenth edition, he noted that "it is also observed that, if, as has been thought, living creatures have been concerned in the production of limestone, then living creatures must have existed in the time of this formation, as it includes several beds of that kind of rock." Basically the same idea was presented in

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[1] CV IV:54-60.

[2] CV V:62.

the sixth through ninth editions but in a different form.[1] In these later editions, the reader was referred to "De la Beche's Geological Researches, 1834" in a footnote. An additional reference was found in the tenth edition; Chambers mentioned in another part of this chapter that possibly from the family polypiaria "the materials were formed, out of which, in a reduced and modified state, were formed the few limestone strata which occur among the first sedimentary rocks."[2]

Earliest Evidence of Life

Since the earliest fossils were not primitive enough to bolster the case of the developmentalist, Chambers sought other examples besides that of the limestone hypothesis to indicate an early origin of life. Fragments resembling the shells of infusoria, he explained in the third through tenth editions, were found in the primary rocks. Although in the third through sixth editions, this discussion preceded that of the limestone hypothesis, in the eighth through tenth editions it succeeded it. Accepting these fragments as infusorians in the fourth and fifth editions, Chambers concluded that these shells would be "what might have been expected, seeing that these infusoria, though of humblest form of animal being, possessed hard parts capable of being preserved."[3] However, in the sixth through tenth editions, although he repeated the example, Chambers doubted the infusorial nature of the fragments, announcing that the presence of infusorians would be decisive proof of an early origin of life "if this fact, which

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[1]CV VI:49-50; VIII:31; IX:31; X:32.

[2]CV X:36-37.

[3]CV III:56; IV:59; V:61.

has been announced, could be satisfactorily verified."[1]

Whenever possible, Chambers included experimental evidence to support his position. In searching for proof of an early origin of life, Chambers discovered the experiments of Henri Braconnot (1781-1855). Braconnot distilled portions of primary rocks in porcelain retorts, resulting in "ammoniacal and combustible" products, according to the fourth and fifth editions, and "ammoniacal" products according to the sixth through tenth editions, indicating to Chambers the existence of organic creatures in the primary rocks. Chambers' revision of this chapter in the sixth through tenth editions resulted in a change in position of the discussion of Braconnot's experiment. Whereas in the fourth and fifth editions, the experiment was described after the discussion of infusorian shells, in the sixth through tenth editions it preceded it. In the tenth edition Chambers did not credit Braconnot with the experiment although he did in the earlier editions.[2]

The Possibility of an Azoic Formation

The Developmental Hypothesis would be well-served by an obscure formation in which there were no organic remains, for preceding the time in which the simplest organisms were found, there would, of necessity, have been an era in which no living forms had yet developed. Chambers, however, appeared uncertain about the existence of such an azoic formation, for it was treated inconsistently in the different editions. In the first edition he closed the previous chapter, the "Era of the Primary Rocks" with a discussion of such a

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[1] CV VI:49; VIII:31; IX:31; X:32.

[2] CV IV:59; V:61-62; VI:50; VIII:31; IX:31; X:32.

formation. In this edition, he mentioned that whereas most geologists considered the early rocks to be azoic, a few "have indeed endeavoured to show that the absence of organic remains is no proof of the globe having been then unfruitful or uninhabited, as the heat to which these rocks have been subjected at the time of their solidification, might have obliterated any remains of either plants or animals which were included in them."[1] Chambers, however, indicated his disbelief in such "an hypothesis of negation" and concluded that "it certainly seems very unlikely that a degree of heat sufficient to obliterate the remains of plants or animals when dead, would ever allow of their coming into or continuing in existence."[2]

The question of the reality of an azoic formation was considered in the third edition in the first part of the chapter on the Silurian formations. "The primary rocks are usually said to be non-fossiliferous," wrote Chambers.[3] This non-commital statement preceded his discussion of the infusoria, Braconnot's experiment, and the limestone hypothesis. Chambers was faced with a dilemma. On one hand, his hypothesis required more primitive organisms than those available in the fossil record for the primary forms of life, but on the other, it would be advantageous to his theory to have the primary rocks devoid of life.

Chambers' continued uncertainty regarding the reality of an azoic formation is evident from examining his statements in subsequent

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[1] CV I:52-53.

[2] CV I:53.

[3] CV III:55.

editions. Although in the fourth edition he stressed that the non-appearance of fossils did not necessarily mean that life did not appear in these rocks and cited the limestone hypothesis, Braconnot's experiments, and the appearance of shells of infusoria as examples, in the fifth edition he mentioned that evidence seemed to indicate that the primary rocks were devoid of fossils. But in the sixth, he stressed that there was no proof that living forms had not existed in these strata. In the eighth and ninth editions, Chambers mentioned that although the gneiss and mica slate systems had previously been considered to be azoic, high temperatures subsequent to deposition would have made the preservation of fossil forms unlikely. There were those who thought, he explained, "that an exception from the general character of the sedimentary rock was unlikely in itself," a point of view with which he apparently concurred, for his evidence for life in the primary rocks (the infusoria, Braconnot's experiments, and limestone hypothesis) was presented after this discussion.[1]

However, by the tenth edition, Chambers was again considering the possibility of the azoic nature of the gneiss and mica slate system, finding the evidence indicating "that, at the same time when these rocks were forming, no living things existed on the face of the earth."[2] But as in the eighth and ninth editions, he recognized the possibility of subsequent high temperatures obliterating any organic remains. Although accepting that the infusorian tests, Braconnot's experiments, and the limestone hypothesis suggested life in these rocks,

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[1] CV IV:58-59; V:61; VI:40; VIII:31; IX:31.

[2] CV X:32-33.

he considered it a definite complication that "it is admitted that there are strata of immense thickness in this portion of the rock series in some parts of the earth which exhibit no tokens of that metamorphose from heat which has been spoken of, and yet are truly Azoic, or destitute of fossils."[1]

Geologists are in disagreement over the presence of an azoic formation, admitted Chambers. Some conclude that the "evidence of azoism is merely negative," whereas "others, of the highest reputation, seem disposed to admit that there is an azoic formation."[2] Sedgwick, he noted, indicated that the Skiddaw slates marked the descending limit of organic life, whereas Murchison described an azoic series in Scandinavia and Barrande noted an azoic basis for the lowest fossiliferous deposits in Bohemia.[3] Chambers obviously had not made up his mind! His final judgment was equivocal, concluding that "the probability for the present seems to be, that any animals entombed in these non-fossiliferous rocks, must, for the most part, have been animals possessing soft parts only, totally unfit for preservation."[4]

The Inadequacies of the Fossil Record

Chambers was well aware of the deficiencies of the fossil record. Its failings, however, served him well, for when the data did not conform to his hypothesis he was always able to direct attention to its imperfections. Despite its defects, he realized that

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[1] CV X:32-33.

[2] CV X:32-33.

[3] CV X:32-33.

[4] CV X:32-33.

the fossil record was the only real tool available for deciphering the history of life on earth. "A kind of history of the organic departments of nature from perhaps its beginning to the present time," results from a study of the fossil record, wrote Chambers in the third through the fifth editions.[1] He would use this "piece of knowledge entirely new to man, . . ." to unravel the mysteryof past life.[2] The fossil record as history was discussed in the sixth through tenth editions as an introduction to the sub-chapter on the silurian formations.[3]

Problems of Preservation

Chambers' statement in the first edition that certain early organisms were "of too slight a substance to leave any fossil trace of their existence," was more abbreviated than was the account in the third through fifth editions in which he commented in detail about the problems involved with the preservation of animals with soft parts.[4] As was mentioned in the earlier editions, Chambers reiterated in the eighth through tenth editions that organisms with soft bodies would be unlikely to be preserved. But, in addition, he mentioned in the sixth through tenth editions that organisms subjected to a great heat would be likely to be destroyed.

Not only the destruction of the early organisms, but the limited amount of exploration of fossil beds contributed to the

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[1]CV III:55; IV:54; V:55-56.

[2]CV III:55; IV:55; V:55-56.

[3]CV VI:49-50; VIII:30-31; IX:30-31; X:31-32.

[4]CV I:58; III:55; IV:55; V:55-56.

incompleteness of the fossil record. Chambers suspected that many new forms whose discovery would support the Developmental Hypothesis would be unearthed as new areas of the earth were explored for their fossil contents. "It is therefore necessary, in looking over this singular chronicle, to make certain allowances for falterings and shortcomings, even while we pause breathless in admiration at the wondrous historical detail which it has so unexpectedly disclosed to the perusal of modern men," concluded Chambers in the eighth through tenth editions.[1]

Plants and the Fossil Record

The position of plants in the fossil record presented a problem to Chambers, for, according to the Developmental Hypothesis, they should either have preceded animals or have developed concurrently with them. As he wrote the first edition, the evidence contradicted this developmental ideal, for the record showed quite complex animal forms appearing before any plants at all were evident. This discrepancy between fact and theory did not daunt Chambers. Postulating that "it is probable that there were sea plants, and also some simpler forms of animal life before this period, although of too slight a substance to leave any trace of their existence," he, as was customary, allowed his theoretical commitments to influence his interpretation of the record.[2]

In the third edition Chambers did not mention that it was "surprising" to find animal forms before vegetable forms as he had in

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[1] CV VIII:30-31; IX:30-31; X:31-32.

[2] CV I:58.

the first edition. He only briefly alluded to the problem by stating that "so also might the fragile plants of the primary sea fail to come down to us."[1] By the writing of the fourth edition, evidence in the form of reports of early plants began to support his proposal. "In Russia," he noted in a footnote, "Mr. Murchison has lately found fucoids in the Silurians below any point at which animal remains occur."[2]

Chambers knew that eventually his deductions from theory would be observationally confirmed. His delight was apparent when evidence supporting his contention of the early appearance of plants was discovered. He gloated in the fifth edition that "the necessity of abstaining from rash assumptions with regard to the first forms of life is fully shown by the history of the early vegetable fossils."[3] The premise has been, Chambers related, that because plant remains had not been found in the lower silurian and animal forms had, animals preceded plants as life forms. The evidence of early fucoids from Russia, America, and Sweden proved "the absurdity of such a supposition from merely negative evidence."[4]

Chambers reached similar conclusions in the sixth through eighth editions, but without the self-righteous emphasis of the fifth edition. Although in the tenth edition he reviewed the history of the apparent incongruity between the proposed time of the appearance of the first plants and their actual appearance, he did not mention

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[1] CV III:56.

[2] CV IV:64-65.

[3] CV V:63.

[4] CV V:63.

the fossil fucoids of America and Russia but did mention the Swedish fucoids, as well as a new example--a lower silurian coal basin in Portugal.[1]

It was still possible to apply a non-developmental interpretation to the appearance of these early plants. The reviewer for the British Quarterly Review did not see anything of developmental significance to these findings. Since, he wrote, members of the same families are found in the seas of today, the discovery of simple fuci in the silurian rocks does not present evidence for a developmental sequence in the plant kingdom.[2]

Early Animal Forms

The First Animal Fossils

Having established that the earliest forms of life were probably not preserved in the fossil record, Chambers discussed the first forms of animals found as fossils. In this description, organization as well as content varied between editions.

Although in the first edition the first forms of animal life and the rocks in which they were found were discussed after the description of evidence for previous life forms, in the third and fourth editions part of the material appeared in the opening paragraph of the chapter and more of it within the description of evidence for earlier life forms. The "Clay Slate and Grawacke Slate System," according to the first edition, or the "Clay Slate and Grauwacke Slate Systems," according to the third and fourth editions, contained

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[1]CV VI:51; VIII:31; IX:32; X:41-42.

[2]Review of Vestiges, British Quarterly Review, p. 496.

the first incontrovertible traces of life. In the first and third editions but not the fourth, Chambers explained that the earliest fossils were found in this system and belonged to the orders polypiaria, crinoidea, crustacea, and conchifera.[1] Certain unconfirmed reports suggested the presence of still earlier fossils in seams of grawacke within the gneiss and mica formations of Bohemia, wrote Chambers in the first edition. However, the example of the dubious Bohemian fossils was not repeated in the third and subsequent editions.[2]

The Use of the Term Silurian

Chambers changed terminology in the fifth and subsequent editions to describe these early fossiliferous strata. "From their being presented on the surface in a portion of Western England formerly occupied by a people whom the Roman historians call Silures," the assemblage above the primaries was known as the Silurian. Chambers opened this chapter in the fifth edition with the description and definition of the silurian formation.[3]

Although the term "silurian" was introduced in the first edition and used consistently throughout the other editions, its use in the first through fourth editions was more circumscribed. In these editions, the silurian formation was considered to be a group of rocks above the clay slate and grawacke slate systems. By the fifth edition its scope was enlarged to include the earlier slate systems.[4] When the silurian formation was first named,explained Chambers in the

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[1]CV I:59-60; III:54; IX:54.

[2]CV I:58-59.

[3]CV V:55.

[4]CV I:61; III:60; IV:61; V:55.

eighth and ninth editions, it supposedly represented a line beyond which no fossil forms were to be found. But this was not accurate, he remarked, since sub-silurian forms of life had been reported. However, in the tenth edition, the earlier fossils were considered as a part of the lower silurian system.[1]

In all of the editions, Chambers attempted to collect evidence from the lower silurian rocks to support his contention that a developmental sequence was apparent in this formation. More examples and more detail in description characterized each subsequent edition. In the first edition, Chambers did nothing more than to enumerate the orders found in the lower rocks, whereas in the tenth edition he included numerous descriptions of lower silurian forms complete with diagrams.[2] Although some of the progressive additions to this chapter were the result of new fossil discoveries, others were expanded presentations of previously announced fossil finds.

Sedgwick was highly critical of Chambers' Platonic propensity for creating an ideal progressive scale of organic life in opposition to the observational evidence. Sedgwick's experience in studying the "Protozoic system" had convinced him that not only were simple forms of life present in these early rocks but highly organized forms as well. He insisted that he had looked in vain for an ascending scale of nature and had, unlike the author of Vestiges, chosen to bow to nature.[3]

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[1] CV VIII:31; IX:32; X:33.

[2] CV I:60-61; X:33-42.

[3] Sedgwick, Review of Vestiges, p. 31.

Bowen was also critical of Chambers' assumption that a progressive natural scale was apparent in the fauna of this formation, but for a different reason than Sedgwick. He apparently accepted Chambers' assertions that the fossil record did show a progression from the simple to the complex, but blamed its vagaries for presenting this improper picture. Chambers had also stressed the importunities of this record but for opposite reasons. He was convinced that, because of the non-preservation of certain forms, it occasionally did not show the evolutionary sequence which he knew was actually there. Bowen also stated his concern that the record showed only simple forms in the lowest strata because the geologists had not yet discovered the more advanced ones. Using the same evidence to support opposing conclusions, Bowen argued, as had Chambers, that only hard-shelled forms were likely to be preserved. But he used these data to explain why more complex organisms had not been found in the early rocks, the same argument that Chambers had advanced to explain why occasionally more complex animals appeared to precede the simpler forms in the fossil record.[1]

The Position of the Crinoids

Descending "to a few particulars" to illustrate the kind of simple forms found in the early rocks, Chambers discussed the crinoids as simple echinoderms in the third through fifth editions. Although not considering the earliest records of life to be simple enough to be first forms, Chambers did regard them as basically simpler than subsequent forms. The structure of the crinoids suggested simplicity,

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[1]Bowen, Review of Vestiges, pp. 445-46.

he noted, describing them as "composed of innumerable minute calcareous masses, connected by a gelatinous substance, . . . a stomach surrounded by tentacula to provide itself with food, and mounted upon a many-jointed stalk, so as to bear a considerable resemblance to a flower growing on its stem."[1]

Although Chambers also used the crinoids as an example in the sixth through tenth editions, he provided additional information in these presentations, such as the conclusion that "the echinodermata, . . . to which order it belongs, are destructives of their grade."[2] He included a statement in the sixth through ninth editions, but omitted from the tenth, that the echinoderms were "animals set up as a police over the rest, to effect the great providential object of controlling the numbers of living beings."[3]

The only controversial addition to the description of the echinoderms occurred in the tenth edition, in which Chambers described an evolutionary sequence within this group. By this time, he apparently had realized that crinoids are relatively complex echinoderms, and their appearance in the early rocks would not favor the Developmental Hypothesis. This may have been the rationale behind Chambers' tenth edition statement that "the true Crinoidea do not make a prominent appearance in the Lower Silurians, and certainly not in such a style in England as to allow of species being determined."[4]

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[1]CV III:59; IV:56-57; V:59.

[2]CV VI:52-53; VIII:32-35; IX:33; X:37-38.

[3]CV VI:53; VIII:33; IX:33.

Since he was able to state that crinoids were not a prominent part of the early record, and armed with new evidence of a "lower crinoidal form," Chambers turned the opposing evidence to his benefit. By considering this new lower crinoid, caryocrinites ornatus, as an ancestral crinoid, he was able to establish an evolutionary sequence. "The eminent geologist, M. de Verneuil," noted Chambers by way of documentation, considered it to have preceded the other crinoidea both in time and in its unspecialized nature.[1]

"A more dense ignorance as to the facts of comparative anatomy than is even usual with him," characterized Chambers' phylogenetic positioning of the crinoids in the tenth edition according to Huxley.[2] This particular gap in knowledge was inexcusable, since the studies of Johannes Müller (1801-1858) of "some ten or fifteen years ago," indicated that the crinoids are "as highly organized as the asteridae . . . ."[3]

The Corals

The polypiaria, or corals, are other organisms characteristically found in the lower silurian rocks, noted Chambers. Although he merely mentioned their presence in the first through third editions, in the fourth through ninth he included a brief description, explaining that their products often obstruct "the course of the mariner, and even laying the foundations of new continents."[4]

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[1] CV X:37-38.

[2] Huxley, Review of Vestiges, p. 337.

[3] Ibid.

[4] CV I:60; III:53; IV:56; V:59.

An addition occurred in the tenth edition, for, after the description, Chambers mentioned their possible importance in the formation of limestone.[1]

Trilobites

In all of the editions but the first, Chambers discussed the trilobite as an important lowly crustacean of the lower silurian rocks. The description was more detailed in the sixth through tenth editions than in the earlier forms; whereas in the sixth through ninth editions, this description preceded that of the brachiopods, in the tenth edition it followed this description.[2]

From an examination of the "facet-covered eyes" of the trilobite an inference can be made as to the nature of the silurian seas, concluded Chambers in every edition. This inference had been made by Dr. Buckland, who has assumed that "the sea in which it lived was a clear medium, as existing seas generally are, and that light was the same in character in those inconceivably remote ages as it is now."[3]

Huxley scoffed at Chambers' assertions that the trilobites as the first crustaceans were primitive. The trilobite, he stated, is a very advanced crustacean which should, if the Developmental Hypothesis is correct, be preceded by such simple forms as the daphnidae and cypridae. Even assuming that the trilobites are primitive, which they are not, "still, in the series of annular animals, annelids are

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[1]CV VI:52; VIII:32; IX:33; X:36.

[2]CV III:59-60; IV:57; V:59-56; VI:54-56; VIII:34; IX:34-35; X:38-39.

[3]CV III:59-60; IV:57; V:59-60; VI:54-56; VIII:34; IX:34-35; X:38-39.

below them, and should have been found earlier," but the reverse is the case.[1] Brewster also considered the presence of the trilobite with "the most perfect organs of sensation," in "the first era of organic life to be incongruous with a developmental philosophy."[2]

Lingula

Chambers included additional examples of early fossils in the sixth through tenth editions. The tenth edition represented a major revision from the sixth through ninth editions in this section and included diagrams of the different forms described. One of these new examples was that of a simple bivalve mollusk, lingula, newly discovered and described. This fossil was found beneath the base of the silurian system, pushing back the date of the earliest forms of life. Although this new discovery was mentioned in the eighth and ninth editions, it was in the tenth that Chambers thoroughly assimilated the new material into his text. In this edition he mentioned Sedgwick's description of the "Lingula Flags, from their containing this fossil." "When the reader has acquainted himself with the order of these sub-Silurian strata, and their approximate thickness, he will be able to appreciate the interim importance to the theory of the present work of the fact of this humble animal being found unattended by higher grades of existence in such a situation." Thus, Chambers was able to incorporate the new information into an added support for his theory.[3]

But Huxley would not allow Chambers this little triumph. He

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[1]Huxley, Review of Vestiges, pp. 336-37.

[2]Brewster, Review of Vestiges, p. 486.

[3]CV VIII:37; IX:37; X:34-35.

claimed that lingulae, the oldest and lowest fossils, "are anything but the lowest in the scale of organization of their class: they have a well-developed intestine and well-developed hearts, a nervous system, and long, peculiarly organized arms."[1]

The Graptolites and Annelids

Graptolites, according to Chambers in the tenth edition "a humble polypian family, allied to the sea-pens of our modern seas," and the annelids or sea worms were described in the sixth through tenth editions as fossils characteristic of the very early rocks. The discovery of the annelids "a little above the Llandillo rocks" was also discussed in the first through fifth editions. Chambers considered them to form a link between the "annulosa (white-blooded worms) and a humble class of the vertebrata." However, this connection was not mentioned in the sixth through tenth editions possibly because the worms were found too early in the rocks to be a linking group.[2]

Huxley scoffed at Chambers' conclusion that the graptolites were humble polypians, asserting that "all the evidence that we have leads us to believe, that they were either pennatulidae--which belong to the more highly-organized helianthoid polypes--or polyzoa, which are higher still."[3] Huxley argued that the lower forms of polyps, "the sertularians," would have been easily preserved, and if they had existed there would have been no problem in locating them. "And as if to spite the progressionists, . . ." he continued, "those forms of

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[1]Huxley, Review of Vestiges, p. 336.

[2]CV I:62; III:62; IV:63; V:58; VI:52; VIII:33-34; IX:33-34; X: 34-35.

[3]Huxley, Review of Vestiges, p. 336.

animal life which lie below them, the sponges and foraminifera are the most easily preserved of all, from their calcareous spicula and shells; but of these hardly a trace has been found in the lowest strata."[1]

Cephalopods

It was in explaining the appearance of the complex cephalopod mollusks in the silurian rocks that Chambers' Developmental Hypothesis seemed most inapplicable. The reviewer in the Athenaeum was amazed by Chambers' assertion that the early life forms were primitive. Chambers, he asserted, would "evidently have us infer that the mollusks of this period were low or 'unpretending' forms of creatures, whilst further on he admits that there were at that time Cephalopoda created, which far from being low forms of creatures, stand verging on the vertebrate division of animals."[2] This reviewer recognized but condemned Chambers' Platonic bias, indicating that he was willing to overlook the facts in order to prepare "for the great theory of his book, the theory of progressive development."[3]

Sedgwick also argued that the presence of the highly organized cephalopods in the early rocks was irreconcilable with the Developmental Hypothesis.[4] Sir David Brewster agreed with Sedgwick's conclusion. Any attempt to consider the cephalopods as simple, he stated, would be to ignore the facts,"for the eyeball of the cuttlefish is

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[1] Ibid.

[2] Review of Vestiges, Athenaeum, p. 11.

[3] Ibid.

[4] Sedgwick, Review of Vestiges, p. 31.

scarcely surpassed in beauty by the human organ" and yet this animal was found in the early rocks indicating that "the theory of development is thus utterly at fault in its very earliest application."[1]

Although Chambers in the first edition did not use the term cephalopod, he did mention the genus orthis of the early rocks, described as a cephalopod in the fifth edition. In the third and fourth editions he mentioned the cephalopods by name, describing them as being the most highly organized of the mollusca "possessing in some families an internal osseous skeleton, together with a heart, and a head having some resemblance in form and armature to that of the parrot tribes."[2] Chambers omitted this general description of the early cephalopods from the fifth edition but mentioned without comment that in western England, the lowest bands, besides inferior animals, give specimens of "orthis, a family belonging to a destructive class of molluscs, (the cephalopoda,) which are ranked as the highest of that sub-kingdom."[3]

Chambers was conscious of the impact which the discovery of cephalopods in the early rocks had upon his hypothesis. Cephalopods, he stated in the third edition, are "sometimes represented as having been co-existent with the humbler molluscous forms; and on this point conclusions have been drawn against the idea of a progress of animated being; but it seems to me, when the pre-Silurian era and its fossils are distinguished with sufficient care, that simpler mollusca as well

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[1] Brewster, Review of Vestiges, p. 486.

[2] CV III:61; IV:62.

[3] CV V:58.

as radiata, preceded it."[1] Using Professor Phillip's tentative statement that gasteropods and cephalopods had not yet been found in the slate systems of Britain, Chambers concluded that the highest orders of the mollusca "were added in the Silurian system."[2] This rationalization made the data conform to a developmental point of view.

"What produced, or at least countenances, mistakes of this kind, . . ." he explained in the third edition, "is the taking a number of rock systems together as one, and reckoning all the fossils of these systems as co-existent . . . in reality, those peculiar to the upper beds may be unc[illegible]recent than those of the lower."[3] However, [illegible]included a footnote indicating that "afte[illegible]written for the present edition, . . [illegible] were "two or three examples of moll[illegible]e rocks, in a table of that formation, prepared [illegible]ns by Messrs. Salter and De Carle Sowerby, in the [illegible]rnal of the Geological Society, No. I. (Feb. 1845),"[4]

Although the cephalopod mollusks were considered in detail in the sixth through tenth editions, it was after a description of some of the more primitive mollusks. "Highly organized for the catching and destroying of the weaker marine animals, . . ." and "the lords of the organic world in their day," the cephalopods held

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[1] CV III:61.

[2] CV III:61.

[3] CV III:61.

[4] CV IV:62.

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[1] CV III:61.

[2] CV III:61.

[3] CV III:61.

[4] CV IV:62.

a high position among the invertebrates.[1] Chambers in the tenth edition had discovered a way to circumvent some of the criticism which the presence of these complex invertebrates in the early rocks had elicited. He claimed that the lower silurian genera of cephalopods were not "the most exalted of their order, . . ." and that these higher mollusks were less numerous in the lower silurian era than they became afterwards.[2] Huxley did not accept this explanation. He wrote that one of Chambers' illustrated examples of a lower cephalopod, the lituite, might not apply as one learned more about it. Huxley considered it probable that it was a higher form and would be proved to be so as more was learned about it.[3]

Chambers' Interpretation of Phylogeny

A revised organizational approach based on phylogeny characterized the sixth through tenth editions. Following a phylogenetic pattern, the brachiopods as primitive mollusks were discussed first. Although brachiopods are the most numerous forms in the lower silurian rocks, Chambers only briefly mentioned them in the first five editions. But in the later editions, he remarked that "so prominent does the order appear in this part of creation that an eminent geologist distinguishes the Lower Silurian period as the Age of Brachiopods."[4] In the sixth through tenth editions, Chambers also discussed the univalve mollusks common in the lower silurian fossil record, explaining

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[1] CV VI:57; VIII:35; IX:36; X:40-41.

[2] CV X:41.

[3] Huxley, Review of Vestiges, p. 337.

[4] CV I:61; III:60-61; IV:62; V:58; VI:56; VIII:34-35; IX:35; X:38.

that "the first and humblest order, . . ." was "Pteropoda," followed by the "Gasteropoda" of which "there are many fossil species."[1]

Apparently all of the contradictory opinions concerning what was intended by the use of the terms "high" and "low" when applied to organisms stimulated Chambers to attempt to define these terms. The fifth edition appeared as a transitional form in this discussion, for whereas no definition for these terms was provided by the first four editions, and a comprehensive description was discussed in the sixth through tenth editions, an intermediate single sentence definition was included in the fifth edition.

"An animal is said by naturalists to be low, when its organization is of a simple kind, subservient to a comparatively narrow range of functions, and suited to a comparatively narrow field of existence--. . ." whereas "elevation is marked in the scale by an animal ceasing to be compound, . . . assuming a power of locomotion, having sex assigned to separate individuals, exchanging a multiplicity of parts serving one end, . . . for a smaller number; attaining, in short, at once a more complex and more concentrated organization," concluded Chambers in the sixth through tenth editions.[2] The fifth edition converged with the sixth through tenth editions as Chambers explained the divisions of the animal kingdom based on this definition of organization.[3]

The totality of the evidence indicated creation at a lowly

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[1]CV VI:56-57; VIII:35; IX:35-36; X:39-40.

[2]CV VI:54; VIII:33; IX:33-34; X:35-36.

[3]CV V:57; VI:54; VIII:33-34; IX:34; X:36.

stage, concluded Chambers after summarizing the protozoic period--the sub-silurian and lower silurian forms--in the tenth edition. He was convinced that the apparent contradictions would be resolved when more evidence had been gathered and, to add substance to his argument, referred the readers to his appended "Proofs and Illustrations," entitled "The Genera of the Lower Silurian Formation are Humble in their Respective Lines of Gradation."[1] But Huxley was in disagreement. Concluding his review of Chambers' presentation of the lower silurian fauna, he stated that "it contains animals which are, to use the weakest phrase, far above the lowest in their respective lines, and of the very lowest classes of animals, sponges, foraminifera, and sertularian polypes--all of which are very easy of preservation--it offers few traces."[2]

The Upper Silurian

The Change from Lower to Upper Silurian

After dicussing the lower silurian forms, Chambers turned his attention to the rocks of the upper silurian formation, a formation in which, according to Sedgwick, one cannot find any order representing a natural scale. The new species, insisted Sedgwick, are as sharply defined as the old ones with no indication of an intergradation.[3] Although in the fifth edition Chambers also indicated that there was a marked difference between the lower and upper silurian forms, in the sixth edition he did not consider the change particularly

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[1] CV X:11-12.

[2] Huxley, Review of Vestiges, p. 337.

[3] Sedgwick, Review of Vestiges, p. 32.

dramatic. Stating, in the fifth edition, that whereas most of the general forms of the lower silurian were to be found in the upper, "most of the specific characters-- . . . are changed; only a few of the Lower Silurian creatures survive (at least in their original forms) into this era," in the sixth through ninth editions he stated that this formation differed from the lower only "in the introduction of new species of the same families and a greater abundance of specimens."[1] In the tenth edition, Chambers appeared to regard this break as even less definite, remarking that the upper silurian rocks "may be described as giving us a continuation of the fauna of the preceding formation, with some changes of species, and some additions."[2]

Geographic Uniformity of Silurian Fossils

Chambers was intrigued by the similarity of silurian fossils throughout the earth. Such geographically disparate locations as Russia and the Mississippi Valley contain the same species, a uniformity which does not exist even among the lower classes of animals today, noted Chambers in the first four editions. Uniform climatic conditions must have prevailed over the earth, he assumed, in order to explain this lack of diversity. A theory by Brongniart, quoted by Chambers in the first four editions, explained the uniformity by assuming that the temperature arising from the internal heat of the earth was "sufficiently great to overpower the ordinary meteorological influences and spread a tropical clime over the globe."[3]

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[1] CV V:64; VI:57; VIII:35; IX:36.

[2] CV X:42.

[3] CV I:64-65; III:63-64; IX:64-65.

Since by the sixth edition, Chambers had begun to question the reality of the internal heat, Brongniart's theory was no longer attractive to him and he did not use it. Nevertheless, he did note the uniformity but he allowed for more variation than he did in the early editions, as he explained that "there are differences of species-- . . . but even this is only partial, and does not materially interfere with the general fact that there has been a remarkable uniformity of life in the primeval seas."[1] Chambers, in need of a hypothesis to replace that of Brongniart which he had discarded, substituted the postulate that the uniformity was the result of "the comparative newness of life upon earth, and its little experience of those external agencies by which it is liable to be affected . . ."[2]

The Scope of the Upper Silurian

Rather than use the term "upper silurian" in the first four editions, Chambers referred to it by its constituent parts. Even though "upper silurian" was used in the fifth through ninth editions, no explanation of what the term embraced was included; he was more precise in the tenth edition, noting that this formation in England consisted of "the Wenlock shale, the Wenlock limestone, the Lower Ludlow rocks, the Aymestry Limestone, and the Upper Ludlow rocks . . ."[3] Although these terms were used in the earlier editions, Chambers did not explain how they related to the two parts of the silurian system.

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[1] CV VI:58; VIII:35; IX:36; X:42.

[2] CV VI:58-59; VIII:36; IX:37; X:43.

[3] CV I:61-63; III:60-62; IX:61; V:55, 64; VI:57; VIII:35; IX:36; X:42.

The First Fish

The first appearance of fish was of critical importance to those who adhered to the Developmental Hypothesis. This hypothesis would be best served by an era of invertebrates in which no vertebrate remains were found, superseded by a period in which a few primitive vertebrate fossils were intermixed with the invertebrates. The whole silurian formation had formerly been considered by geologists as an entirely invertebrate assemblage; however, newer evidence indicated the presence of fish in these rocks. Chambers explained in the eighth and ninth editions that although a few fish relics had been described from the silurian "sufficient to show that the vertebrate grade of life was not of subsequent introduction, as had at one time appeared," this would not invalidate the Developmental Hypothesis but push down the phenomenon of an invertebrate period to a lower level.[1]

Moreover, Chambers stressed in the fifth through tenth editions, no fish were found in the lower silurian; they first appeared in the upper formation.[2] To further buttress his position that the lower silurian was an invertebrate era, Chambers in the tenth edition in his "Proofs and Illustrations" quoted Sir Roderick Murchison who considered the lower silurian a record of invertebrate animals only.[3]

Although the arguments of most of the reviewers revolved around the premise that the earliest fish were not primitive but

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[1] CV VIII:36-37; IX:37.

[2] CV V:66-67; VI:57; VIII:37; IX:38; X:43.

[3] CV X:vii.

complex, those of Brewster stressed that fish remains had been found in the lower silurian, citing remains of fish bones and teeth in the grauwacke series of England and Ireland. According to Brewster, these remains were sufficient to discredit the Developmental Hypothesis, for "here then we have in the first era of organic life animals of high organization. . . ."[1]

Upper Silurian Fish Fossils

In all of the editions, Chambers discussed the fish fossils from the upper silurian formation. Fish of the Aymestry limestone, he explained in the first, third, fourth, and tenth editions, probably represented this planet's first vertebrate life. In addition, in the first four editions, he mentioned another example, the "remains of six genera of fish," from the upper Ludlow rocks, an even earlier formation. These fish, he explained in some detail in the first edition, "belong to the order of cartilaginous fishes, an order of mean organization and ferocious habits, of which the shark and sturgeon are living specimens."[2]

Controversies over the Phylogenetic Status of Silurian Fish

The reviewers were critical of Chambers' contention that the early fish were primitive forms. Sedgwick was convinced that the fragments chosen by Chambers to be nature's first and "half-abortive" efforts to make fish out of lower animals were most unfortunate, since

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[1]Brewster, Review of Vestiges, p. 386.

[2]CV I:63-64; III:62-63; IV:63-64; X:43.

these early fish were highly developed.[1] The reviewer for Fraser's Magazine agreed, assuring his readers that "there can be no question that the earliest known fishes are highly organized fishes of the cestraciont family of placoids."[2]

Brewster also argued that the fish in the Aymestry limestone were of the "highest type" and chided Chambers for glossing over the fishes of the upper Ludlow rocks. He challenged Chambers' statement that the remains of six genera of fish had been found in these rocks and his fourth edition statement that these fish were of an "obscure character." Agassiz, claimed Brewster, "has formed out of them seven new species, all with a high degree of organization, and two of them of the very highest type."[3] This combination of facts on the part of Brewster was misleading, for he combined Agassiz' taxonomic work with the implication that he considered cartilaginous fish to be advanced. The false impression was thereby created that Agassiz considered these fish to be primitive which he did not. The reviewer for the British Quarterly Review disagreed with Chambers' assumption that the silurian rocks showed a developmental sequence, for he considered the presence of fish in this system to be opposed to a process of development; "no argument, . . ." he stated, "can convert a fish, with its back-bone, and highly developed nervous and muscular systems into an animal of low organization."[4]

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[1]Sedgwick, Review of Vestiges, p. 33.

[2]Review of Vestiges, Fraser's Magazine, p. 362.

[3]Brewster, Review of Vestiges, p. 386.

[4]Review of Vestiges, British Quarterly Review, p. 495.

The Climate of the Silurian

To support his proposition that a torrid climate had prevailed in silurian times, Chambers discussed traces of fuci in the upper silurian rocks. Citing a theory by Brongniart which stated that marine plants were classifiable with regard to the zones of climate, he concluded that the fuci of the early rocks were inhabitants of a torrid climate, but as "we ascend, a gradually diminishing temperature" is shown.[1]

The Age of Fishes

Although a few fossil fish were reported from the silurian rocks, their numbers were so sparse as to cause these rocks to be characterized as an invertebrate assemblage. But in the formations immediately above the silurian, fish became prominent forms. These new fish-containing strata were called the "Old Red Sandstone System" in the first five editions and the "Devonian Era" in the sixth through tenth editions.[2] The apellative "Old Red Sandstone" was discarded, Chambers explained in the later editions, because although these strata are red in England, "redness is not found to be a prevailing peculiarity of the strata in other countries."[3] He replaced the offending "Old Red Sandstone" with the term devonian, derived from a district in the south of Devonshire where the formation is especially well developed.[4]

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[1] CV I:64; III:63; IV:64.

[2] CV I:66-67; III:65-66; IV:66-67; V:68-69; VI:60-61; VIII:38; IX:38-39; X:43-44.

[3] CV VI:61; VIII:38; IX:38; X:44.

[4] CV VI:60; VIII:38; IX:38; X:43.

The Devonian Rocks

Although Chambers described the rocks present in this system in the first five editions, he did not in the later forms. These rocks, he claimed, are a "mixture of flagstones, marly rocks, and sandstones, usually of a laminous structure, with conglomerates."[1] The presence of bitumen in schist is significant, wrote Chambers in the first four editions, since "it is a vegetable production."[2] However he did not explicitly draw the obvious conclusion that since coal was produced by land plants, bitumen indicated the presence of dry land during this time, for in the earlier editions he expressed the conviction that dry land had not appeared until the carboniferous era; the statement concerning the bitumen was omitted from the fifth edition.[3]

From the evidence of the rocks, Chambers assumed in the first five editions, that the lower rocks of the system had been deposited in seas "having been subjected to a violent and long-continued agitation, probably from volcanic causes," whereas the upper rocks were probably deposited in "comparatively tranquil seas."[4] The sixth through tenth editions then converged with the earlier ones in explaining that the depth of this system in England is 10,000 feet.[5]

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[1]CV I:66-67; III:66-67; IV:66; V:68.

[2]CV I:66-67; III:65; IV:66.

[3]CV V:68.

[4]CV I:67; III:66; IV:67; V:69.

[5]CV I:67; III:66; IV:67; V:69; VI:61; VIII:38; IX:39; X:44.

Silurian Versus Devonian Life Forms

Whereas in the first four editions Chambers assumed that the devonian was basically a continuation of the silurian with the addition of fish, in the fifth edition he asserted that "most of the forms which existed in the Silurian era are found no more; only about one hundred out of eight are continued."[1] Differences as well as continuities were discussed in the sixth through tenth editions, indicating that Chambers had synthesized his views of the first four editions with those of the fifth.[2]

In the later editions he reported that although many of the general silurian marine forms were to be found in the devonian, they differed specifically from the earlier forms, and, as the fifth edition had noted, only one hundred out of every eight hundred silurian species passed into the devonian.[3]

Sedgwick agreed with Chambers that the fauna of this formation represented a connecting link between the silurian and carboniferous eras, but denied that it indicated a gradual transmutation of specific forms. A "good fauna" of characteristic species characterized the devonian, concluded Sedgwick.[4]

In all of the editions, Chambers postulated possible physical causes for these changes in species. Although in the first through fifth editions he was convinced that varying temperatures or differing

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[1] CV I:65; III:66; IV:67-68; V:69.

[2] CV VI:61; VIII:38; IX:29; X:44.

[3] CV IX:61; VIII:38; IX:39; X:44.

[4] Sedgwick, Review of Vestiges, pp. 34-35.

depths of the sea would be sufficient to cause specific variation, in the sixth through tenth editions he was more cautious, stating that "on this point much obscurity at present rests; for, as our survey is extended into other countries, it is found that extensive changes of species occur without any apparent dependency on at least some of these causes; so that, in these instances, some other explanation remains to be sought for."[1]

Those general invertebrate forms which survived into the devonian were briefly noted. Although in many cases the genera or even families of the devonian forms differed from the silurian, the general forms--corals, crinoids, trilobites, and brachiopods survived into this era, explained Chambers.[2] Cephalopods continued to appear abundantly in the devonian, but their form was changed from the simple, straight, or slightly curved shells of the orthocerites of the silurian to the devonian clymenia with a shell that was a complete spiral.[3]

The Devonian Fish

The Importance of the Devonian Fish

In all of the editions, Chambers stressed the importance of devonian fish. For the first time, the strata were crowded with vertebrate remains, for fish evidently had swarmed the devonian seas. Agassiz was cited as the authority on numbers of these fish. Although

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[1]CV I:68; III:67; IV:68; V:60; VI:61-62; VIII:39; IX:39-40; X:44-45.

[2]CV VI:62-63; VIII:38-39; IX:39-40; X:44-45.

[3]CV VI:62-63; VIII:39; IX:39-40; X:45-46.

in the first five editions Chambers stated that Agassiz recognized twenty genera and "thrice the number of species," by the time of the writing of the sixth through tenth editions, he wrote that Agassiz "has ascertained upwards of a hundred species of Devonian fish, to which number it is to be expected that many additions will yet be made."[1]

From the first four editions to the tenth edition a progressively more evolutionary tone was apparent in Chambers' discussion of changes in species from silurian to devonian fish. Whereas in the first four editions he had indicated that "the whole of the species of that era (silurian) had already passed away," a statement with special creationist overtones, it was replaced in the fifth edition by a more evolutionary statement that "species of that time (silurian) had already been changed." And in the sixth through tenth editions, he did not mention that the devonian fish were specifically different from the silurian.[2]

The Classification of Devonian Fish

Since the experts were unable to agree on a definition of primitive and advanced characteristics, the classification of fish was open to a variety of interpretations. Although naturalists agreed that fish could be divided into two groups according to the structure of their skeletons, there was no consensus as to the phylogenetic significance of these groups. As Chambers noted in the

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[1]CV I:68; III:66-67; IX:67-68; V:69-70; VI:63; VIII:40; IX:40; X:46.

[2]CV I:68; III:67; IV:68; V:70; VI:63-64; VIII:39; IX:40; X:46.

eighth through tenth editions, cartilaginous fish far outnumbered their bony counterparts in devonian seas, whereas in contemporary waters the reverse is observed.[1] Because of the apparent earlier appearance of the cartilaginous fish, he accepted the conclusions of those who considered these forms primitive rather than those who considered them more advanced, since this postulate would best support the Developmental Hypothesis.

The form of the fish's scales was also used by naturalists as a classificatory tool. Agassiz considered scale type as indicative of internal organization, and Chambers, from the third edition forward, described Agassiz's classification of devonian fish according to scale type. According to Chambers in the third through ninth editions, the devonian fish all possessed either placoid or ganoid scales, whereas most current fish possess either cycloid or ctenoid scales. In the tenth edition, Chambers merely described and illustrated the scale types without implications as to complexity.[2]

The reviewers tended to be critical of Agassiz as well as Chambers for considering the placoid and ganoid fish primitive. Citing the opinion of Sedgwick who "is generally understood to have been one of the great masters of geology; . . ." as considering them to be of the highest types of fish, the reviewer for Fraser's Magazine disagreed with Agassiz and Chambers.[3]

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[1] CV VIII:40; IX:40, X:46.

[2] CV III:67-68; IV:68-69; V:70-71; VI:63-64; VIII:40; IX:40; X:16-17.

[3] Review of Vestiges, Fraser's Magazine, pp. 363-64.

Skeletal structure, complained Brewster, should not be equated with scale type as Chambers had done. He argued that both cartilaginous and osseous forms existed in all four orders of fish. He also claimed that the description of several new ctenoid fish, formerly only thought to have existed in the carboniferous and subsequent eras, from the old red sandstone of Russia weakened Chambers' position.[1]

The Affinities of Devonian Fish

The relationship between the first vertebrates and the highest invertebrates was important to the developmentalist, and in the early editions Chambers tried to link the more primitive fish to the crustacea--an attempt which was harshly criticized by the reviewers. In the first edition he was quite specific as to the possible linkage, stating that the primitive fish, cephalaspis, coccosteus, pterichthyes, and holoptychius seem "to form a sort of connecting link between the crustacea and true fishes."[2] Even though Chambers was less specific in the third and fourth editions concerning the nature of the connection with the crustaceans, he stressed that such a relationship was probable for, "of certain of the ganoids, it is remarked by every geologist, how much they approximate to the form and armature of the crustaceans, an order of the next lower department of the animal kingdom."[3]

In all of the editions, Chambers described the fish cephalaspis as the most primitive vertebrate; in the first four editions he

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[1]Brewster, Review of Vestiges, p. 487.

[2]CV I:69.

[3]CV III:68; IV:69.

stressed its crustacean-like characteristics and noted its resemblance to the trilobite, asaphus, from earlier formations.[1] The reviewers did not accept this invertebrate linkage. Sedgwick ridiculed Chambers' idea that cephalaspis resembled a trilobite.[2] Brewster, after describing Chambers' assertions that certain ganoid fish such as cephalaspis and coccosteus resemble crustaceans states that "it is averred by modern geologists that these statements are incorrect, and that the Ganoid fishes rather approach to the higher class of reptiles, than to the lower crustacea."[3]

Whereas in the fifth edition Chambers mentioned the resemblance of cephalaspis to asaphus he did not explicitly discuss its crustacean character. Cephalaspis was described as a primitive form in the sixth through tenth editions, but no mention was made of asaphus; nothing was explicitly stated about affinities with the crustacea.[4]

Huxley denied any possibility that the exo-skeleton of the ganoid fishes in any way approximates that of the invertebrates, stating that "the arrangement of the plates upon a Pterichthys, or Holoptychius, or a Coccosteus, is totally unlike anything articulate-- . . ." Huxley also denied that the ganoid exoskeleton "is either more extensive or better developed than that of osseous fishes, unless more thickness is to be called better development." He named some osseous fish that had a covering as "thick and as strong as those

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[1] CV I:69; III:68-69; IV:69-70; V:71; VI:64; VIII:40-41; IX:40-41; X:47.

[2] Sedgwick, Review of Vestiges, p. 36.

[3] Brewster, Review of Vestiges, p. 487-88.

[4] CV V:71; VI:64; VIII:40-41; IX:40-41; X:47-48.

of any extinct Ganoid."[1]

Coccosteus, a fish discussed in all editions, was considered to be related to the crustacea in the first four editions. In these editions, Chambers remarked that "while the tail establishes this creature among the vertebrata and the fishes, its mouth has been opened vertically, like those of the crustaceans, but which is contrary to the mode of the vertebrata generally."[2] The teeth of coccosteus were chiselled "out of the solid bone of the jaw, like the nippers of a lobster," he stated in the third and subsequent editions.[3] Sedgwick lambasted the statement that coccosteus had a jaw like the nipper of a lobster![4]

By the fifth edition, Chambers had become more skeptical, admitting that an alliance with the crustacea while suggested by the appearance of the animal "may be fanciful."[5] From the first edition where appearance proved to Chambers' satisfaction the "link character of the coccosteus between these two great departments of the animal kingdom," Chambers moved to the position of the sixth through ninth editions that observation "suggests its propinquity to the invertebrate part of creation."[6]

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[1]Huxley, Review of Vestiges, p. 340.

[2]CV I:69-70; III:69; IV:70.

[3]CV I:69; III:69; IV:70; V:71-72; VI:41; VIII:41; IX:41; X:47-48.

[4]Sedgwick, Review of Vestiges, p. 36.

[5]CV V:71-72.

[6]CV VI:65; VIII:41; IX:41; X:48.

The size of one of the devonian fish, holoptychius, was stressed in all of the editions. In the first four editions, Chambers mentioned that whereas "the specimens in the lower beds are not above the size of a flounder," those in the higher beds "attained a comparatively monstrous size;" in the fifth through tenth editions he noted that some were at least thirty-six feet long.[1]

In the first edition, Chambers mentioned three additional devonian fish. Osteolepis, glytolepis, and dipterus generally resembled modern fish, but they had certain peculiarities--bony plates enamelled externally, heterocercal tails, and cartilaginous skeletons. Uniting "the characters of cartilaginous fishes with a character peculiar to themselves, in these fish we see pretty clear vestiges of the pre-existent crustaceous form."[2] By the third edition, Chambers was no longer trying so hard to link the early fish with the crustacea. But he mentioned one characteristic in the fifth edition indicating that he had not entirely discarded the possibility. He considered that the "distinct marks which the dermal plates bear, in many specimens . . . were processes for muscular attachments," hinting at a placoidean-crustacean relationship. The cartilaginous skeleton, he suggested, had not been as in higher vertebrata, the grand support of the frame and the basis of its strength.[3]

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[1] CV I:70; III:69-70; IV:70-71; V:72-73; VI:66; VIII:41; IX:41; X:48.

[2] CV I:70-71.

[3] CV V:75.

Embryological Evidence of Relationships

To support the postulate that the early fish were primitive, Chambers turned to embryology. He cited the structure of the tail of the fish as illustrative of embryological development. Most modern fish possess a circular or homocercal tail, whereas many older forms possess a one-sided or heterocercal tail. But the question as to whether or not the heterocercal condition represented a primitive condition was not universally agreed upon. Chambers supported his assertion that the heterocercal tail was primitive by noting that the "perfect" modern fish, e.g. the salmon, showed embryologically characteristics of the mature devonian fish.[1]

The reviewer for Fraser's Magazine accepted Hugh Miller's postulate that the placoid and ganoid fish are superior forms because of their large brain size; in addition, he quoted Miller's opinion that the heterocercal tail is more advanced than the homocercal because it more clearly approaches that of the reptiles.[2] Huxley also found Chambers' arguments regarding the presence of a heterocercal tail invalid. He complained that "the highest fish," lepidosiren, has no tail fin at all, "a particular in which it is exactly resembled by Coccosteus, Pterichthys, and Cephalaspis; which have been on this ground, among others, relegated to the lowest division."[3] He also stated that lepidosteus, considered by Chambers to be one of the higher ganoid fishes because of the ball and socket structure of its vertebrae, has a heterocercal tail. To further invalidate his conclusions, amia,

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[1]CV I:71; III:70-71; IV:71-72; V:73-74; VI:66-67; VIII:41-42; IX:42; X:49-50.

[2]Review of Vestiges, Fraser's Magazine, pp. 363-64.

[3]Huxley, Review of Vestiges, p. 340.

which has ordinary vertebrae, has a homocercal tail.[1]

Another characteristic was introduced in the third through tenth editions to emphasize the primitive nature of the early fish. Instead of a vertebral column, Chambers explained, adult devonian fish possess a gelatinous cord, a situation present in the embryos of osseous fish.[2] However, the reviewer for Fraser's Magazine again quoted Miller to negate Chambers' embryological assumption. This reviewer stated that when Miller subjected the cartilage of cartilaginous fish and that of embryonic higher mammals to a fire, "the form of the joint, and that of the cartilage of their internal skeleton differs from that of embryo birds and mammals in not containing gelatine, and consequently not dissolving in hot water." Nothing was written about whether or not the embryos of osseous fish also contained gelatine.[3]

Since, Chambers noted in all of the editions but the first, the placoids are represented by a very few forms in modern seas and "the ganoids are all but unrepresented in our time," the replacement of what he considered a primitive form by one more complex supported his Developmental Hypothesis.[4] Chambers had attributed an article to Richard Owen in his "Proofs and Illustrations" which indicated that Owen had similar ideas. Huxley scoffed at Chambers' presumption, claiming that Chambers had mistakenly attributed an article to Owen

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[1] Ibid.

[2] CV III:71; IV:72; V:74; VI:67; VIII:42; IX:42; X:50.

[3] Review of Vestiges, Fraser's Magazine, pp. 363-64.

[4] CV III:70; IV:71; V:73; VI:66; VIII:41; IX:42; X:49.

which he had never written. Huxley quoted Owen's Hunterian Lectures upon Fishes to explain that Owen devoted an entire chapter "to a most successful demonstration of the non-embryonic nature of cartilaginous fishes, and the author speaks, not without some contempt, of the progressionist. . ."[1] Huxley also claimed that Owen in his arrangement of fishes placed ganoid fishes "above the Cycloid and Ctenoid fishes, and the Placoid fishes again above them."[2] Huxley concluded that "we cannot think that any man who is acquainted with these published opinions of the Hunterian Professor, and can ascribe the article in the 'Quarterly' to him--or, on the other hand, who, not being acquainted with them, can dare to write on the Palaeontology of Fishes, must have a superhuman allowance of the 'aes triplex' about his conscience. . . ."[3]

Although Chambers had correctly cited Agassiz's data and his conclusions that ganoid and placoid fish were primitive, his extrapolation to indicate that Agassiz accepted the idea of transmutation was entirely unwarranted. Sedgwick claimed that Chambers' interpretation of Agassiz's work on fossil fish was inexcusable, being convinced that Chambers either had not read Agassiz or was deliberately misinterpreting him to gain his authority for a spurious position. According to Sedgwick, Agassiz had even discarded the evidence of heterocercal tails as comparable to embryonic forms of higher fish as invalid, a fact which Chambers did not indicate when citing this evidence.[4] The reviewer for Fraser's Magazine also claimed that

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[1]Huxley, Review of Vestiges, pp. 338-39.

[2]Ibid.

[3]Ibid.

[4]Sedgwick, Review of Vestiges, pp. 38-39.

whereas Chambers had the support of Agassiz for his interpretation of classification, Agassiz never intended that his be meant to suggest a doctrine of transmutation.[1]

Devonian Plants

Silurian marine plants were carried over into the devonian with less change than were the animal forms, explained Chambers in the first four editions. Although he did not change his basic ideas in the fifth edition he expressed them in less detail, merely stating that the early animals were not as "uniform over large geographic areas as the plants."[2] Why, speculated Chambers, would the plants show less change from one era to another than the animals? One possibility, mentioned in the first through fourth editions, was that an infusion of lime into the sea might be favorable to vegetation yet destroy the animal life.[3] He provided another possible explanation in the third, fourth, and fifth editions. These editions contained a discussion derived from Agassiz, suggesting that the ocean in early times did not contain as much salt as it does today; Chambers concluded that such a comparative absence of salt in the early ocean could affect "animal and vegetable marine life in different ways and degrees."[4]

In the fifth through tenth editions, Chambers proposed the theory of M. Brongniartstating that the distribution of fossil fuci indicated an equable distribution of a tropical climate throughout

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[1]Review of Vestiges, Fraser's Magazine, p. 365.

[2]CV I:72; III:72; IV:73; V:76.

[3]CV I:72; III:72; IV:73.

[4]CV III:72-73; IV:73-74; V:76.

the globe and ascribed it to the internal heat of the earth. This same theory was used in the preceding chapter in the first through fourth editions to explain the uniformity of organisms in the silurian era.[1]

Explanations for Lack of Land Organisms

Although Chambers observed, in all of the editions, the lack of land organisms in the devonian, he arrived at radically different reasons for this in the first through fourth editions and in the fifth through tenth. In the earlier forms, Chambers explained that no land organisms appeared in the devonian for, "the presumable reason, . . . that no dry land as yet existed."[2] Not only did the absence of land forms in the fossil record indicate this, he wrote, but such an inference could also be obtained from the study of the stratified rocks. For although these rocks were deposited in a horizontal position at the bottom of the sea, today they are found in a sharply inclined position with granite protruding through them. Whereas this upthrusting occurred since the deposition of the primary rocks, the deposition of subsequent strata are at a slight inclination, showing "that these strata were laid down after the swelling mountain eminences had, by their protrusion, tilted up the primary strata."[3] This first uplifting, the Era of the Oldest Mountains, produced the first dry land and, although there were subsequent times of mountain formation, no dry land existed

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[1]CV V:75-76; VI:68; VIII:42; IX:42-43; X:50-51.

[2]CV I:72; III:73; IV:74.

[3]CV I:72-73; III:73-74; IV:74-75.

previous to this.[1]

But by the writing of the fifth edition, Chambers had changed his point of view. Although he still mentioned that certain evidence favored the view that no dry land existed during the devonian--the exclusively marine fossil fauna and evidence from the history of mountains--he revised his interpretation of these data. As in the early editions, Chambers mentioned that the protrusion of granitic masses had been ejected from below at a period after the deposition of the strata. Therefore, "it is thought, we see causes for an emergence of land at a time following the formation of the primary series of rocks."[2] However, he could not understand "how the vast disintegration which produced the early stratified rocks should have been effected, if there were no emerged masses, as the wearing down of rocks chiefly takes place at the point where land and water meet, and in a very small degree within the bosom of the waves."[3] Thus, Chambers concluded in this edition that dry land had existed in the very early days but for an unknown reason had produced little or no vegetation and sustained no animals.[4]

In the sixth through ninth editions, Chambers explained that "overlooking possible exceptions of a narrow and dubious kind" traces of land plants and animals had not been found in the early rocks.[5]

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[1]CV I:73; III:74; IV:75.

[2]CV V:77.

[3]CV V:77.

[4]CV V:77.

[5]CV VI:69; VIII:42-43; IX:43.

As in the fifth edition, he noted that the vast disintegration of the primary rocks probably took place in the atmosphere and concluded that "there was dry land in the eras of the earliest stratified formations although it apparently was not the scene for the development of land forms of life."[1] Although he reached the same conclusion in the tenth edition as in the fifth through ninth, he mentioned the probably existence of land plants, which he had considered doubtful in the earlier editions.[2]

Chambers closed this chapter in the first five editions by enumerating the systems comprising the palaeozoic rocks and approximating their depth. In the first edition, he concluded that the great depth of these strata must have necessitated their deposition in an ocean of "enormous profundity." This conclusion was not found in the third or fourth editions and by the fifth edition Chambers mentioned "changes of relative level between the solid and water surfaces" in this era.[3]

The Carboniferous Era

In the course of Chambers' survey of the ascending geological formations he arrived at the carboniferous era. The opening paragraph of his discussion of this era reflects his change in attitude concerning the time of the appearance of the first land. In the first four editions, he explained that because of the first emergence of dry land in the carboniferous, "we now enter upon a new great epoch

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[1] CV VI:69; VIII:43; IX:43.

[2] CV X:50-51.

[3] CV I:75; III:76; IV:77; V:78.

in the history of our globe."[1] After explaining that this new "epoch" represented a habitat in which land life forms could have existed, he noted that "it remains to be inquired if these accordingly were produced."[2] This opening paragraph was deleted from the fifth edition because of Chambers' changing views about the first land, although this edition was essentially similar to the first four. The entire introductory section found in the first five editions was omitted from the sixth through tenth editions.

Erosion through the action of air and water, Chambers noted in the first five editions, caused secondary rocks to be formed from the primary rocks. Although in the fifth through tenth editions, he had previously mentioned this process of erosion in the formation of the secondary rocks in the discussion of the devonian formation, he repeated this information in the fifth edition.[3] In spite of the method of formation, Chambers noted in these editions a rather uniform composition within the strata, being more "distinct in the matter of its composition than might be expected."[4]

Although Chambers had excluded the introductory material of the earlier editions from the sixth through tenth editions, he noted in every edition that the carboniferous formation commenced with beds of mountain limestone which, unlike the coal formation, contained numerous remains of corals, crinoids, and shells.[5] Superimposed upon the

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[1]CV I:76; III:77; IV:78.

[2]CV I:76; III:77; IV:78.

[3]CV I:77; III:77-78; IV:78-79; V:79.

[4]CV I:77; III:78; IV:79; V:79-80.

[5]CV I:78; III:79; IV:80; V:80; VI:71; VIII:44; IX:44; X:51.

mountain limestone are the coal beds, described by Chambers in the first edition as having been formed from terrestrial vegetation "transmuted by pressure" and in the third through tenth editions "transmuted by putrefaction of a peculiar kind, beneath the surface of water and in the absence of air."[1]

Animal life, emphasized Chambers, underwent great changes from the strata of the mountain limestone to those of the coal, for the marine forms of the mountain limestone, zoophytes and crinoids, were absent from the coal beds. Although a few fresh water forms were found, he noted that animal life of any type was rare in the coal beds.[2]

The coal beds are "esteemed as the most valuable of mineral productions, from the important services which the substance renders in manufactures and in domestic economy," asserted Chambers. These valuable coal beds, he noted, were subject to geographic variation. To explain this variation, he assumed that these differences indicated that all parts of the world were not subject to the same geological events at the same time. Even though in the first four editions he concluded that this evidence indicated that dry land had occurred earlier in America than in Europe, he contradicted his previously stated views in these editions that dry land did not appear until the carboniferous.[3] In France, he reported in all of the editions, the coal beds lie immediately on the granite and other primary rocks;

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[1] CV I:78; III:79-80; IV:80-81; V:81; VI:72; VIII:44; IX:44; X:52.

[2] CV I:78-79; III:79-80; IV:81; V:81; VI:72; VIII:45; IX:44; X:52.

[3] CV I:79; III:80; IV:81; V:81-82; VI:72-73; VIII:45; IX:44-45; X:52.

however, only in the first four editions did he present the example that anthracite exists among the slate beds in America and that this area has an abundance of mountain limestone.

During the early part of the carboniferous, a large amount of carbonate of lime was formed, accompanied by a large population of corals and encrinites. However, the early editions differed from the later ones in their interpretation of the location of the formation of this carbonate of lime; in the first through fourth editions he stated that it was formed at the bottom of profound seas and in the fifth through tenth editions remarked that this substance was formed along the shores and islands of the ocean.[1] But in all of the editions, he concluded that a brief period of volcanic disturbance interrupted the abundant production of limestone, and that an increase in dry land with the corresponding increase in land vegetation followed. The carboniferous climate was torrid, and Chambers speculated that the atmosphere may have contained more carbonic acid gas than today. In the first through fourth editions he stated that "perhaps the atmosphere" contained more of this substance than today, and in the fifth through tenth editions that "it has been supposed by some that the atmosphere contained more carbonic acid gas than it currently does."[2]

The Vegetation of the Carboniferous

All of the carboniferous land plants are specifically different from modern forms, observed Chambers. Stressing the enormity of these

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[1] CV I:79-80; III:80-81; IV:82; V:82; VI:73; VIII:45; IX:45; X:52.

[2] CV I:80; III:81; IV:82; V:83; VI:73-74; VIII:45; IX:45; X:52.

plants, he concluded in the first edition that even those related to modern forms were much larger than their recent "small and lowly" descendants.[1] Evidently some large modern tropical forms were unknown to Chambers at the writing of this edition, for in the third and all subsequent forms he modified the statement to read that the modern representatives "in temperate climes at least, are now only found in small and lowly forms."[2]

Hypotheses of Coal Formation

Chambers presented two possible hypotheses to account for the production of coal. He suggested as the first possibility, that the detritus of decayed forests was carried by rivers to estuaries where it gathered into large natural rafts, eventually sank to the bottom, and was subsequently covered by a layer of sand or mud. The second hypothesis assumed that the vegetation was first transformed into peat-moss, overrun by the sea, covered with a layer of sand or mud, exposed to the air again as the sea level decreased, and finally covered by a new forest. Although in all of the editions, Chambers favored this second hypothesis since it would explain the presence of marine fossils in the shale where they are not found in the coal, he complained in the first through ninth editions that he found it difficult to accept the innumerable "risings and sinkings of surface as would be required of this hypothesis, to form a series of coal

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[1] CV I:80.

[2] CV III:81; IV:82; V:83; VI:74; VIII:45-46; IX:45; X:53.

strata."[1] In all of the editions but the tenth, in which he stated that the peat moss theory was "generally believed," Chambers concluded that "we may most safely rest at present with the supposition that coal has been formed under both classes of circumstances, though in the latter only as an exception to the former."[2]

Numbers of Species Found in the Coal

Increased fossil finds were reflected in Chambers' revisions of the number of species found in the coal formation. In the first through fourth editions, he declared that "upwards of three hundred" had been ascertained, in the fifth through ninth editions that "above eight hundred species" had been found, and in the tenth "about five hundred species," revising the figure downwards again.[3] Chambers expressed skepticism in the fifth through tenth editions that these figures represented anything like the total number of plant species which actually lived in that era, for, extrapolating from current numbers of species, 80,000 according to the fifth through ninth editions and 120,000 according to the tenth, "it is difficult to suppose the flora of that remote age to have been so much more limited."[4]

Plants and the Developmental Hypothesis

The evidence from the plant fossil record was unfavorable to

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[1] CV I:81-82; III:82-83; IV:83-84; V:83-85; VI:74-75; VIII:46; IX:45-47; X:53.

[2] CV I:82; III:83; IV:84; V:85; VI:75; VIII:46; IX:46; X:53.

[3] CV I:82; III:83; IV:84; V:85; VI:75; VIII:47; IX:46; X:53.

[4] CV V:85; VI:76; VIII:47; IX:46; X:53-54.

the acceptance of the Developmental Hypothesis. This record did not suggest a gradual transformation from the simple to the more complex; in fact, the evidence indicated that some of the more complex forms antedated the simpler. Chambers attacked this problem both by indicating that some of the simple forms might be missing from the record and by selectively interpreting the record to indicate a progression of forms.

Experiments indicate, reported Chambers in all of the editions, that certain groups of plants decompose in water more readily than others. But only in the first four editions did he conclude that the groups of plants "which decompose soonest [comprise] one of the classes found most rare, or not at all, in the coal strata."[1]

According to the critic for the British Quarterly Review there is no evidence to indicate that the cryptogamic tribes perish more rapidly than plants of the higher groups as Chambers had indicated; his assumption that if the whole carboniferous flora had been available for study a higher proportion of cryptogams to higher plants would have been evident was false.[2] Huxley also disagreed with Chambers' assertion that the lower forms of plants were not suitable for preservation as fossils. In refutation of Chambers' claim, he wrote that "lichens, at any rate, are hard and indestructible enough, and had there been a 'cryptogamic age' in which the flora was composed of fungi, algae, and lichens, we see no reasons why the two latter should not have been preserved."[3]

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[1]CV I:82; III:83; IV:84; V:85-86; VI:76; VIII:47; IX:47; X:54.

[2]Review of Vestiges, British Quarterly Review, pp. 496-97.

[3]Huxley, Review of Vestiges, pp. 336.

Nonetheless, Chambers, in the first through fourth editions, interpreted the fossil evidence to indicate that the "terrestrial botany of our globe begins with classes of comparatively simple forms and structure."[1] He arrived at this conclusion through a comparison of the relative numbers of the various groups of plants; since a large number of simpler plants was found earlier in the fossil record, he concluded that a progression of forms was occurring, chosing to ignore the exceptions of a few higher forms interspersed with the lower.[2] In the fifth through ninth editions he also indicated that the carboniferous flora was basically simple, concluding in the sixth through tenth editions that this flora was "greatly less varied than the present."[3] Sedgwick was unconvinced. He stated that lack of evidence made it impossible to know when land plants first appeared, although it was certain that the early land plants were not simple as Chambers had indicated but quite highly developed.[4]

The appearance of a single dicotyledonous plant in the carboniferous or earlier formations was sufficient to cast doubt upon the entire Developmental Hypothesis, as Chambers' critics were quick to note. Brewster explained that Dr. Fleming had described dicotyledonous plants from the grauwacke slates of Cork, and indicated that Chambers' attempt to specify an ascending scale in the plants of the carboniferous, as "positive as these statements are, and bold as are the conclusions

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[1]CV I:83; III:84; IV:85.

[2]CV I:83-84; III:84-85; IV:85-86.

[3]CV V:86; VI:76; VIII:47; IX:47; X:54.

[4]Sedgwick, Review of Vestiges, p. 36.

which are drawn from them," was manifestly false.[1]

The reviewer for the British Quarterly Review was disturbed that Chambers did "not see that, however few they [dicotyledons] may be, it entirely upsets the theory of progressive advance, especially in the absence of any proof as to whether they were created first or last."[2] This writer continued by suggesting that "if human bones were found amongst the lowest rocks, then the theory of progressive development of animals corresponding with geological epochs, must be given up; and the existence of dicotyledonous plants in the coal measure is not less fatal to his argument."[3]

Criticisms such as these stimulated Chambers to look for further support for his proposition. In the fifth through ninth editions, he included a note not found in the other editions referring to an experiment by Professor John Lindley (1799-1865) which appeared to prove that the reason dicotyledonous trees were not found in the carboniferous era was that they perished in water sooner than monocotyledons. From this experimental evidence, Lindley concluded that the only reason that the carboniferous vegetation appears primitive is that the higher trees could not be preserved. Chambers discounted this, of course, since it was opposed to his theory; dicotyledons, he noted, abounded in the tertiary and would not if Lindley's hypothesis were correct.

Lindley's hypothesis represented the type of evidence which

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[1] Brewster, Review of Vestiges, p. 490.

[2] Review of Vestiges, British Quarterly Review, p. 497.

[3] Ibid.

Chambers tended to accept if it supported his preconceptions and reject if it did not. In this note he admitted that, although rare, dicotyledons had been found in the tertiary. Of course this was the objection voiced by his opponents. But Chambers selectively noted it when it was useful to his purpose. Moreover, the developmental conclusion that he drew was unwarranted from the early appearance of the dicotyledons. In the same note to justify his assertion that "Development" was occurring in the vegetable kingdom, he summarized this progression by explaining that we find "simple sea-plants in the earlier fossiliferous strata and dicotyledons abundant in the last, while the intermediate carbonic period presents the intermediate kinds of plants . . . it appears the most legitimate inference in the case, that the earth has witnessed a botanical progress."[1]

Continuing in his inconsistency in answering one of Hugh Miller's objections to the Developmental Hypothesis, that "the discovery of a conifer in the Devonian Age is adduced as a fact much opposed to the theory of the present work," Chambers offered an explanation in a note in the eighth and ninth editions.[2] He assumed that Miller's objection was unwarranted since traces of simpler vegetation had now been discovered in earlier strata, thus allowing for progress. Although the time of commencement for all of the organic groups was always being pushed back, observed Chambers, "the general march, however, remains as it was presented a few years ago, and even the sporadic ones observe something like the general order."[3]

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[1]CV V:417-18; VI:493-94; VIII:300-301; IX:298.

[2]Hugh Miller, Footprints of the Creator, pp. 207-14.

[3]CV VI:493-94; VIII:301; IX:299.

Even though there are certain apparent exceptions, most of the carboniferous plants are simple. "Two-thirds of the plants of the carboniferous era are of the cellular or cryptogamic kind, a proportion which would probably be much increased if we knew the whole Flora of that era," reported Chambers in the first four editions, whereas dicotyledons are comparatively scarce in this formation. The greater numbers of these lower plants indicated that they had been developed first; he continued to ignore the implications from the existence of a few higher forms.[1]

Although Chambers in the fifth through tenth editions did not assign a percentage to the cellular and cryptogamic forms as he had in the earlier editions, he again indicated that they were dominant with the dicotyledons rare. But more dicotyledonous fossils had been discovered since the writing of the earlier editions, and he recognized this fact in the later forms. Although he admitted that conifers were actually present in considerable numbers in the carboniferous, he explained this apparent discrepancy by rationalizing that since conifers are considered "the lowest family of its class, having an imperfection in its flowering apparatus, . . ." they are brought "into affinity with the cryptogamic forms."[2]

Ferns, Horsetails and Club Mosses

Ferns, explained Chambers, are dominant carboniferous plants which are most successful in warm, shaded, moist situations such as now exist in the tropics. From the enormous size of these carboniferous

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[1]CV I:84; III:85; IV:86; V:86; VI:77; VIII:47-48; IX:47; X:54.

[2]CV V:86; VI:77; VIII:47-48; IX:47; X:54.

ferns over the entire earth, he concluded that a uniformly tropical climate must have covered the entire earth during this era.[1]

The second most common carboniferous plant form, the equisetum or horsetail, also requires tropical conditions. Although the equiseta of the carboniferous were uniformly large and arborescent in all latitudes, those in existence today are small. Chambers omitted a statement found in the first edition that modern equiseta are confined to the tropics from the third and subsequent editions. Although the present equiseta are of the same family as the carboniferous specimens, reported Chambers in all of the editions, species of the carboniferous had disappeared before the tertiary.[2]

The third common plant of the carboniferous, the club mosses, "usually seen in a lowly and creeping form in temperate latitudes, but presenting species which rise to a greater magnitude within the tropics" were very large in the carboniferous and were thought to have "contributed more to the substance of the coal than any other family."[3] The fossil genus, lepidodendra was described as a very important form since Chambers considered this genus to be a link between the monocotyledons and dicotyledons, "a fact worthy of note, as it favors the idea of a progress in vegetable creation, in the line of an improved organization."[4]

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[1]CV I:84-85; III:85-86; IV:86-87; V:87; VI:77-78; VIII:48; IX:47-48; X:55.

[2]CV I:85-86; III:86-87; IV:87; V:88; VI:78-79; VIII:48; IX:48; X:55-56.

[3]CV I:86-87; III:87-88; IV:88; V:88-89; VI:79-80; VIII:48-49; IX:48-49; X:56-57.

[4]CV I:86-87; III:87-88; IV:88; V:89; VI:79-80; VIII:49; IX:48-49; X:57.

Huxley was unimpressed with Chambers' contention that the fossil plants of the carboniferous suggested the idea of transformation. A comparison of the modern ferns with the carboniferous forms indicated, he noted, that they were only generically different. Since so many thousands of years had elapsed between the two types, if a progression of forms had been occurring, it seemed strange that the differences were so slight. He found another contradiction in an apparent regression from the lycopodiaceae and equisetacea of the carboniferous to those of today. The earlier ones were "much more highly organized plants than any of their present representatives. . . ." Therefore, he concluded, "we can definitely say, as regards the cryptogamia, that since the carboniferous epoch, there had been no advance in some respects, and a very decided falling off in others."[1]

Huxley was most disturbed by Chambers' failure to react to the implication of his own statements. Chambers had indicated that in the very lowest fossiliferous rocks in Portugal and America, fossil ferns and lepidodendra had now been discovered. Both Chambers and Huxley agreed that the lepidodendra are among the highest of the cryptogams. But Chambers reacted to the statement in the same way that he reacted to other new and controversial data which would have adverse implications to his theory--he mentioned the existence of the new finds and then stated that "it appeared inexpedient to make extensive alterations in the original structure of the work, on account of matters so isolated and perhaps scarcely as yet generally accepted."[2]

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[1]Huxley, Review of Vestiges, p. 336.

[2]Ibid., CV X:59.

He continued with a further rationalization that these finds "may be regarded as standing in no inconsistency with the general strain of the palaeontological history, but only like certain similar discoveries of animal remains and tracings, pointing to the general probability of an earlier origin for all the forms and grades of existence than was indicated by geology in its infant years."[1]

Additional Carboniferous Monocotyledons

In addition to the dominant plants, Chambers described other carboniferous forms in all of the editions, including two genera of plants not represented in today's flora, sigillaria and stigmaria. Although he considered these two forms to be separate species in the first through ninth editions, in the tenth he had assimilated some new information and concluded that "masses to which the term stigmaria is applied were originally described as distinct plants, but are now generally regarded as fragments of the root and stem of sigillariae."[2] Palms were the monocotyledonous forms found in the carboniferous, he reported in all of the editions.[3]

Dicotyledons of the Carboniferous

The highest of the carboniferous plants, the "dicotyledons of the coal," according to the first four editions, and "the true conifers of the coal," according to the last six editions, were described.[4] In addition to some plants of "doubtful affinity," there

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[1]Huxley, Review of Vestiges, p. 336; CV X:59.

[2]CV I:87; III:88; IV:89; V:89-90; VI:80; VIII:49; IX:49; X:57-58.

[3]CV I:87; III:88; IV:89; V:90; VI:80-81; VIII:49; IX:49; X:58.

[4]CV I:87; III:88; IV:89; V:90; VI:80-81; VIII:49; IX:49; X:58.

occurred "a few of the pine family, which seem to have been the highest class of trees of this era, and are only as yet found in isolated cases and in sandstone beds," reported Chambers in the first four editions. The place of the discovery of the early conifers was, according to Chambers in all of the editions, in the Craigleith quarry near Edinburgh, as well as at Newcastle.[1]

Since the leaves and fruit of these fossil plants are unavailable as classificatory guides, Chambers explained another method of ascertaining their affinities. The "ingenious mode of detecting the nature of these trees" invented by "Mr. Witham of Lartington," according to the first edition, and by "some naturalists residing in the northern capital," in the third through tenth editions with a reference to Witham's work on the Internal Structure of Fossil Vegetables, 1834, involved microscopic examination of a cross section of the stems. Chambers explained that a particular conifer, the auraucaria, was identified in this way.[2] He concluded in all of the editions that "the conifers of this era may be said to form the dawn of dicotyledonous trees, to which, it has already been noticed, the lepidodendra are a link from the Monocotyledons."[3]

Chambers had previously mentioned that the size and form of the carboniferous plants indicated a relatively universal uniform climate during this era, and now discussed a further confirmation of this hypothesis obtained from the examination of cross sections of

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[1]CV I:87; III:88; IV:89; V:90; VI:80-81; VIII:49; IX:49; X:58.

[2]CV I:88; III:89; IX:89-90; X:90-91; VI:81; VIII:49-50; IX:49-50; X:58.

[3]CV I:88; III:89; IV:90-91; V:91; VI:81-82; VIII:50; IX:50; X:58.

conifers. The microscopic examination of the annual rings indicated uniform climatic conditions in the carboniferous era.[1] "Monotonous in its forms and destitute of brilliant colouring, its sward probably unenlivened by any of the smaller flowering herbs, its shades uncheered by the hum of insects, or the music of birds, it must have been but a sombre scene to a human visitant," wrote Chambers of the carboniferous forest.[2] But even a poetic statement like this one was not immune to criticism. Brewster accused Chambers of a grave mistake in indicating that insects were not found in the carboniferous. Chambers should have been familiar with an account of insects in this era published eight years previously in Buckland's Bridgewater Treatise, he scolded. Chambers' omission of the "hum of insects" from the later editions made it evident that he was aware of his mistake.[3]

Results of the Carboniferous Vegetation

In the first through fourth editions, Chambers mentioned two important effects of the carboniferous vegetation, "clearing (probably) the atmosphere of matter noxious to animal life, and storing up mineral masses which were in long subsequent ages to prove of the greatest service to the human race, even to the extent of favouring the progress of its civilization."[4] But in the fifth through ninth

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[1] CV I:88-89; III:89-90; IV:90-91; V:91; VI:81-82; VIII:50; IX:50; X:58.

[2] CV I:89; III:90; IV:91.

[3] Brewster, Review of Vestiges, p. 490.

[4] CV I:89-90; III:90-91; IV:91.

editions, he expressed more doubt about the first function, stating that this vegetation was probably useful in "clearing perhaps the atmosphere of matter noxious to animal life, and certainly storing up mineral masses. . . ."[1] And in the tenth edition, the first function was omitted altogether, leaving only the second, which indicated that the purpose of earlier forms of creation was to prepare the earth for the coming of man.[2]

The Appearance of Land

Chambers was very tentative as he explained in the fifth edition that "till we know more about them, they [the new data indicating that the first land appeared before the carboniferous] cannot be allowed greatly to affect our views of the botanical history of the globe."[3] In this edition, the first one in which he suggested the earlier appearance of land, he cited examples of land plants from the silurian of Wales and America and the old red sandstone of America, remarking that these discoveries would "not interfere with general deductions from the mass of early land vegetation found in the coal era" because possibly there were small pieces of land bearing vegetation before the large coal masses were formed.[4]

In the sixth through ninth editions, Chambers was still describing these early fossils as "scanty and isolated," and even in

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[1] CV V:92; VI:82; VIII:50-51; IX:50.

[2] CV X:59.

[3] CV I:76; III:77; IV:78; V:92.

[4] CV V:92-93.

the tenth he considered them "partial and newly announced."[1] Besides the examples of early land plants presented in the fifth edition, Chambers included additional examples in the sixth through tenth editions. Land plants from the silurian of England which "have not, as far as the author is aware, been described," plants from the American lower devonian, and, in the eighth and ninth editions only, "a lignite of coniferous structure found by Mr. Hugh Miller in a lower devonian rock in Scotland," all support the early existence of land.[2]

The reviewer for Fraser's Magazine described his understanding of fossil land plants from the silurian and devonian, emphasizing a fragment of coniferous wood which he said was discovered by Miller in the old red sandstone of Scotland and which Chambers had placed in the devonian. "This ancient tree floating in the ocean of the old red, like the trunks, few and far between, which navigators encounter in the Pacific, proves the existence of land, of greater or less extent, in some quarter or other, during that period; and when geologists shall have the good fortune to explore deposits bordering some silurian or devonian island, as large as Britain or New Zealand, we may expect to hear of traces of air-breathing mammals," wrote this reviewer.[3] This coniferous fragment from the old red sandstone, he concluded, "furnishes a refutation of that part of the transmutation doctrines which asserts the earliest vegetation to have been of the humblest kind."[4] It is interesting that Chambers only mentioned this coniferous

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[1]CV VI:82-83; VIII:51; IX:50-51; X:59.

[2]CV VI:83; VIII:51; IX:50-51; X:59.

[3]Review of Vestiges, Fraser's Magazine, p. 367.

[4]Ibid.

fragment in the eighth and ninth editions but omitted it from the tenth. The reason for this omission is unclear.

However, in the tenth edition he did mention a different example, a plant related to the lepidodendron found in the American silurian which also challenged his preconceptions. In the eighth and ninth editions he rationalized that the new discoveries were not detrimental to the Developmental Hypothesis by assuming that "all the great events of the history of organized bodies seem to have had their vaunt-couriers; but even the vaunt couriers come in an order, and this order is generally harmonious with that of the great events."[1] But Chambers' conclusion in the tenth edition indicated that, in spite of his wariness, he attached a good deal of significance to these finds but, as in the case of the discovery of Neptune, he declined "to make extensive alterations in the original structure of the work, on account of matters so isolated and perhaps scarcely as yet generally accepted."[2] But he stressed that if such a discovery were proved it "may be regarded as standing in no inconsistency with the general strain of the palaeontological history, but only like certain similar discoveries of animal remains and tracings, pointing to the general probability of an earlier origin for all the forms and grades of existence than was indicated by geology in its infant years."[3]

Animals of the Carboniferous

With the exception of the mountain limestone in which corals

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[1] CV VIII:51; IX:51.

[2] CV X:59.

[3] CV X:59.

and crinoids were common, few animal fossils were found in the carboniferous. Nevertheless a few mollusks and some fish were found above the mountain limestone, in the shales which alternated with the coal.[1] The fish, Chambers explained, were of a new type, the sauroids, a controversial form because of their alleged relationship to the lizards. Since lizards are not among the more simple reptiles, the lizard-like sauroid fish appear to contradict the Developmental Hypothesis. Chambers, however, was more interested in finding an organism which might link the two vertebrate classes, the fish and reptiles, than in concerning himself overly with an apparently contradictory detail. In all of the editions he mentioned this relationship to the lizards, stating in the first edition that they "partake of the nature of the lizard," in the third and fourth editions that they "make an advance to the lizard character," and in the fifth through tenth that they resemble "that of the Sauria, and evidently . . ." lead "on to that section of reptiles."[2]

Brewster objected to Chambers' considering the sauroid fish as advancing towards the lizard character, stating that "this attempt to assimilate the Sauroid fishes to the lizards deserves the severest censure, for Agassiz has shown, that their general structure is so peculiar, that they cannot be united with the reptiles, or the one class in any way descend from the other."[3] In the third and fourth editions, Chambers included a footnote explaining that "the sauroid

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[1]CV I:90; III:91; IV:91-92; V:93; VI:83-84; VIII:51; IX:51; X:59-60.

[2]CV I:90; III:91; IV:92; V:93; VI:83-84; VIII:51; IX:51; X:60.

[3]Brewster, Review of Vestiges, p. 490.

fishes are often adduced as a proof that animals do not make their appearance in the series of rocks in the order of their comparative organization." Chambers evaded the implication of this statement by simply discounting its importance.

Chambers referred to a problem in a footnote in the third and fourth editions. Subsequent to the sauroids, two groups of fish arose, the cycloids and the ctenoids, with no lizard-like characteristics; their position in a developmental sequence after the sauroid fish was questioned, but Chambers was not exceptionally concerned. He concluded that "the subsequent rise of orders of fishes (ctenoid and cycloids) which do not so nearly approach the reptilian type, seem to me indifferent, as far as that question is concerned."[1]

Although Chambers discussed the presence of insects in the carboniferous in the fifth through tenth editions, he did not mention them in the first four. After Brewster called attention to his ignorance of the presence of insects in these rocks, he corrected this problem.[2] The result was that in the fifth through tenth editions he detailed the discovery of fossil insects, stating in the eighth through tenth editions that "two species belonging to the family of curculionidae, as well as some relics of neuropterous, orthopterous, and lepidopterous insects and a 'scorpion-like creature,' have been described."[3]

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[1] CV III:92; IV:92.

[2] Brewster, Review of Vestiges, p. 490; CV V:94; VI:84; VIII: 52; IX:51-52; X:60.

[3] CV V:94; VI:84; VIII:52; IX:51-52; X:60.

Carbonic Acid and the Carboniferous

The coal strata are chiefly confined to the carboniferous era, although occasionally thin beds occurred subsequently. Chambers concluded that some of the conditions leading to the formation of such an abundant vegetation must have ceased; in the first through fourth editions he again brought forth his theory of a superabundance of carbonic acid gas in the air to explain the lush carboniferous vegetation. In these editions he concluded that "on the exhaustion of the superabundance of carbonic acid gas, the coal formation would cease, and the earth might again become a suitable theatre of being for land animals."[1] In the fifth through tenth editions, Chambers apparently no longer was convinced of this superabundance of carbonic acid gas, so no attempt was made to explain the cessation of coal formation.

Evidence of Reptiles and Birds in the Carboniferous

Chambers changed his mind as to the time of the first appearance of reptiles between the first through fifth editions and the sixth through tenth. In the early editions he assumed that reptiles did not appear until the era of the new red sandstone, although in the fifth edition he was changing his views and mentioned the possibility of a reptilian footprint in the carboniferous; in the sixth edition, reptilian prints from Westmoreland County, Pennsylvania, were mentioned, but in a note only.[2]

Brewster, when criticizing Chambers, objected to his omission

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[1]CV I:90-91; III:92-93; IV:93-94; V:94; VI:84; VIII:54; IX:54; X:64.

[2]CV V:94; VI:494-95; VIII:52; IX:52; X:60.

of these data from the early editions. But in the eighth through tenth editions, Chambers assimilated this information; he concluded in the tenth edition that although "for many years, no remains or traces of any animals superior in organization to fishes were discovered in the carboniferous system, . . . within the last few years, some scattered instances of reptilian life have been found in the coal era, and even in the Devonian. . . ."[1] Such an early appearance of reptiles, according to the reviewer in the British Quarterly Review, was opposed to a hypothesis of progressive development which, if correct, should postpone the appearance of reptiles until the time of the lias and oolite, "whereas proofs of their existence are abundant in the new red sandstone, and in beds still lower."[2] Chambers was undaunted by this challenge to his theory and, in the tenth edition, rationalized their appearance in the devonian by assuming that this implied "a closer succession of this grade of existence upon that of Fish, than had previously been observed."[3]

Birds also appeared earlier than would have been desired by the developmentalist. In the eighth and ninth editions, Chambers mentioned that footprints of "a biped animal, apparently of the order Grallae, besides several reptilian vestiges have been found in strata of the carboniferous era," in Westmoreland County, Pennsylvania.[4] But in the sixth and eighth editions Chambers was still very skeptical

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[1] CV VIII:52; IX:52; X:60; Brewster, Review of Vestiges, p. 491.

[2] Review of Vestiges, British Quarterly Review, p. 495; CV X:60.

[3] CV X:60.

[4] CV VIII:301-302; IX:299.

of the existence of birds "at so early a period" and stated in a note that it would "require strong evidence for him to accept their existence at this time. Although Chambers did not discuss the bird prints in this section in the tenth edition, he did include a diagram.[1]

The reviewer for the British Quarterly Review was convinced that according to the developmental hypothesis "birds, . . . ought not to be seen till after the reptiles, but indications of their existence are found contemporaneous with the existence of the earlier saurians."[2] W. H. Allen also considered the discovery of bird remains in the carboniferous to be "fatal to the hypothesis that 'species followed each other in an order at once of development and of time.'"[3] He insisted that this one fact would be enough to negate the entire hypothesis, for the second highest class of vertebrates should not have been found "in the first geological series which was formed after the appearance of dry land above the surface of the primeval ocean. . . ."[4]

Casts, footprints, tidemarks, and rain drops are extremely important in interpreting fossil history. Chambers, although including the discussion in all editions, followed a different organizational scheme in the first through sixth editions and in the eighth through tenth. In the later editions, the importance of these imprints was discussed in the descriptions of the carboniferous, but in the earlier

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[1]CV VIII:301-302; IX:53-54; X:62.

[2]Review of Vestiges, British Quarterly Review, p. 495.

[3]W. H. Allen, Review of Vestiges, pp. 307-308.

[4]Ibid.

editions it was supplied in the next chapter. According to Chambers, "these facts have the same kind of interest as the season-rings of the Craigleith conifers, speaking of the identity of the familiar processes of nature in those early ages with those of our own."[1]

In the later editions, Chambers was apparently reconciled to the early appearance of reptiles, describing the first actual reptilian remains, from the coal formation in Bavaria. He asserted that this animal, archegeosaurus, was probably related to the labyrinthodont of a higher formation. After describing these animals, Chambers remarked that they were saurians, "arrested in their development, on the level of the Batrachians, 'furnishing a proof that representatives of the ancient world, in the like manner as the sirens do among the recent batrachians.'"[2]

The closing section of this chapter was similar in all of the editions, stressing that the close of the carboniferous was characterized by volcanic activity. But, Chambers indicated, "it is to be admitted for strict truth, that in some parts of Europe the carboniferous formation is followed by superior deposits, without the appearance of such disturbances between their respective periods; but such cases apparently are exceptive."[3]

The New Red Sandstone

Superimposed upon the carboniferous rocks were those referred to by Chambers in the first five editions as the new red sandstone.

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[1] CV VIII:52-53; IX:52-54; X:60-63.

[2] CV VIII:54; IX:54; X:64.

[3] CV I:92-93; III:93-95; IV:94-95; V:94-95; VI:84-85; VIII:54-55.

Again, the arrangement differed in the earlier and the later editions. The material included in this chapter in the first through fifth editions was divided between three sub-chapters in the eighth through tenth editions; some of the material was included in the sub-chapter on the carboniferous, the bulk in a sub-chapter entitled, "Permian Era, Reptiles," and the remainder in a sub-chapter on the trias. In the sixth edition the material was divided between two sub-chapters. The fourth edition even differed in arrangement from the first three. In this edition, Chambers omitted much of the material included in the first three editions and inserted it instead in the succeeding chapter on the oolite.[1] Thus Chambers extensively revised this section from the third to the fourth editions, the fourth to the fifth, and the fifth to the sixth. In the first four editions, Chambers considered this era to be one of special importance since it illustrated "the commencement of land animals;" however, by the fifth edition since he was aware of the earlier existence of these forms he consequently modified his text to read that the rocks of the new red sandstone reveal "the abundant appearance of land animals."[2]

The Rocks Comprising the New Red Sandstone

Chambers began the discussion in the first five editions by enumerating the groups of rocks comprising this system. Although a revision occurred between the first three editions and the fourth and fifth, the changes were in the style of presentation rather than

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[1] CV I:94-104; III:96-105; IV:96-103; V:97-109; VI:86-101; VIII:52-63; IX:52-62; X:60-77.

[2] CV I:94; III:96; IV:96-97; V:97-98.

in the content. Chambers assumed in the first five editions that the system was composed of, in ascending order, the lower red sandstone, magnesian limestone, red and white sandstones and conglomerate, and variegated marls.[1] Although the term "Permian," used in the sixth through tenth editions, was not mentioned in the first four editions, it was introduced in a footnote in the fifth edition, which explained that the lower new red sandstone and the magnesian limestone "have lately been called the Permian System from their being largely developed in the ancient kingdom of Permia."[2]

The term permian was defined in the sixth through tenth editions in much the same way as it had been in the fifth edition footnote, with the added explanation that this era represents "a short series of strata, following, whether conformably or otherwise upon the carboniferous formation. . . ."[3] After defining this formation, Chambers proceeded as he had in the earlier editions, by listing its component parts; however, he only described the two subdivisions of the permian, the lower new red sandstone and the magnesian limestone, since the remainder of the rocks considered in the first five editions' chapter on the new red sandstone were described in the sub-chapter on the trias.[4]

Characterization of the Fossils

Although in the first through third editions Chambers

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[1] CV I:94; III:96; IV:96-97; V:97-98.

[2] CV V:97.

[3] CV VI:86; VIII:55; IX:55; X:65.

[4] CV VI:86; VIII:55; IX:55; X:65.

represented the era of the new red sandstone as a basically autonomous unit, by the fourth and fifth editions he considered it to be "a sort of transitionary series, from the Carboniferous to the Oolitic; and, though peculiar in mineral constitution, might, as far as fossils are concerned, be very properly divided between the preceding and succeeding formations."[1] The transitional nature of this formation was also indicated in the sixth through tenth editions as Chambers wrote that it "is, in respect of fossils, a continuation of the carboniferous system."[2] However, in these later editions he also recorded that this formation has a special significance since it "ends a range of animal forms which first appeared in the Silurians, and passed, with the changes which have been indicated, through the Devonian and Carbonigenous eras."[3]

Although Chambers mentioned in the first through third editions that the number of specific forms was reduced from earlier times, he was more specific in the later editions, mentioning that the coral species were reduced, crinoids almost absent, trilobites missing, few brachiopods present, and almost no cephalopods evident.[4] Chambers speculated as to whether this diminution of life was apparent only. In the later editions he asked if it could not be explained by "some such simple cause as the occurrence of deposits which were not

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[1]CV IV:97; V:98.

[2]CV VI:86; VIII:55; IX:55; X:65.

[3]CV VI:86; VIII:55; IX:55; X:65.

[4]CV VI:86-87; VIII:55-56; IX:55; X:66.

favourable to the preservation of animal remains," or that the principal cemeteries of the age have not yet been hit upon by research?"[1] However, he admitted in these editions that changes in physical conditions might not be necessary for extensive changes of specific forms.[2]

In the early editions, however, Chambers stressed the importance of physical changes as causes of biological changes. The paucity of fossils might be expected, he speculated in the first through third editions "from the appearance of disturbance, and the red tint of the rocks, the latter being communicated by a solution of oxide of iron, a substance unfavourable to animal life."[3] Although he did not mention the shortage of fossils in the fourth and fifth editions, he stated that "the lowest beds are those alluded to in the preceding chapter as presenting indications of disturbance."[4]

Chambers elaborated on the continuity thesis in the sixth through tenth editions. He disagreed with the customary procedure of regarding the permian era as closing the palaeozoic period, based on the assumption that a completely new set of organisms then entered the field. In challenging the validity of this point of view, Chambers cited "carry-overs" to emphasize his point, concluding that "in the regular advance of life from inferior to superior classes there is here no interruption."[5] He concluded that the reason for the appearance

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[1]CV VI:87-88; VIII:56; IX:55-56; X:66.

[2]CV VI:88; VIII:56; IX:56; X:66.

[3]CV I:95; III:97.

[4]CV IV:96; V:97.

[5]CV VI:88; VIII:57; IX:56-57; X:67.

of such a total change was a suspension of deposits for a while--a time in which no record of intermediate forms was apparent although they, no doubt, were present.[1]

The Flora of the New Red Sandstone

In the first through fifth editions, Chambers discussed the meagre and "unobtrusive" nature of the flora of this time. In the first through third editions this discussion was included after a description of the reptiles of these rocks, whereas in the fourth and fifth editions it was inserted near the beginning of the chapter. But Chambers concluded in all of these early editions, with a slight difference in wording, that "equiseta, calamites, ferns, Voltzia, and a few of the other families, found so abundantly in the carboniferous series, here present themselves, but in diminished size and quantity."[2]

Recurrence of Circumstances Favoring Animal Life

Chambers explained, in the first through third editions, that superimposed upon the rocks of the lower new red sandstone was "a limestone with an infusion of magnesia," in which occurred "a recurrence of circumstances favourable to animal life;" specifically, he noted the presence of zoophytes, conchifera, a few land plants, and some fish.[3] Although in the fourth and fifth editions he mentioned the occurrence of these organisms he did not mention a "recurrence of circumstances" favorable to their existence, but reworded the sentence to stress that these forms were a part of the continuum. The phrasing

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[1] CV VI:89; VIII:57; IX:56-57; X:67.

[2] CV I:100; III:101; IV:97; V:98.

[3] CV I:95-96; III:97-98.

of the earlier editions could have suggested a special creation, whereas that of the reworded fourth and fifth editions would not.[1]

The Appearance of Reptiles

According to the reviewer for Fraser's Magazine, a complete look at the evidence would show a great variety among the reptiles from the time of their first appearance in the earliest rocks. Therefore the developmentalist's conclusion that the variation apparent in the later fossils resulted from an evolutionary sequence from a common reptilian ancestor would be incorrect.[2] But Chambers in his discussion of the early forms did not indicate diversity among the early reptiles.

The problem of the time of the appearance of the first land reappeared in Chambers' discussion of the early reptiles. The first reptile mentioned in the first through third editions was a lizard related to the monitor, found in "cupriferous (copper-bearing) slate connected with the mountain limestone at Mansfield and Glucksbrunn, in Germany." This, he concluded, "may be taken as evidence that dry land existed in that age near those places."[3] Before discussing the appearance of reptiles in the fourth and fifth editions, Chambers discussed the probable aquatic character of all of the organisms previous to those found in the new red sandstone. But since by the fifth edition he recognized the possible existence of earlier air-breathing forms, he changed his fourth edition statement that "hitherto, no animal capable of breathing that atmosphere has been

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[1] CV IV:97; V:98.

[2] Review of Vestiges, Fraser's Magazine, p. 368.

[3] CV I:95-96; III:97-98.

presented to our observation," to read in the fifth edition that "no distinct traces" of earlier land animals had been acknowledged."[1]

Relationship of Reptiles to Fish

Since it would be convenient for the developmentalist to be able to show a close relationship between the reptiles and the fish, Chambers attempted to demonstrate such a relationship. Although in the first and third editions he mentioned that the reptiles represented the group closest to the fish, only in the fourth edition did he go into any detail as to this relationship. The reptiles were so near "to fishes, that certain species stand doubtfully between the two classes, having extremities which can hardly be distinguished from fins," he stated in this edition.[2] The cause of their appearance, postulated Chambers, might have been in part the flat muddy shores of the era.[3] The Lamarckian implications that a suitable geography was the reason for the new abundance of reptiles may have caused these statements to be removed from the subsequent editions.

In searching for the cause of the numerous reptiles existing in the new red sandstone, Chambers reverted to the carbonic acid theory as an explanation in the first four editions. Possibly, he suggested, there was still too much carbonic acid gas in the air to allow for the existence of mammals, but reptiles, because of their slow rate of respiration could adapt to this.[4]

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[1] CV IV:97; V:98-99.

[2] CV I:96; III:98; IV:97-98.

[3] CV IV:98.

[4] CV I:96-97; III:98-99; IV:98.

Sedgwick was most skeptical of any supposed relationship of the early reptiles to the fish. Insisting that the first reptiles were not simple forms connected to the sauroid fish of the carboniferous, he related that instead they were members of a higher group of reptiles, the lacertilians.[1]

Early Reptilian Fossils

Although the monitor-like lizard previously alluded to in the first through third editions was not mentioned in the fourth, it was characterized in the fifth through tenth editions. While specifying, in the fifth edition, that the first actual reptilian fossils were found in the magnesian limestone, the wording allowed for the earlier, less positive evidence of footprints. The term "magnesian limestone" was not used in the sixth through tenth editions, but the same idea was presented in these forms; in these editions, Chambers stated that in the permian there occurred "undoubted remains of the reptilian class."[2]

Owen's placement of the early reptiles in the lacertilian order was described in the later editions. These early forms, Chambers noted, differed from modern lizards because of their fish-like vertebral column and, according to the fifth edition only, they possessed teeth "fixed to the jaws in the manner of fish teeth."[3] But Chambers changed his idea that the teeth of these early lizards were primitive in his discussion in the sixth through tenth editions. In these editions

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[1]Sedgwick, Review of Vestiges, p. 40.

[2]CV V:101-102; VI:89-90; VIII:57; IX:57; X:67-68.

[3]CV V:102; VI:89-90; VIII:57; IX:57; X:68-69.

he explained that two of the early lizards, the thecodonts and palaeosaurs, had teeth "fixed in distinct sockets, like those of the modern crocodiles."[1] Chambers explained, without discussing the phylogenetic implications, that these animals were "in this respect; . . . superior to the modern varanians, the nearest living tribe, which have the teeth imbedded in comparatively shallow cavities along the bottom of a groove in the jaw."[2]

The Secondary Formation

Since the rocks encompassed by the terms permian and triassic were considered in a single chapter in the first five editions, there was no introduction to the term "Secondary Formation" as there was in the sixth through tenth editions. In these later editions, Chambers defined the secondary formation as embracing the period from the end of the permian to the close of the cretaceous; in the fifth edition, he considered the carboniferous a part of the secondary formation.[3]

The strata above the magnesian limestone differed in England and on the continent, explained Chambers. The English rocks consist only of upper new red sandstone and variegated marls, whereas on the continent there is an additional limestone stratum full of shells called the muschelkalk. Although the material was similar, this explanation varied in form between the first through fifth and the sixth through tenth editions.[4] In the sixth through tenth editions,

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[1]CV VI:90; VIII:57; IX:57; X:69.

[2]CV VI:90; VIII:57; IX:57; X:69.

[3]CV VI:91; VIII:58; IX:58; X:69.

[4]CV I:96; III:98; IV:96-97; V:104-105; VI:91; VIII:58; IX:58; X:69.

Chambers added that the system was called the trias because of the three layers involved in the continental formation.[1]

Organisms of the Muschelkalk

The muschelkalk contains numerous organic remains, stressed Chambers. In the first four editions he explained that it was the first stratum to present land animals in any abundance; in the fifth through tenth editions he noted that after the triassic system the most abundant organic remains were to be found in the muschelkalk.[2] Although in the first through third editions, Chambers did not mention specific invertebrates found in these rocks, in the fourth and fifth he explained that animals which had previously existed, "zoophytes, conchifers, mollusks, crustacea, and fishes" were especially common in the muschelkalk, and in the sixth through tenth editions he described some of the invertebrates. He characterized these forms as "all differing in specific character from their predecessors of the same order," with a new crinoid, ostracea--an organism of the shallow sea--replacing brachiopods, as well as shallow sea forms of univlave mollusks, and cephalopods without shells.[3] Many of these forms were illustrated in the tenth edition.[4]

The muschelkalk further demonstrated the improbability of the developmental outlook to Sedgwick. He noted that in the muschelkalk not a single species was found which also had existed in the

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[1] CV VI:91-92; VIII:58; IX:58; X:69.

[2] CV I:96; III:98; IV:97; V:104-105; VI:92; VIII:58; IX:58; X:70.

[3] CV IV:97; V:98-99; VI:92; VIII:58; IX:58; X:70.

[4] CV X:70 ff.

palaeozoic series.[1]

In all of the editions, Chambers was concerned with the types of reptiles found in the muschelkalk, although the order of their description varied in the different editions. "Three out of Cuvier's four orders of reptilia (sauria, chelonia, and batrachia) are represented in this formation, the serpent order (ophidia) being alone wanting," concluded Chambers in the first three editions.[2] The presence of tortoises was merely mentioned in the first through fourth editions, but in the fifth through tenth editions Chambers explained that "footmarks attributed to tortoises" were common.[3]

The first reptiles to be discussed in the first three editions were the spectacular icthyosaurs and plesiosaurs; they were also described in all of the later editions, except the fourth, subsequently in this same chapter. Although the fourth edition contained a similar description, the discussion was found in the next chapter on the oolite.[4]

In the first three editions, Chambers briefly explained that the icthyosaur was a large animal, fit for living in the water although air-breathing, and with "the vertebral column and general bodily form of a fish, but to that were added the head and breast-bone of a lizard and the paddles of the whale tribes." Furthermore, he explained that it had a beak like a porpoise and teeth like a crocodile and

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[1] Sedgwick, Review of Vestiges, p. 52.

[2] CV I:99; III:101.

[3] CV IV:99; V:104; VI:96; VIII:60; IX:59-60; X:73.

[4] CV IV:109-110.

"must have been a most destructive creature to the fish of those early seas."[1]

The fifth edition described it as having "the paddles of the turtle," but in the sixth through tenth editions, Chambers returned to the "paddles of the whale" of the first three editions, adding that these paddles were "composed of a greater number of bones and thus. . . ." showed "an affinity to the fins of fishes."[2] A "huge voracious stomach," a skin resembling cetaceous animals, and a sternum "resembling that of the ornithorhynchus or duck-rat of Australia" added to Chambers' composite description of these animals in the later editions. Even more than the first three editions, the later forms stressed the predatory nature of these animals. A new bit of information was added to the fifth through tenth editions, for coprolites, or pellets voided from the icthyosaurus, had been discovered in which fragments of both fish and reptiles were found, "arguing that the animal must have been a destructive creature both to its own class and to that below it."[3] Although in the first and third editions some of this material on coprolites was included in a footnote in the chapter on the oolite, no mention was made of reptilian fragments in these pellets.[4]

The plesiosaur with "a long serpent-like neck, terminating in a saurian head," was described in all of the editions although the

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[1]CV I:97; III:99.

[2]CV V:105-106; VI:97-98; VIII:61; IX:61; X:73-75.

[3]CV V:105-106; VI:98-99; VIII:61; IX:60-61; X:73-75.

[4]CV V:110; III:111.

fourth edition account was in the succeeding chapter.[1] Comparing the plesiosaur to the icthyosaur in terms of predatory habits in the fifth through tenth editions, Chambers concluded that it was less predaceous than the icthyosaur. The head contains, added Chambers in the sixth through tenth editions, "the same superior arrangement of teeth seen in the thecodonts."[2]

Marine saurians such as the plesiosaur do have relatives in the modern world, related Chambers. Stating that although it had been previously thought that "no creatures approaching them (marine saurians) in character now inhabit the earth," Darwin's discovery in the Galapagos Islands of "a marine saurian from three to four feet long," negated this presumption.[3]

Even the first and third editions were not exactly alike in the description of other lizards of the muschelkalk. For example, the descriptions of the pterodactyl and the iguanodon were in more detail in the third than in the first edition.[4]

Labyrinthodon

The history of the taxonomy of the animal called labyrinthodon by Owen can be traced throughout Chambers' different editions. In the fourth through tenth editions, these animals were discussed before the description of the marine saurians, but in the earlier editions they were merely mentioned after the discussion of these large lizards.

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[1] CV I:98; III:100; IV:109-10; V:106-107; VI:99-100; VIII:61-62; IX:61-62; X:75-76.

[2] CV V:107; VI:99-100; VIII:62; IX:61; X:76.

[3] CV I:98; III:100; IV:110.

[4] CV I:98-99; III:100-101; IV:110-11.

In the first through third editions, Chambers stated that labyrinthodon was a member of the batrachian order; in the fourth edition he elaborated on the description of the earlier editions by describing these animals as "huge newts . . . walking about the muddy shores of the new forming land."[1]

Brewster alluded to Chambers' discussion of labyrinthodon, claiming that Owen stated that if these species existed today they would have formed the "batrachian representatives of the highest order of reptiles, --viz., the Crocodileans."[2] Therefore, the batrachian would have appeared first under its highest rather than its lowest or simplest structure. Brewster stated that "to use the language of the transmutation theory, the labyrinthodonts are degraded crocodiles, not elevated fishes!"[3] However, he regarded this as a moot question because the first form in which reptiles appeared in the rocks was not in the batrachian model but instead a monitor of the Thuringian Zechstein, older than the labyrinthodonts.[4]

The reviewer for Fraser's Magazine did not mention the earlier monitor-like forms, but stated that the first reptiles were "huge four-footed reptiles of the batrachian order" of the carboniferous not the fish-like ichthyosaurus as they should have been according to a transmutation doctrine.[5] This reviewer stressed the early appearance

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[1]CV I:99; III:101; IV:98-99.

[2]Brewster, Review of Vestiges, p. 492.

[3]Ibid.

[4]Ibid.

[5]Review of Vestiges, Fraser's Magazine, p. 366.

of labyrinthodon, mentioning that Lyell "during his second visit to America, satisfied himself that the strata in which the footsteps of the labyrinthodon, one of the large batrachians before mentioned, had been found were undoubtedly deep in the palaeozoic coal-measures of Pennsylvania. . . ."[1]

In the fifth edition, Chambers still classified labyrinthodon with the batrachia, but in the sixth through tenth editions a change was made. In these editions, he stated that "they were at first classed with the Batrachia--that order of reptiles to which the frog and toad belong; but they are now associated with the Saurians, though considered as only developed in that imperfect manner of which an example is presented by the Siren among the Batrachia."[2] The change in classification was evident, for in the fifth edition Chambers stated that "these batrachia, like the lacertilia, present affinities to the fish class," whereas, in the sixth through tenth editions it was stated that "these reptiles" show an affinity to the fish class.[3]

Rhynchosaurus as a Link between Reptiles and Birds

Another lizard, the rhynchosaurus was described in all of the editions but in different locations within the chapters. In the first through third editions it was described towards the conclusion of the chapter within a discussion of footprints as a diagnostic tool. Chambers described it in these editions as "uniting with the body of a

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[1] Ibid.

[2] CV V:102-103; VI:95-96; VIII:54; IX:54-55; X:63-64.

[3] CV V:103; VI:95-96; VIII:59-60; IX:59; X:71-72.

reptile the beak and feet of a bird," . . . a "link between these two classes."[1]

In all of the editions, he continued to suggest this linkage with the birds even though these fossils were found in some of the lower rocks of the formation. In the fourth edition, rhynchosaurus was mentioned along with nothosaurus after the discussion of labyrinthodon in the fifth edition, it was discussed after the description of the palaeosaurs, thecodonts, and monitors of the magnesian limestone; in the sixth through tenth editions the much more detailed discussion occurred after the presentation of the invertebrates of the muschelkalk.[2]

Salt Beds in the Upper Red Sandstone

Only in the first edition did Chambers mention the formation of salt beds in the upper red sandstone. A theory of how such beds of salt could be formed was described in this edition; however, in the later editions he elaborated on this idea in his theory of estuaries in the next chapter.[3]

Fossil Impressions

Although Chambers concluded this chapter in the first four editions with a discussion of fossil impressions, a similar discussion was found earlier in this chapter in the fifth edition, in the preceding chapter in the eighth through tenth editions, and in the

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[1] CV I:103; III:104; IV:99; V:102; VI:95; VIII:59; IX:59; X:70-71.

[2] CV I:103; III:104; IV:99; V:102; VI:95; VIII:59; IX:59; X:70-71.

[3] CV I:99-100.

succeeding chapter in the sixth edition. Whereas in the first through third editions Chambers intimated that the first footmarks were found in the new red sandstone, in the fourth through tenth editions he did not specify when such evidence first appeared. More detail about the footprints in the coal beds of Westmoreland County, Pennsylvania was included in the sixth through tenth editions. This information was unavailable earlier, for it was published in the April, 1845, American Journal of Arts and Sciences. In the fifth edition, Chambers acknowledged this discovery later in the text in a footnote.[1]

In all of the editions, the sixth through tenth in the previous chapter, Chambers considered a quarry at Corncockle Muir in Dumfriesshire where the footprints of a tortoise were preserved. The imprints of raindrops showing shower direction were also considered.[2]

The footprints of a web-footed animal "considered as a cogener of the crocodile, . . ." the cheirotherium, was described in the first through fourth editions. But Chambers went on to state in the first through third editions that Owen believed this to be "the same batrachian of which he has found fragments in the new red sandstone of Warwickshire." In the fourth edition, he indicated that this batrachian, cheirotherium, was now thought to be the same as labyrinthodon; the later editions assumed that it was labyrinthodon.[3]

Footprints of Birds

The reader's attention in all of the editions was called to

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[1]CV I:100-103; III:101-104; IV:99-103; V:99-101; VI:94-95; VIII:52-53; IX:52-53; X:63-64.

[2]CV I:101-102; III:103; IV:101; V:104; VI:96; VIII:60; X:72.

[3]CV I:102; III:103-104; IV:101-102.

evidence of the prints of birds in sandstone in Connecticut. These footprints, according to Chambers in the first through fourth editions, were produced by "birds of the order grallae, or waders;" the fifth through tenth editions added a new order of birds, the rasores or scrapers, to the find.[1]

Brewster stressed that the addition of birds to the fauna was evident from their footprints, but that Chambers "unscrupulously asserts that they were 'probably of a low type,' an opinion which their recent discovery in America, in the pre-existing formation, so completely refutes."[2] Chambers also had no doubts that these prints represented vestiges of birds, the only question remaining being that of dating, "for the phenomena of superposition only denote their being between the carboniferous and cretaceous formations, and an exact place is assigned them, merely upon the strength of the discovery that they present fish of a certain genera never found above the Triassic series."[3]

W. H. Allen in writing of the research of Dr. Hitchcock on the Connecticut Valley indicated the possibility that mammals might even eventually be found in this formation. He quoted Hitchcock's caution to geologists in "asserting the non-existence of land animals from the absence of their remains in a formation."[4] Even Chambers had to accept the possibility, for the tenth edition contained a footnote

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[1] CV I:103-104; III:104-105; IV:102-103; V:108-109; IX:62; X:76-77.

[2] Brewster, Review of Vestiges, p. 491.

[3] CV 108-109; IV:101; VIII:62; IX:62; X:76-77.

[4] W. H. Allen, Review of Vestiges, p. 308.

not found in the other editions considering two molars found "between the lias and keuper" which might represent mammal teeth.[1]

The Oolite

"An aggregation of small round grains or spherules" deriving its name, the oolite, from "its fancied resemblance to a cluster of eggs, or the roe of a fish," rests upon the trias. Only in specific parts of the world, notably in England, France, Westphalia, northern Italy, parts of northern India and Africa, with patches in Scotland and in the Mississippi Valley, is this system well-developed. "It may of course, . . ." conjectured Chambers, "be yet discovered in many other parts of the world;" in each edition, Chambers enumerated the strata comprising this formation.[2]

The Uniqueness of the Oolite

Although no evidence of a disturbance was found "between the close of the new red sandstone and the beginning of the oolite system," according to the first through fifth editions, or "between the close of the Trias and the beginning of the Lias and Oolite system," as recorded in the sixth through tenth editions, both the kinds of rocks and the botany and zoology varied from one formation to the next. The formations of the lias and oolite had many more traces of life than did those of the new red sandstone system.[3] Brewster found no

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[1] CV X:77.

[2] CV I:105-106; III:106-107; IV:104-105; V:110-11; VI:102-103; VIII:63-64; IX:63-64; X:78-79.

[3] CV I:106-107; III:107-108; IV:105-106; V:111-12; VI:103; VIII:64; IX:63-64; X:78-79.

evidence of a developmental sequence between the earlier and later formations, explaining that he would have expected to find in Chambers' account of organic life in the "secondary, tertiary, and superficial formations; . . . accumulated proofs of an ascending scale of creation, if it did exist, he seems incapable of finding even the pretence of an argument for it."[1]

Since geologists tended to view the oolitic species as unique, differing from both the preceding and succeeding formations, these fossils did not support a transformationist doctrine. Chambers, in the first four editions, subscribed to the view of the uniqueness of these fossils but in the fifth edition noted the incongruity of this position and modified his statement. In this edition he stated that although geologists generally considered the oolitic species as unique, "there are in reality no certain marks establishing distinction of species, and here, as in similar cases, we are only to understand that the animals display certain external peculiarities."[2] Brewster had seized upon Chambers' statement in the earlier editions to demonstrate a lack of internal consistency in his thoughts, asking "where then is the link in the chain of transmutation, and how could the new species of the following age have come into existence?"[3]

The Vegetation of the Oolite

Cycads were important forms of land vegetation in the oolite as were "equisetaceae, lilia, and conifers;" although ferns were present

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[1]Brewster, Review of Vestiges, p. 492.

[2]CV I:107; III:108; IV:106; V:112.

[3]Brewster, Review of Vestiges, pp. 492-93.

they were less common than in the former era.[1] The universality of the oolitic fossils suggested to Chambers a uniform climate throughout the globe. In the first four editions, he stated that there must have been a universal climate "between the tropical and temperate," but in the fifth through tenth editions he did not explicitly mention this universal climate.[2] The vegetation had been luxuriant enough in some places to produce thin seams of coal, noted Chambers, mentioning in all of the editions the presence of coal in Yorkshire and Sutherland; in the tenth edition he added another locality--Virginia.[3] Although algae were found in the oolitic oceans, few of the species are extant today.[4]

Invertebrates of the Oolite

Corals were so abundant in the oolitic seas that in certain places they constituted entire strata. Although in the first through fifth editions, Chambers noted the abundance of both crinoids and encrinites, in the sixth through tenth editions he only mentioned the numerous crinoids, stating that they showed "an advance of organization from those of the preceding system."[5] Descriptions of specific crinoids,

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[1]CV I:108; III:109; IV:107; V:113; VI:104; VIII:64; IX:64; X:79.

[2]CV I:108; III:109; IV:107; V:113; VI:103-104; VIII:64; IX:64; X:79.

[3]CV I:108; III:109; IV:107; V:113; VI:104; VIII:64; IX:64; X:79.

[4]CV I:108; III:109; IV:107; V:113; VI:104; VIII:64; IX:64; X:79.

[5]CV I:108; III:109; IV:107; V:113-14; VI:104-105; VIII:64; IX:64-65; X:80.

pentacrinite, comatula, ophiura, echinus, and goniaster were included in the later editions with the tenth edition presenting diagrams of many.[1]

Although the oolitic mollusks were discussed in each edition, the presentation in the sixth through tenth was more detailed than that of the earlier editions; the tenth edition contained diagrams. Chambers stated in the first five editions that the mollusk, belemnite, commenced in the oolite and terminated in the next formation. This time reference was omitted from the later editions although the description of the animal was included. However, a part of the characterization, that it "could raise or depress itself in the water at pleasure by a pneumatic operation upon the air tube pervading its shell," was omitted from the tenth edition.[2]

The statement of the first five editions that the number of crustaceans decreased in the oolite was deleted from the sixth and subsequent editions.[3] Two specific crustaceans, limulus, the king crab, and eryon, a decapod crustacean, were described in the sixth through tenth editions but not in the first five. The appearance of limulus at this time was significant, asserted Chambers, because it represented "the genus of our time to which the trilobite make the nearest approach. . . ."[4] In the tenth edition he presented additional evidence of the relationship of limulus to the trilobite,

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[1]CV VI:105; VIII:65; IX:64-65; X:79-81.

[2]CV I:108-109; III:109-10; IV:108-109; V:114; VI:106-107; VIII:65-66; IX:65; X:82-83.

[3]CV I:109; III:110; IV:108; V:114.

[4]CV VI:105-106; VIII:65; IX:65; X:81.

finding it "remarkable as in its embryotic state . . ." it bears "a resemblance to the trilobite."[1] Quoting Murchison that this represented "one of those beautiful links in natural history of which the strata forming the earth's crust have afforded so many proofs," Chambers regarded this as a replacement of forms and as evidence for transmutation.[2]

Cartilaginous Fish of the Oolite

After the discussion of the oolitic crustaceans and mollusks, Chambers alluded to the cartilaginous fish of this formation. He stressed that the pycnodonts and lepidoids were especially prevalent.[3]

Oolitic Reptiles

For unknown reasons, Chambers included material discussed in the previous chapter in the other editions in the chapter on the oolite in the fourth edition. Although in the first through third editions he had described the ichthyosaur, "plesiosaurus, and other huge saurian carnivora of the preceding age" in detail in the previous chapter, they were again mentioned as being found in the oolite; however, in the fourth edition he described them for the first time in this chapter, with an almost identical description to that presented in the discussion in the first through third editions in the previous chapter.[4]

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[1] CV X:81.

[2] CV VI:106; VIII:65; X:81-82.

[3] CV I:109-10; III:110-11; IV:108-109; V:114-15; VI:107; VIII:66; IX:66; X:83.

[4] CV IV:109-10.

Another important oolitic reptile discussed in all of the editions was the land dwelling pliosaurus, described in the first and third editions as seeming to form "a link between the plesiosaurus and the crocodile."[1] Although in the fourth edition Chambers characterized it as being as large as "the largest of existing whales," he did not mention the crocodilian relationship.[2] However, in the fifth through tenth editions he incorporated the ideas found in all of the earlier editions, describing it as an enaliosaur "in which there is a very close approach made to the crocodilian order, but upon a scale of enormous magnitude, the animal having apparently been as large as the existing whales.[3]

Although in the first three editions, Chambers had discussed the pterodactyl in the preceding chapter, it was mentioned again in these editions as being present in the oolite. In the fourth edition he had not previously discussed it, but in this chapter described it in much the same way as he had previously in the first three editions, characterizing it as "a lizard about the size of a snipe, provided with bat-like wings extended on the forefinger, wherewith to pursue its prey in the air."[4] In the fifth through the ninth edition he described them as "being not larger than a modern cormorant," but in the tenth edition he did not attempt a size comparison.[5] Although

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[1]CV I:110; III:111.

[2]CV IV:110.

[3]CV V:116; VI:108; VIII:67; IX:66; X:84.

[4]CV IV:110-11.

[5]CV V:115-16; VI:107-108; VIII:66-67; IX:66; X:83-84.

in the fifth and sixth editions he stated that "this order became extinct in the cretaceous," he revised this view in the eighth through tenth editions, stating that it was the genus which became extinct then.[1]

The Appearance of Insects

Even though in the fifth through tenth editions Chambers had previously discussed insects as first appearing in the carboniferous, in the earlier editions he did not recognize their occurrence until the oolite. While admitting that insects were not well suited for preservation, he stated, in the first and third editions, that they appeared for the first time in the oolite. But by the publication of the fourth edition, he was inclined to push back their origin to an earlier date, adding in a footnote that "it is extremely likely that insects lived before the reptilia, some families of which require them for food, and in point of fact, remains of this great class are now said to be found in the carboniferous rocks."[2] The presence of insects in the oolite was ignored in the fifth edition, but in the first four editions, "dragonfly-like insects" of the oolite were mentioned in connection with their proximity to pterodactyl remains "to which undoubtedly they served as prey."[3]

The First Mammals

The oolite provided a most exciting addition to the fossil

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[1] CV V:115; VI:108; VIII:67; IX:66; X:84.

[2] CV I:111; III:111-12; IV:111.

[3] CV I:111; III:112; IV:111.

fauna, the remains of the first mammals. Chambers described, in all of the editions, what he considered to be the first mammalian fossil, a jaw bone believed "to have belonged to the marsupial family," found in the Stonesfield slate.[1]

According to Brewster, the classification of this specimen had been the subject of much controversy. The more recent opinions, he related, consider this fossil to be an insectivore rather than a marsupial. Its actual position in the scheme of classification is irrelevant, for any species "which has been the subject of so much controversy, overturns the supposition of its having been derived from any pre-existing species."[2]

Chambers was willing to allow for the existence of mammals before the oolite, but, he indicated in all of the editions, it was most improbable.[3] "Mammalian teeth recently brought forward as having been found in a bone breccia at Würtemburg, between the lias and keuper," were mentioned in the tenth edition as possible earlier mammals, but since this was dubious information Chambers proposed to overlook it in his discussion.[4] Additional complications would be avoided if he was not forced to fit early mammals into a developmental sequence.

Another mammalian fossil from the oolite was mentioned by

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[1]CV I:111; III:112; IV:111-12; V:116-17; VI:109-10; VIII:67; IX:67; X:85.

[2]Brewster, Review of Vestiges, p. 493.

[3]CV I:111-12; III:112-13; IV:112; V:117; VI:109; VIII;67; IX:67; X:85.

[4]CV X:85.

Chambers in a footnote in all of the editions except the first--the remains of a cetacean which, because of its aquatic habits, Chambers regarded as probably as primitive as the marsupial.[1] However, the reviewer for Fraser's Magazine disagreed, indicating that there was no evidence that marine mammals preceded terrestrial forms even though Chambers would have it so.[2]

In the first four editions, Chambers explicitly stated that marsupials represented links between oviparous vertebrates and higher mammals.[3] But, indicated the reviewer for Fraser's Magazine, there is the most palpable absurdity in tracing the lineage of the small marsupial mammals of the Oxfordshire oolite from the gigantic mammal-like reptiles of the same epoch; or in connecting these last with the extinct mammalian quadrupeds of the Paris Basin. . . ."[4]

Rudimentary organs, Chambers contended in the first four editions, supported his supposition that marsupials possessed a reptilian ancestor; these organs in marsupials were comparable to fully developed reptilian structures. Rudimentary organs are, he concluded, "most conspicuous in families approaching in character to those classes to which the full organs are proper." The evidence from rudimentary organs was not included in the later editions. To establish the primitive nature of the marsupial, in these editions he

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[1]CV III:112; IV:112-13; V:117; VI:496; VIII:302; IX:300; X:85.

[2]Review of Vestiges, Fraser's Magazine, pp. 368-69.

[3]CV I:112; III:113; IV:112; V:117; VI:109-10; VIII:67-68; IX:67; X:85.

[4]Review of Vestiges, Fraser's Magazine, pp. 368-69.

[5]CV I:112; III:113; IV:113.

used the additional evidence of their primitive brain and mode of gestation.[1]

The "Dirt-Bed" and the "Wealden"

The next division of the rock series, "called by workmen the dirt-bed," was discussed in all of the editions. In this formation, Chambers explained, silicified tree trunks were found "imbedded on the surface of the soil in which they grew."[2] Above this "dirt-bed" lies the wealden, so named because of the extensive development of these beds in the Weald of Sussex. According to Chambers, these beds "incontestably argue that the dry land forming the dirt-bed had next afterwards become the area of brackish estuaries, or lakes partially connected with the sea; for the Wealden strata contain exuviae of fresh-water tribes, besides those of the great saurians and chelonia."[3] Chambers believed that the wealden deposit represented a local rather than a general condition, but he concluded in all editions that there may have been in that age "a series of river-receiving estuaries along the border of some great ocean as the Atlantic, of which that of modern Sussex is only an example."[4]

Chambers discussed the reptiles found in the wealden in the fifth through the tenth editions; the tenth edition includes diagrams.

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[1] CV V:117; VI:109-10; VIII:67-68; IX:67; X:85.

[2] CV I:112-13; III:114; IV:113-14; V:117-18; VI:110; VIII:68; IX:67-68; X:85-86.

[3] CV I:113-14; III:114-15; IV:114; V:118-19; VI:110-11; VIII:68-69; IX:68; X:86-87.

[4] CV I:115; III:116; IV:114-16; V:120; VI:112; VIII:68-69; IX:69; X:86-87.

The group described by Owen as dinosauria and discussed in the later editions with special emphasis on megalosaurus and iguanodon. In the fifth through ninth editions, Chambers suspected that an error in classification had been made in the case of iguanodon, since it was as large as megalosaurus and yet alleged to be herbivorous. By the tenth edition, however, he had accepted the classification and added that Dr. Mantell had shown it to possess "a tongue of prehensile character, like certain ruminant mammalia of our day."[1] The relationship of the dinosaurs to the mammals was discussed in the fifth edition. From the scapula of a dinosaur, hyloeosaurus, the "approximation of the whole of the dinosaurs to the mammalian type of structure . . ." could be observed.[2]

Only in the fifth edition did Chambers include a section on the bird fossils of the wealden in this chapter, although all of the other editions mentioned their presence in the next chapter. The first fossil birds occurred in this formation, noted Chambers in this edition.[3]

Chambers concluded this chapter in the sixth through tenth editions with a poetic description of "the world of the Oolitic Era." He wrote that

> day after day, through long drawn ages, the sun passed on his course. Night after night, the sparkling garniture of the sky looked down on this green world. But a being of superhuman intelligence, coming to examine our globe, would have seen all this existing only for fishes and still humbler creatures in the sea, and for reptiles, insects, and perhaps

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[1] CV V:121; VI:113-14; VIII:69-70; IX:69-70; X:87-88.

[2] CV V:121; VI:114; VIII:70; IX:70; X:88.

[3] CV V:112.

> a few birds, and still fewer opossums, upon land. . . . And not only were not human beings to be seen, but our supernatural visitant would know that this scene must lie spread out in perfect capability for their reception during whole milleniums, before such beings were to exist, the stream flowing and glittering in the sun, but not to cheer the eye of man; the whole jocund earth spread out in unenjoyed beauty, as yet unwitting of the glory and the gloom which human impulses were to bring upon it.[1]

Although he was convinced that the earth could have supported human life at this time, it did not, supposed Chambers, because "the Age of Reptiles, as it has been called, is interposed between an age of fishes and an age of Mammals, reptiles being also intermediate to these in the animal scale, we cannot but surmise that the fact depends on some organic law, rather than upon one in physical geography."[2] The change of emphasis from the earlier editions which stressed the physical environmental causes for change is apparent in this statement.

The Cretaceous Formation

Although Chambers' discussion of the cretaceous formation was quite uniform throughout all of the editions, his evidence, claimed Brewster, was insufficient to support a theory of development. "Though the fossil remains which it (cretaceous system) embodies are extremely numerous," he contended that not a single species existed which was found in the palaeozoic system, "and where a resemblance occurs between the fossils of these systems, no links connecting them are to be found."[3]

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[1] CV VI:114-15; VIII:70-71; IX:70-71; X:87.

[2] CV VI:116-17; VIII:71-72; IX:71; X:89-90.

[3] Brewster, Review of Vestiges, p. 493.

Characterization of the Cretaceous

The cretaceous, explained Chambers, represents a marine deposit which usually lies conformably on the oolite and characteristically contains chalk beds. Although the geographical areas in which this formation is prominent are relatively few, he indicated that it is probably more widespread than had been ascertained by geological research. Certain of the organic remains in the area of the marine cretaceous deposits "prove that, in the neighbourhood of those seas, there were tracts of dry land."[1]

Although there were local variations in this formation, Chambers explained that the usual beds are the "shankland or greensand, . . . Galt, . . . Hard chalk, . . ." and "Chalk with flints. . . ." In England, although the lower beds may be absent, the chalk beds are always present, whereas in the Mississippi Valley, "the true chalk is wholly, or all but wholly absent."[2]

Hypotheses for the Formation of Chalk

Several possibilities existed, suggested Chambers, for the formation of chalk. It had been observed that the detritus of coral reefs in the present tropical seas formed a powder which, when dried, could not be distinguished from chalk; "it then appeared likely that the chalk beds were the detritus of the corals which were in the oceans of that era."[3]

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[1] CV I:116-17; III:117-18; IV:117-18; V:123-24; VI:118-19; VIII:73; IX:72; X:90-91.

[2] CV I:117; III:118; IV:118; V:124; VI:119; VIII:73-74; IX:72; X:91.

[3] CV I:117-18; III:118-19; IV:118-19; V:124-25; VI:119-20; VIII:74; IX:72-73; X:91.

A second alternative, Chambers indicated, was suggested by Darwin, "that the matter might have intermediately passed through the bodies of worms and fish, such as feed on the corals of the present day, and in whose stomachs he has found impure chalk."[1] But his favorite possibility was one proposed by a Professor Ehrenberg who, by microscopic investigation, discovered both microscopic organisms and inorganic particles in the chalk and concluded that it was composed of both of these components. In the north of Europe, he noted, the inorganic matter prevailed, while in the south the organic material was more common. Chambers stated in the first editions that Ehrenberg was able to classify many of the organisms of the chalk as being allied to "nautili, nummuli, cyprides, & c," but this statement was omitted from the tenth edition.[2]

The uppermost chalk beds in England contain flint nodules. Although geologists conceded that these nodules were formed by aggregations of particles of silica, this still did not explain the origin of the silica. Chambers approved of Ehrenberg's suggestion that the nodules were composed "of the siliceous coverings of a portion of the microscopic creatures, whose shells he has in other instances detected in their original condition."[3] Since the chalk with flint was common in the north and the chalk without the flint in the south, corresponding to presence or absence of recognizable organisms, Chambers concluded that

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[1] CV I:118; III:119; IV:119; V:125; VI:120; VIII:74; IX:73; X:91.

[2] CV I:118-19; III:119-20; IV:119-20; V:125-26; VI:120; VIII:74; IX:73; X:91-92.

[3] CV I:119; III:120; IV:120; V:126; VI:121; VIII:75; IX:73-74; X:93.

it seemed "but natural, that in the one case the siliceous exuviae have been left in their original form; in the other dissolved chemically and aggregated on the common principle of chemical affinity in nodules of flint. . . ."[1]

The Microorganisms of the Chalk

Since the microorganisms of the chalk represent species which have existed from the cretaceous into the present apparently unchanged, Chambers found them especially interesting. This retention of the same specific form throughout such a long period of time was unusual, he noted, since the higher invertebrates and the vertebrates "have been changed again and again, since the cretaceous era. . . ."[2]

The unchanging specific nature of these forms required an explanation for the developmentalist. In the first through fourth editions, Chambers ascribed this static quality to their "very humility" which made them more adaptable to various conditions than higher forms. But he was evidently not quite satisfied with this explanation even in these editions, for he asked if there was a requirement "to look for some other explanation of the phenomenon? . . ."[3] In the fifth and subsequent editions, Chambers postulated that the reason for these organisms' unchanging nature was the "uniformity in the conditions under which they have lived, while all other animals have been exposed to circumstances productive of

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[1] CV I:119-20; III:120-21; IV:120-21; V:126-27; VI:121; VIII:75; IX:74; X:93.

[2] CV I:119-20; III:120-21 IV:120-21; V:126-27; VI:121; VIII:75; IX:74; X:93.

[3] CV I:120-21; III:121-22; IV:121-22.

change."[1]

Fish and Reptiles of the Cretaceous

In discussing other cretaceous organisms, Chambers made a typographical error in the first edition, stating that in Europe remains of marine saurians had been found. However, in the third through fifth editions this had been changed to "no remains."[2]

The place of these saurians as destructive marine marine organisms had perhaps been taken by "cartilaginous fishes, of which the teeth are found in great quantities," suggested Chambers in the first through fourth editions. But in the fifth edition he did not mention this replacement by cartilaginous fish, perhaps because this would indicate a reverse phylogenetic trend. Although Chambers in the sixth through tenth editions did not discuss the marine saurians at this point, he mentioned them briefly later in the chapter.[3] Whereas in the first through fifth editions Chambers referred to remains of plesiosaurus from the American cretaceous, this reference was omitted from the sixth through tenth editions.[4]

Chambers noted in the third through tenth editions that two new orders of fish were added to the previously existing ganoids and placoids. Only in these editions did he describe the scales of the new forms, called cycloid and ctenoid by Agassiz, "who, as has been remarked, asserts that the outer covering of fishes is a sufficient

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[1]CV V:127-28; VI:122; VIII:75-76; IX:74; X:93-94.

[2]CV I:121; III:122; IV:122; V:128.

[3]CV I:121; III:122; IV:122; V:128; VI:123; VIII:76; IX:75; X:74.

[4]CV I:121; III:122; IV:122; V:128.

indication of their whole structure."[1]

Where, queried Brewster, did all of these new species come from? The fossil record presents no evidence for a developmental approach. Chambers' assertion that the two new orders of cycloid and ctenoid fish had a superior organization was absurd, he continued, for the placoids "to which the first fossil fish belonged, is of a higher order of organization than the Cycloids and Ctenoids, and several Ctenoids have, as has been previously stated, been brought by Mr. Murchison from the old red sandstone of Russia."[2]

Cretaceous Plants

Fuci were common and confervae were found in flints, but terrestrial vegetation, consisting of some ferns, conifers, and cycads, was scarce, concluded Chambers in all of the editions. Pieces of wood drilled by the teredo are found in the cretaceous formation all over the world, he noted.[3]

Cretaceous Bird Fossils

Instead of discussing Mantell's discovery of the bones of birds in the wealden in the previous chapter as he had in the fifth through tenth editions, Chambers described these bones in the chapter on the cretaceous in the first four editions. In these editions he also mentioned the earlier footprints in the new red sandstone and the subsequent bird fossils in the cretaceous. Brewster referred to

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[1] CV III:122; VI:122; V:128; VI:123; VIII:76; IX:74-75; X:94.

[2] Brewster, Review of Vestiges, p. 483.

[3] CV I:121-22; III:123; IV:123; V:129; VI:124; VIII:76; IX:75; X:95.

Chambers' report of the bird remains in the cretaceous at Maidstone by stating that Chambers was "sensible that this alleged occurrence is not consistent with his theory, that birds must precede mammalia, and he gets out of the difficulty by saying that they may nevertheless have lived, though no remains are found in a particular formation."[1]

Chambers concluded this chapter in the first four editions with another discussion of the vagaries of fossil preservation with particular reference to the birds. It is difficult to understand why the appearance of birds at Maidstone in the cretaceous should have impressed Brewster as being particularly opposed to the Developmental Hypothesis. For even though mammals preceded these birds, so had other birds. And Chambers had discussed these earlier fossils in the same paragraph. Although there is scant evidence for the early birds, Chambers indicated that it is possible to deduce their presence even when they are not to be seen in the fossil record. "The birds are below the mammalia in the animal scale; and therefore, they may be supposed to have existed about the time of the new red sandstone and oolite, although we find but slight traces of them in those formations, and, it may be said, till a considerably later period," he postulated. The cretaceous birds were mentioned in the sixth through tenth editions, but the speculation was omitted.[2]

The Tertiary Formation

According to Chambers, the tertiary formation was limited in

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[1]Brewster, Review of Vestiges, p. 493.

[2]CV I:122-24; III:124-25; IV:124-25; V:130; VI:124; VIII:77; IX:75; X:95.

extent, but found in basins of cretaceous beds in various parts of the world. He enumerated the geographic locations of these beds in each edition; in addition, in the first edition only he mentioned a "fragment of the formation in one of the Hebrides."[1]

The Uniqueness of the Tertiary

Each edition stressed the importance of the tertiary formation even though it represented relatively localized phenomena. In the first four editions, Chambers asserted that "as in other formations, it is marked, in the most distant localities, by identity of organic remains."[2] Sedgwick characterized this era as containing very little left over from the secondary system, in fact, "it might seem as if we had been transported to a new planet." He asserted that "as we ascend towards the middle divisions of the series, there is a development of nature's kingdom nearer and nearer to living types," but not according to the developmental scheme outlined by Vestiges.[3]

The hollows filled by the tertiary rocks were beds of estuaries which were left at the close of the cretaceous, reported Chambers. According to the progressions and regressions of the sea, these hollows were alternately estuaries or open water areas. The Paris basin represented this alternation, with the lower rocks consisting of a fresh-water formation of limestone beds, followed by a marine limestone formation, then a second fresh-water formation,

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[1]CV I:125; III:126; IV:126; V:131; VI:125; VIII:78; IX:76; X:95-96.

[2]CV I:125-26; III:126-27; IV:126-27; V:131; VI:125-26; VIII:78; IX:76; X:96.

[3]Sedgwick, Review of Vestiges, p. 53, 60.

followed by a second marine formation of sandy and limey beds, and finally another series of fresh-water strata.[1]

Although he agreed with Sedgwick that the tertiary marked the arrival of a new set of animals on the earth, writing in the sixth through tenth editions that the end of the secondary formation presented "in some respects a remarkable resemblance to the close of what is called the Palaeozoic period in the Permian strata," Chambers modified Sedgwick's conclusions.[2] Even though, he explained, it appeared that all of the forms of the tertiary differed specifically from the secondary forms this was not actually the case. A few of the specific forms did pass into the higher strata and, very importantly, "there is in the higher formation, an apparent following of an order applicable to the whole palaeontological history, as something under one law, seeing that birds and mammalia, the next classes in the vertebrate scale, are then added."[3] To support his position, Chambers quoted Sir Roderick Murchison as contending "that a true geological passage may be found between the two formations. . . ."[4]

Chambers explained the apparent rejuvenation of life in these strata by concluding that "the final cretaceous beds were deposited in seas more than usually deep, and which were therefore no proper habitat for the animals previously existing; that an interval of time

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[1]CV I:126; III:127; IV:127; V:132; VI:126; VIII:78-79; IX:76; X:96.

[2]CV I:126-27; III:127-28; VI:127-28; V:132-33; VI:126-27; VIII:79; IX:76-77; X:96.

[3]CV VI:127; VIII:79; IX:77; X:96-97.

[4]CV VI:127-28; VIII:79; IX:77; X:97.

afterwards took place, which is not represented by any strata which have been discovered; and that, by the time the tertiary formation commenced, the usual modifying influences having never ceased, the fauna had undergone such an amount of change as naturalists are accustomed to described (their language being wholly arbitrary) as a renewal of species."[1]

In the early editions Chambers did not detail the extent of the changes from the secondary to tertiary rocks or their causes as he did in the later editions. Although in the first through fifth editions he did not mention species carried over from the secondary to the tertiary, in the fifth he indicated that the reason the tertiary species appeared to be new was that "a considerable time had elapsed, during which the usual progressive change of animals had been going on, but, from geognostic causes, without the usual record having been kept."[2] But in all of the editions he concluded that with the tertiary, "we had now reached the dawn of the present state of the zoology of our planet."[3]

Lyell's division of the tertiary into the eocene, miocene, older pliocene, and newer pliocene, by using the shells as indicators of the proportions that they present of surviving species was considered in all of the editions. However, in the later editions, Chambers indicated that this division was "to be regarded as not

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[1] CV VI:128; VIII:79-80; IX:77; X:97.

[2] CV V:132-33.

[3] CV I:126-27; III:127-28; IV:127-28; V:133; VI:128; VIII:80; IX:77-78; X:97.

safely applicable to the Tertiaries generally, except as a convenient means of indicating various portions of the series."[1]

Mammals of the Eocene

The mammals of the eocene, fifty species according to Cuvier all of which are now extinct, were described in every edition. The pattern Chambers followed in discussing these mammals differed in the first through fourth editions and in the fifth through tenth; however, the general topics discussed were similar in the two edition types.

"Thick-skinned animals to which our modern elephant, rhinoceros, horse, and pig belong," the pachyderms, were very abundant in these rocks.[2] Most of the modern species of pachyderms are members of the tapir family, now confined to South America and Sumatra, observed Chambers. It was "curious, . . ." he stated, "to find that a family now so limited in its range, had formerly been distributed over France, England, and other parts of the earth."[3] Although in every edition, Chambers mentioned the following genera of tapirs: palaeotherium, anthracotherium, anoplotherium, and lophiodon, in the fifth through tenth editions he added an additional genus, coryphodon, to the collection. One of these ancient tapirs, palaeotherium, was characterized in the first through fourth editions and another, the anoplotherium, in the fifth through tenth editions.[4]

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[1]CV I:127; III:128; IV:128; V:133; VI:128-29; VIII:80; IX:78; X:97.

[2]CV I:127; III:128; IV:128; V:133-34; VI:129; VIII:80; IX:78; X:97-98.

[3]CV V:134; VI:129-30; VIII:80-81; IX:78-79; X:98.

[4]CV I:128; III:129; IV:129; V:134; VI:130; VIII:81; IX:79; X:98-99.

Certain eocene forms were not described in the earlier editions but were included in the fifth through tenth editions, such as the hog-like choeropotamus and zeuglodon, an herbivorous whale.[1]

Mammals of the Miocene

In every edition, Chambers explained that in the miocene, pachyderms were still predominant with tapiroid animals still especially conspicuous. Dinotherium was an animal characteristic of the miocene described in each edition; a diagram of its skull was included in the tenth edition. Buckland, noted Chambers, considered dinotherium as well as other miocene animals as adapted for a semi-aquatic existence in a place where lakes were common. Felids and marine mammals were new mammalian forms first appearing in the miocene, he observed.[2]

Mammals of the Pliocene

In discussing the older and newer pliocene periods, Chambers explained that as the older groups became extinct, the newer replacements tended to resemble existing groups of animals; for example, when the miocene pachyderms disappeared they were replaced by organisms belonging to families, though not species, which are still extant, such as the rhinoceros, hippopotamus, and elephant. In the first four editions he stressed that these pliocene pachyderms were "startling, because of their enormous magnitude."[3]

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[1] CV I:128; III:129; IV:129; V:135; VI:131-32; VIII:81; IX:79; X:99.

[2] CV I:128-29; III:129-30; IV:129-30; V:135-36; VI:131-32; VIII: 81-82; IX:79-80; X:99-100.

[3] CV I:129-30; III:130-31; IV:130-31; V:136-37; VI:132-33; VIII:82; IX:80; X:100.

Conspicuous examples of the gigantic pachyderms of the pliocene were the mastodon and mammoth. An emphasis was noted in the fifth through tenth editions not observed in the earlier presentation--a consideration of the mastodon and mammoth as a single species--as forms which succeeded each other in time. The reasons for considering them specifically different were minor--based on insignificant peculiarities in their dentition, noted Chambers. In the tenth edition, he included an illustration comparing a molar of a mastodon to one of a mammoth. Whereas Chambers suggested in the fifth through ninth editions that the consideration of these two forms as different species was a "purely arbitrary distinction," this statement was deleted from the tenth edition, with this omission suggesting a change in opinion. He stressed the extensive range of both mastodon and mammoth--a range which far exceeded that of comparable contemporary forms. In order to illustrate the comparative recentness of the mammoth, Chambers cited, in all of the editions, the example of an entire frozen specimen of this new form found in Siberia in 1801.[1]

More examples of faunal additions in the pliocene were included in the later editions than in the first four. Two sloth-like animals, megatherium and megalonyx, were described. The characterization of these forms was brief in the first editions; in the fifth through tenth, he characterized the group as a whole, adding two more forms, scelidotherium and mylodon, to those mentioned in the earlier editions.

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[1]CV I:130; III:131; IV:130-31; V:137; VI:132-33; VIII:82-83; IX:80; X:100-101.

He included a diagram of the skeleton of mylodon in the tenth edition.[1]

According to the first four editions, ruminants, "oxen, deer, camels, and other specimens; appeared for the first time in the pliocene fauna. Their presence, although mentioned in the later editions, was included within a discussion of other new additions to this fauna, many of which differed from existing forms only in the matter of dentition. Sivatherium, a specific ruminant, was described in these editions.[2]

New fossil finds modified Chambers' impression of the tertiary fauna. His presentation was, he claimed in the first four editions, "as ascertained by the illustrious naturalists who first devoted their attention to it." However, he admitted in the fourth edition that their efforts had not been entirely successful since new forms such as a "serpent" had recently been discovered.[3]

In the first four editions Chambers was especially concerned with the sparse examples of the quadrumana in the tertiary formations. Since a few specimens had been unearthed from the tertiaries, he concluded in the first and third editions that the group might have originated in this formation, for "it sometimes happens, however, as we have seen, that a few rare traces of a particular class of animals are in time found in formations originally thought to be destitute of them, displaying as it were a dawn of that department of creation."[4]

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[1]CV I:130; III:131; IV:131; V:130; VI:135; VIII:83-84; IX:80-81; X:100-103.

[2]CV I:130; III:131; IV:131; V:138-39; VI:133-35; VIII:83; IX:81; X:102.

[3]CV I:131; III:132; IV:131-32.

[4]CV I:131; III:132.

In the later editions, Chambers did not include the long discussion about the appearance of the quadrumana found in the earlier editions, but mentioned the presence of fossil monkeys in the general discussion of new pliocene forms.[1]

The prevalence of volcanic action during the tertiary resulted in the elevation of much of the land. This activity served a purpose, Chambers concluded, for "the general effect of these operations was of course to extend the land surface, and to increase the variety of its features, thus improving the capability of natural drainage, and generally adapting the earth for the reception of higher classes of animals."[2]

Superficial Formations

The era of the superficial formations constituted the last period of geological time before the appearance of man. It was characterized by two phenomena, denudation and diluvium. Although Chambers did not mention denudation in the first edition, in the other editions he described it as consisting of "great hitches and slips. . ." detected in the superficial strata "such as, if left in their original state must have caused considerable inequalities on the face of the country; yet all is found as smooth--the joinings are all as much reduced to a common level--as if some gigantic artificial force had been used for the purpose."[3] "The operation of moving

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[1] CV I:132; III:133; IV:132-33; V:139; IV:134-35; VIII:83; IX:81; X:102-103.

[2] CV I:133; III:134; IV:133-35; V:139-40; VI:135-36; VIII:84; IX:81-82; X:103-104.

[3] CV I:134; III:135-36; IV:135-36; V:141-42; VI:137-38; VIII:85; IX:82-83; X:104-105.

water," related Chambers, would explain this phenomenon.[1]

The second characteristic phenomenon of this era, the diluvium, was discussed in all of the editions. Although he described the appearances resulting from a widespread flood in all of the editions, he registered an awareness by the eighth edition that the universal application of the diluvium had been called into serious question. Whereas in the early editions these appearances were explained as the process "to which geologists give the name diluvium," in the eighth through tenth editions the statement was qualified by explaining that this phenomenon was one "to which geologists give, or till lately gave, the name of Diluvium."[2]

The phenomena of denudation and of the diluvium were often connected with the appearance of groovings and scratchings on the rock surfaces of hills "such as we might suppose would be produced by a quantity of loose blocks hurried along over them by a flood."[3] Although in the first through eighth editions, Chambers mentioned only the flood as a cause of these scarrings, in the ninth and tenth editions he mentioned that "large rafts of ice" carried by the flood might be responsible.[4]

Another phenomenon associated with the diluvium was that called "crag and tail," consisting of a sharp rocky hill on one side and a

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[1] CV III:135-36; IV:136; V:142; VI:138; VIII:85; IX:83; X:105.

[2] CV I:134-35; III:136-37; IV:136; V:142; VI:138; VIII:86; IX:83; X:105.

[3] CV I:135; III:136-37; IV:136-37; V:142-43; VI:138-39; VIII:86; IX:83; X:105.

[4] CV I:135; III:137; IV:137; V:143; VI:139; VIII:86; IX:83; X:105-106.

gentle slope on the other. The castles of Windsor, Edinburgh, and Stirling were sites of this phenomenon, explained Chambers in the first through sixth editions; no mention was made in the eighth through tenth editions of these sites.[1]

The appearance of long ridges of clay and gravel over certain parts of the world also suggested a widespread flood. Chambers asserted in all of the editions that these appearances, "lines of the grooved rock surfaces, the direction of the crag and tail eminences, and that of the clay and gravel ridges . . . are all from the north and northwest towards the southeast." Therefore he concluded that these phenomena were caused by a powerful current moving from northwest to southeast and carrying with it rocks and other abrasive materials. In the ninth and tenth editions he added that this powerful current was a "commixture of water and ice."[2]

Chambers postulated a cause for such a current in all of the editions. In the first through fourth editions, he proposed that the circumpolar ice had extended into the temperate zones, thawed, and released a large flood "and the southward flow of this deluge, joined to the direction which it would obtain from the rotatory motion of the globe, would of course produce that compound or south-easterly direction which the phenomena require."[3] But even in these editions, he admitted his own doubts as to the validity of this hypothesis.[4]

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[1]CV III:137; IV:137; V:143; VI:139; VIII:86; IX:83; X:105.

[2]CV I:135-36; III:137-38; IV:137-38; V:143-44; VI:139-40; VIII:86-87; IX:83-84; X:105-106.

[3]CV I:136-37; III:138-39; IV:138-39.

[4]CV I:137; III:139; IV:139.

The only valid conclusion from the evidence, he suggested, was that much of the northern part of Europe was under water and that a strong current passed over and, according to the fifth through tenth editions, produced "certain mechanical results." He used the word "Drift" in the tenth edition rather than "Diluvium."[1]

Formation of Ossiferous Caverns

Ossiferous caverns associated with the "diluvium" or "drift" were discussed in all of the editions. The formation of these caverns was explained along with a description of the various animal bones found in them. Chambers accepted the conclusion that the cave was the haunt of hyaenas and other predatory animals which attacked the "gentler" animals, since the bones of the latter were usually found in a broken state. Since these bones were covered by the diluvial clay, he concluded that these events occurred before the flooding. In the first through fourth editions, Chambers explained that Buckland first saw in the Kirkdale cave evidence of the Noachian deluge, but later considered the cave's "phenomena as of a time far apart from that event."[2]

Erratic Blocks

Erratic blocks or boulders are found over much of the north of Europe. Chambers explained that although some of these blocks weigh many tons, they show evidence of having originated in a distant

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[1]CV I:137; III:139; IV:139; V:144; VI:140; VIII:87; IX:84; X:106.

[2]CV I:137-39; III:139-40; IV:139-40; V:144-45; VI:140-42; VIII:87-88; IX:84-85; X:106-107.

place. These blocks, he concluded in every edition, were "carried and dropped by icebergs, while the space between their original and final sites was under the ocean."[1]

The Emergence of Land from the Sea

The emergence of land by the formation of a series of terraces at the points where the margin of the sea once remained was discussed in all of the editions. Chambers concluded from these phenomena that "the highest was first the coast line; then an elevation took place, and the second highest became so, the first being now raised into the air and thrown inland."[2]

In considering "the last rise of the land from the sea, and the concluding great event of the geological history," Chambers assumed, in all of the editions but the eighth through tenth that a quiet elevating movement which was uniform over a large tract was probably responsible. He decided that such a movement must have been gentle from observing that on a single beach "the level continues the same along a considerable number of miles, and nothing like breaks or hitches has as yet been detected in any case."[3]

The Effect of the Diluvium

What, asked Chambers, would be the effect of a large flood? It was likely, he remarked in the first through fourth editions, that

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[1] CV I:139-40; III:140-41; IV:140-41; V:146; VI:142-43; VIII:88; IX:85; X:107.

[2] CV I:140-41; III:142-43; IV:141-43; V:146; VI:142-43; VIII:88; IX:85; X:107.

[3] CV I:142-43; III:144-45; IV:144-45; V:149-50; VI:146; VIII:89; IX:86; X:108.

such a flood would extensively if not universally destroy animal life. However, by the fifth and subsequent editions he began to change his views. In these editions he stated that "some, regarding it as a complete submersion argue that terrestrial life would be . . . extensively, if not universally, destroyed."[1]

In the first through fourth editions, Chambers thought this plausible since "none of the species of land animals heretofore discovered can be detected at a subsequent period."[2] But even in these editions, he was willing to wait to see what future evidence would indicate before making a final decision. And by the fifth edition, he felt that he had sufficient evidence to argue against a universally destructive flood. He provided in the fifth through tenth editions evidence of land species surviving from the tertiary into recent times. He assumed that probably more species survived than those which were known, because the definition of what constituted a species is so variable that undoubtedly many of the recent animals which are designated as belonging to different species are in actuality the same as tertiary species. Also, the present great zoological provinces were apparently originally marked out in the tertiary and remained unchanged ever since. Thus, Chambers concluded in the fifth through tenth editions that "there is . . . enough to justify us in believing that no entire submergence of the earth took place at at the time of the Diluvium, though how nearly it might approach

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[1]CV I:142-43; III:144-45; IV:144-45; V:149-50; VI:146; VIII:89; IX:86-87; X:108-109.

[2]CV I:143; III:144-45; IV:144-45.

completeness we cannot say."[1]

Brewster complained that Chambers did not present any support for his theory from his discussion of the superficial formations. Whereas "our author admits the simple fact of a submersion of a wide range, extensively if not universally destructive of living species, . . . he does not venture to explain how the new creation could have arisen without the immediate interposition of the Deity."[2]

Additional Superficial Deposits

Additional superficial deposits, lacustrine deposits, alluvium, deltas, peat mosses, and vegetable soil, were described in all of the editions. Chambers concluded that the fossil remains found in these deposits "generally testify to a zoology on the verge of that now prevailing, or melting into it, there being included many species which still exist." In each edition examples were given to support this point of view.[3]

The Superficial Formations and the Present

In the sixth through tenth editions, Chambers again expressed his doubts as to what constitutes a species. In these editions he stated that the era of the superficial formations was close enough to the present that we would expect some specific carry over, but yet "so far remote in chronology as to allow of the dropping of many species, through familiar causes--perhaps we should only say the

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[1]CV V:150-51; VI:145-46; VIII:89-90; IX:87; X:109.

[2]Brewster, Review of Vestiges, p. 494.

[3]CV I:143-44; III:145-46; IV:145-46; V:151; VI:147-48; VIII:90; IX:87-88; X:109-10.

obliteration of many peculiarities called specific--in the inverval."[1] In the first through fifth editions, Chambers did not include the part of the sentence enclosed within the dashes and did not express this doubt. Although in the first through fifth editions he mentioned the absence of man from these deposits, in the sixth through tenth editions he mentioned the absence of sheep, goats, and man.[2]

With the conclusion of this section of Vestiges, Chambers had gathered the evidence from the fossil record which he considered to be supportive of the Developmental Hypothesis. Problems pursued him at every level of the fossil ladder as he sought confirmation for this approach. Even the very earliest evidences of life were far too complex to support a doctrine of progressive development from simple to complex forms. Of course, many of the difficulties could be blamed on an imperfect fossil record and man's inadequate knowledge of those forms which were preserved. Faith in the correctness of his position was absolutely essential, for many of the expediencies which he adopted in order to save his theory were not supported by the observable evidence. As more complex forms continued to appear earlier in the fossil record than the developmentalist would have preferred, more elaborate explanations and interpretations became necessary.

Complex cephalopod mollusks in the earliest rocks, fish fossils in a supposedly invertebrate era, plants after animals, higher plants before lower, and myriads of other complications made Chambers' task of a developmental interpretation exceedingly complex.

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[1] CV VI:148; VIII:90-91; IX:88; X:110.

[2] CV I:144; III:146; IV:146; V:152; VI:148; VIII:91; IX:88; X:110.

But being totally committed to a developmental approach, Chambers searched for new facts and reinterpreted old ones until he was able to resolve, at least to his own satisfaction, some of the problems. As an astute man, he was able to understand the criticisms of his opponents but he was convinced that they were incorrect. He knew that when the data were viewed in their totality they would overwhelmingly indicate that God's method in creating the organisms of this planet was one of progressive development.

CHAPTER IV

THE DEVELOPMENTAL HYPOTHESIS

Development had been demonstrated on a cosmic level. The basic palaeontological evidence for process as a terrestrial phenomenon had been provided. If the reader had interpreted these data as Chambers had intended, little doubt should have remained as to the probability of development as a universal phenomenon. He was ready to progress to the theoretical implications of these assumptions.

The three chapters devoted to the explanation of these implications represent the highly criticized essence of the Vestiges. By first summarizing and interpreting the previously described fossil record in the chapter entitled, "General Considerations on the Origin of the Animated Tribes," Chambers concluded that the general geological evidence supported his concept of progressive development--an idea which, he stressed, would enhance the majesty of God in the universe. But, sensing that more persuasive evidence would be needed to convince skeptical readers, he included a chapter with additional examples--most of them unfortunate choices from the standpoint of critical reception--describing the process of development at work. This chapter, entitled "Particular Considerations on the Origin of the Animated Tribes," was especially vulnerable to the abuse of the critics. The reader was well prepared for the Developmental Hypothesis by the time Chambers finally proposed it. It had been suggested from almost the beginning of the book, so its actual statement

in the chapter entitled, "Hypothesis of the Development of the Vegetable and Animal Kingdoms," was not a surprise.

General Considerations on the Origin of the Animated Tribes

In this chapter, Chambers presented very little new material. He attempted, in the form of a general summary, to draw together the information presented previously, in order to convince the reader that progressive development was the most reasonable explanation of the succession of life forms upon this planet.

The Relationship of Uniformitarianism to Development

Uniformitarianism represented a difficult concept for Chambers to assimilate into his hypothesis of progressive development. While on one hand it was desirable to explain the development of life on the earth in the past by applying laws operative in the present, on the other hand a total acceptance of uniformitarian principles implied that life could be created in the present and would subsequently pass up the developmental ladder as it had in the past. And although Chambers suggested that this might be the case, he was loathe to base his entire theory on this possibility. Therefore Chambers, although never using the term "uniformitarianism," applied its principles pragmatically.

"If there is any thing more than another impressed on our minds by the course of the geological history, it is, that the same laws and conditions of nature now apparent to us have existed throughout the whole time, though the operation of some of these laws may now be less conspicuous than in the early ages, from some of the conditions

having come to a settlement and a close," wrote Chambers.[1] Although this uniformitarian preoccupation was apparent in all of the editions, the form of presentation was different in the last five. These later editions contained some experimental evidence for uniformitarianism which was designed both to appease the critics who were steeped in Baconian logic and to satisfy his own need to support his assertions with "facts." For although Chambers' basic inclinations were Platonic, he was not isolated from his fact-loving Baconian environment. He cited this experimental evidence in the later editions to illustrate how law acting in the present under laboratory conditions might have acted under natural conditions in the past. "It is possible to make a substance resembling basalt in a furnace, . . ." explained Chambers, and "limestone and sandstone have both been formed from suitable materials in appropriate receptacles; the phenomena of cleavage have, with the aid of electricity, been simulated on a small scale, and by the same agent crystals are formed."[2]

In addition to the observational evidence of uniformitarian principles at work described in all of the editions, a supplementary example was provided by Chambers in the sixth through tenth editions. He explained that "in a sloping ploughed field after rain, we may often observe at the lower end of a furrow, a handful of washed and neatly deposited mud or sand, capable of serving as an illustration of the way in which nature has produced the deltas of the Nile and

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[1] CV I:146; III:148; IV:148; V:154.

[2] CV I:145-46; III:147-48; IV:148-49; V:154-55; VI:150-51; VIII:92-93; IX:90; X:112.

Ganges."[1] Chambers assumed that since such analogies were conceivable, it would be possible, by studying current phenomena, to understand God's method of creation in the past. "It is the same Nature, . . ." summarized Chambers in the sixth through tenth editions, "that is to say, God through or in the manner of nature--working everywhere and in all times, causing the wind to blow, and the rain to fall, and the tide to ebb and flow, inconceivable ages before the birth of our race as now."[2]

Not only was uniformitarianism apparent in the physical constitution of the earth, Chambers found it applicable to "organic nature" as well. This application was only stated explicitly in the first five editions, although one of the examples illustrating this idea was found in all of the editions. Chambers explained that the alternation of seasons could be observed in the annual rings of fossil conifers with the same degree of accuracy as evidenced in examinations of current forms.[3] Chambers declared in the first five editions that the same predator-prey relationships existed between early forms as are found today, and that early plants and animals were as well adapted to their various habitats as their modern counterparts.[4]

In the first through fifth but not in the later editions, Chambers stressed the differences as well as the similarities between

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[1]CV VI:151; VIII:93; IX:90; X:112.

[2]CV VI:151; VIII:93; IX:90; X:112.

[3]CV I:147; III:149; IV:149; V:155; VI:151; VIII:93; IX:90; X:112.

[4]CV I:147; III:149; IV:149; V:155.

the ancient and modern earth. In the first four editions, he again noted the excess of carbonic acid gas in the atmosphere as one of the limiting factors stifling the early appearance of mammals. Since from the fifth edition forward Chambers had doubted the validity of the carbonic acid hypothesis, he did not include it as a variable factor in the later editions. In the first five editions, he stressed that in the early days of the earth volcanic activity was greater than at present.[1]

Thus, Chambers appeared to be more committed to a uniformitarian approach in the last five editions than he was in the first five. The additional examples included in the later editions as well as the omission of the discussion concerning the differences between the modern and ancient earth imply this. But consistency was not one of Chambers' characteristics, so he was willing to adjust his approach to the circumstances without explanation.

The Fossil Record as a General Support of the Hypothesis of Development

In the first five editions, Chambers summarized the order of appearance of the various groups of organic beings in the fossil record, concluding that this record indicated that a succession of life forms had occurred. Although in the sixth through tenth editions he also noted the advance from lower to higher forms in both plant and animal kingdoms, he did not, as in the earlier editions, cite specific examples of this progressive succession.

The earliest fishes possessed some characteristics of the next

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[1]CV I:147-48; III:149-50; IV:149-50; V:155.

lowest sub-kingdom, the articulata, noted Chambers in the first four editions. This relationship had been questioned by the reviewers and was subsequently omitted from the fifth edition. The controversial statement was replaced with a declaration that the early fish were cartilaginous "and marked by several other traits of inferior organization."[1]

The Defects of the Fossil Record

Nothing which had not been previously discussed in the earlier chapters was included in this summary. But apparently Chambers found it especially important to stress again the importunities of the fossil record and to present possible interpretations consistent with the Developmental Hypothesis because of the severe criticisms articulated by his foes.

Although in this discussion some variation was found within the third, fourth, and fifth editions, the ideas presented were similar. For example, whereas in all three of these editions Chambers mentioned that the fossil record was still somewhat obscure, in the fifth edition he added a phrase to justify this obscurity. A complete record would not be expected, he rationalized, considering "certain obvious circumstances attending first, the inhumation, and afterwards the discovery or investigation of fossils."[2]

Since the early-appearing fuci were not the lowest aquatic plants nor were the plants of the coal-measures the most primitive

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[1]CV I:148; III:150; IV:150-51; V:156-57; VI:152-53; VIII:94; IX:91-92; X:113.

[2]CV III:151-52; IV:151; V:157.

land forms, Chambers admitted, in the third through fifth editions, that the plant kingdom presented problems to a developmental interpretation. This incongruity was explained as it had been in an earlier chapter by stressing the fragile nature of some of the primitive plants making them less likely to be preserved.[1]

The presence of higher invertebrates such as articulates and cephalopods in the same rock system as the lower forms appeared to negate a developmental approach. That this presented a serious problem in Chambers' mind was apparent from his changing emphases in the third, fourth, and fifth editions. In the third and fourth editions, he emphasized that a closer examination ofthe rocks would illustrate that development had actually taken place, since the cephalopods did not appear in the slate systems but in the later rocks of the silurian.

But Chambers' suspicions that cephalopods might be found in these lower strata invaded his fourth edition explanation in which he stated that "even though the cephalopoda could be shewn as pervading all the lower fossiliferous strata, what more would the fact denote than that in the first seas capable of sustaining any kind of animal life, the creative energy advanced it, in the space of one formation, (no one can say how long a time this might be,) to the highest forms possible in that element, excepting such as were of vertebrate structure."[2] Another possible rationalization was mentioned in the fourth edition. Perhaps geologists were mistaken in considering cephalopods high on the organic scale.[3]

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[1] CV III:151; IV:151-52; V:157.

[2] CV IV:152-53.

[3] CV V:158-59.

The non-uniformitarian tenor of the fourth edition was absent from the fifth which presented another possible explanation based on the protozoic rocks of America. Chambers stated that "we may point to America, where the protozoic rocks present no such exalted forms [cephalopods], and ask if the very earliest fossiliferous rocks, the true protozoic formation, have as yet been anywhere found."[1]

How can the early appearance of fish be made to conform to a developmental approach, questioned Chambers? His answer in the third edition was that fish did not appear in the earliest fossiliferous rocks as some critics had stated. Fish, he observed, "are not placed at the top of the Silurian,--ages, probably, after the origination of invertebrate animals."[2] On this basis, Chambers made a plea for the critics to withhold judgment on other cases where the evidence might not be in, for if it were available it might show something entirely different. "Seeing what discrimination of rock chronologies has done in these instances, is it unreasonable to ask that the cotemporaneousness [sic] of crustacea and mollusks with radiata be held at least on suspense, until we shall have had the slate system more rigidly examined, particularly as there are appearances of infusoria in the Primaries?"[3]

The criticism that fish with reptilian characteristics occurred too early was also discussed in the third through fifth editions. In the third and fourth editions he pointed out that in reality they

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[1] CV V:158-59.

[2] CV III:152.

[3] CV III:152.

occurred "a full formation after the earliest and simplest fishes."[1] Chambers admitted that the subsequent rise of a class of fishes without reptilian characteristics might be an important objection, but he stated in the third edition that "when we remember how curiously sub-kingdoms and classes overlap each other, and that the genetic connexions are still generally so obscure, it is not insuperable."[2]

An imperfect system of classification was partially to blame for the problems arising out of the early appearance of the sauroid fish, stressed Chambers in the fifth edition. Even though these fish had a reptilian dentition, they were unrelated to reptiles, he admitted for the first time in this edition. Another incongruity, the appearance of footprints of higher bird forms before the lower was also dismissed by referring "to the partiality of all geological discovery and the doubtfulness of all existing classifications."[3] In this edition, Chambers explained that he would subsequently present a view of the animal kingdom on a "strictly natural arrangement" which will help clear up these difficulties.[4]

Commenting on Chambers' summary of development as illustrated by the fossil record in both plants and animals, Sedgwick claimed that "during our critical labours, of more than forty years' continuance, it has never been our fate to comment on a passage so full of blunders and rash assertions."[5] He asked for his reader's indulgence as he

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[1] CV III:152; IV:154; V:159.

[2] CV III:152-53; IV:154; V:159.

[3] CV V:159.

[4] CV V:159.

[5] Sedgwick, Review of Vestiges, p. 42.

examined Chambers' summary in detail. As far as Chambers' assumption that seaweeds were the first plant forms, explained Sedgwick, there was no proof that this was the case, and "of land plants we have not the shadow of proof that the simpler forms came into being before the more complex, "since both simple and advanced plant forms are bound together in the most ancient plant-bearing rocks."[1] Sedgwick admitted that Chambers correctly reported the presence of polypiaria, crinoidea, articulata, and mollusca in the early rocks, but not in the order stated. Sedgwick agreed that the fish followed the invertebrate groups but argued that the earliest fishes were not linked with the radiata.

Since Sedgwick belonged to the school of thought which considered cartilaginous fish advanced forms, he considered Chambers' views "a grand, and, at the present day, an unpardonable blunder. . . ." Although he agreed with Chambers that reptiles followed fish, he stated that the first reptiles "belong to one of the highest orders of the class, and show no links of an insensible gradation into fishes."[2]

The order of appearance of the birds, although inconclusive because of the paucity of the early fossils, also must be reversed in order for Chambers' theory to be correct, related Sedgwick. He explained that the natatores should be found in the earliest rocks, whereas actually they follow the struthionidae and grallae. Chambers was aware of this inconsistency, charged Sedgwick, since "in his general scale (p. 234,) he has packed them all together."[3] Sedgwick

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[1] Ibid.

[2] Ibid., p. 43.

[3] Ibid., p. 43.

discounted Chambers' argument that the two genera of marsupials appear above the birds and reptiles. He considered these forms to be anomalies among the strata in which they were found for "there are no other organic types to which they offer the shadow of any near affinity."[1]

It seems unusual for Sedgwick to comment in such detail on Chambers' palaeontological errors in this paragraph, when the same errors had been previously presented in the chapters in which Chambers was specifically concerned with the fossil record. But perhaps because this section did represent a summary of what had been formerly presented in such detail, Sedgwick felt compelled to comment again for emphasis. The effect of this criticism may have been reflected in the omission, in the sixth through tenth editions, of specific examples of progressive succession in both plant and animal kingdoms.

The Relationship of Physical Factors to the Transmutation of Forms

Although Chambers admitted in all of the editions that there was some connection between the physical evolution of the earth's surface and the evolution of organic forms, his vision of the way in which these two factors were interrelated differed markedly between the first four and last five editions. In the first four editions, the implications were almost Lamarckian, supposing that changes in the physical environment were sufficient to cause adaptive changes in its organic occupants.

In these editions Chambers presented examples to support this assertion, explaining that "the huge saurians appear to have been

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[1] Ibid.

precisely adapted to the low muddy coasts and sea margins of the time when they flourished. Marsupials appear at the time when the surface was generally in that flat, imperfectly variegated state in which we find Australia, . . ." and not until "the land and sea had come into their present relations, and the former, in its principal continents, had acquired the irregularity of surface necessary for man" did he appear. In these editions Chambers also mentioned that the excess of carbonic acid gas during the early times made the existence of land animals impossible.[1] In the fifth edition, Chambers apparently was unwilling to stress the physical factors, yet unwilling to discard them, stating that besides "a progress which had observed a rule of time; . . ." and, as he would have accepted in the earlier editions, "a progress which has observed a rule of advancing organization," a third rule "will afterwards be seen to have affected organization--namely, external conditions in the earth itself; but this we are not at present called upon to consider."[2]

But in the sixth through tenth editions, Chambers more completely reversed his former conviction that changes in organic forms were related to physical changes in the environment. In these editions, he was convinced that time was the most important element in the evolution of Being. He explained that "at the beginning of geological investigation, it was thought that some immediate external conditions ruled the appearance of particular classes of animals at particular times," specifically, that "the absence of dry land was the

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[1] CV I:149-50; III:153-55; IV:155-56.

[2] CV V:160.

cause of the late commencement of terrestrial animals," and that "an overcharge of the atmosphere with carbonic acid . . ." delayed the appearance of the mammals.[1] But, as implied in the sixth through ninth editions and stated in the tenth, there were fallacies in such a view and he concluded, in contrast to the earlier editions, that "organic progress--both the specific changes in classes formerly existing, and the accession of new and higher classes--depended, not by any means wholly or immediately upon external circumstances, but in great part upon time."[2]

W. H. Allen found Chambers' reversal confusing. Although Allen did not have access to the later editions of Vestiges, the Explanations, in which Chambers' views were changing, was available to him and he was unable to understand Chambers' inconsistency. "What we wish to know, . . ." stated Allen, "is whether the advance in living beings was a consequence of the geological progress, or a mere sequence in time, depending upon a different law."[3]

Chambers' observation that every possible habitat was occupied by some organic form was found in some form in each of the editions. In the first three, but not in the fourth and fifth editions, he stressed the connection of the appearance of new organisms with the changes in the physical habitats which offered new niches for the living things, stating that "there are, indeed, abundant appearances as if throughout all the changes of the surface, the various kinds

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[1] CV VI:160; VIII:98-99; IX:95; X:117-18.

[2] CV VI:160; VIII:98; IX:95-96; X:118.

[3] W. H. Allen, Review of Vestiges, p. 319.

of organic life invariably pressed in, immediately on the specially suitable conditions arising, so that no place which could support any form of organic being might be left for any length of time unoccupied."[1] Chambers remarked again later in the first through fourth editions that life "presses in, . . . wherever there is room and encouragement for it."[2]

W. H. Allen alluded to Chambers' inconsistency, affirming that in Vestiges, meaning the early editions, Chambers considered the advance of species to be a consequence of the geological process. Quoting Chambers' statement in the early editions about life "pressing in" whenever suitable conditions appeared, he compared it to Chambers' statement in the Explanations, in which "he wheels about, . . . to the opposite ground, with apparently the most innocent unconsciousness that he is perpetrating a downright self-contradiction," stating

> The groves which formed the coal-beds might have been a fitting habitation for reptiles, birds, and mammals, as such groves are at the present day; yet we see none of the last of these classes, and hardly any trace of the two first, in that period of the earth. Where the iguanodon lived, the elephant might have lived; but there was no elephant at that time. The sea of the lower Silurian era was capable of supporting fish; but no fish existed. It hence forcibly appears that theatres of life must have lain unserviceable, or in the possession of a tenantry inferior to what might have enjoyed them, for many ages.[3]

Even though in the later editions Chambers had not credited changing physical conditions with changes in the forms of organisms,

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[1] CV I:151; III:155-56.

[2] CV I:160; III:164; IV:164.

[3] W. H. Allen, Review of Vestiges, p. 319.

he had not abandoned the idea of life "pressing in" whenever the habitat was acceptable. However, in the later editions, the purpose of this statement was somewhat different from that of the earlier editions in which Chambers implied that the physical changes were responsible for the organic ones. In the sixth through tenth editions, he was attempting to show that it was logical to assume that since law was operative in the inorganic field it should also be in the organic, since the organic and inorganic were actually inseparable in nature. "Life, as it were, pressed in as soon as there were suitable conditions, and once it had commenced, the two classes of phenomena went on; . . ." it was extremely unlikely, he suggested, that there would have been "two totally distinct modes of exercise of the divine power."[1] However, even though in the later editions he subsequently insisted that the physical environment had little to do with the coming into being of the organic, the implication is here, as in the earlier editions, that such an environment was in part responsible for the types of organisms inhabiting it, resulting in an internal inconsistency within these editions.

Chambers was apparently convinced by the time he wrote the tenth edition that physical factors were only able to modify individuals to a limited extent and that a long time span was the most important ingredient for the occurrence of transmutation. But this did not deter him from using a favorite phrase from the earlier editions such as life being "pressed in" whenever an empty niche occurred. The inclusion of a phrase such as this, along with Chambers'

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[1] CV VI:154; VIII:95; IX:92; X:114.

assertions that time was the most important factor in development lend credence to Allen's accusations of inconsistency. It is also apparent that Chambers never entirely renounced the importance of the environment in stimulating certain adaptive changes, although his emphasis on its importance diminished in subsequent editions.

Theological Implications of Natural Law

Although Chambers had been concerned with the theological implications of creation by natural law throughout the book, he emphasized this aspect before the actual presentation of the theory. His basic postulate, that the orderly foresight necessary for creation by this method enhanced rather than detracted from the glory of the Creator, remained unchanged throughout the various editions, although the method of presentation varied. The first through fourth editions were similar to each other as were the sixth through tenth, with the fifth being somewhat intermediate. Nevertheless, minor changes occurred between all of the editions.

In the first through fourth editions, Chambers, after initially assuring his readers that he took it for granted that "God created animated beings, as well as the terraqueous theatre of their being, . . ." inquired into the modes of this creation, considering, as in the later editions, that the method by which God accomplished this creation was of paramount importance. The "ordinary notion" of God producing the progenitors of all existing species by some sort of personal or immediate exertion was discussed and found to be inconsistent with the evidence of "the gradual advance of species, from the humblest to the

highest."[1] Chambers considered it unworthy of the Creator to waste his creative power, using it "at one time to produce zoophytes, another time to add a few marine mollusks, another to bring in one or two conchifers, again to produce crustaceous fishes, again perfect fishes, and so on to the end."[2]

Chambers used more space in the later editions than in the earlier in preparing the reader for the conclusion that God's method of creation was one of natural law. In these editions he discussed the universality of natural law, remarking in the eighth through tenth editions that "it is a point of stupendous importance in human knowledge; here at once is the whole region of the inorganic taken out of the dominion of marvel, and placed under an idea of divine regulation which we may endlessly admire and trust in."[3] After laying this foundation, he applied the same methods to the operation of the organic world, asking in the sixth through tenth editions if it is not possible for plants and animals to also have been created by means of natural law "thus assigning immediate causes of but one character for everything revealed to our sensual observation; or are we at once to reject this idea, and remain content, either to suppose that creative power here acted in a different way, or to believe unexaminingly, that the inquiry is one beyond our powers."[4] Chambers concluded that it would be extremely unlikely that the Creator would have used two distinct

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[1] CV I:153; III:157; IV:157.

[2] CV I:153; III:157; IV:157.

[3] CV VIII:94; IX:91; X:113.

[4] CV VI:152-53; VIII:94; IX:91; X:113-14.

methods in his creation, one for the inorganic and another for the organic world. As he indicated in the earlier editions, a contradiction would be implied by a Deity who would arrange an astral system by dispositions imparted primordially to matter but when concerned with fuci and corals would change his plan.[1]

Although Chambers in the sixth through tenth editions admitted that the data obtained from the fossil record could also be explained by successive creations, he, as a convinced Platonist, asked, "is the mind entirely satisfied with this explanation?" His was not! Chambers found it petty that a critic should find the fact that certain mammals have not changed for 3000 years to be a difficulty to his theory.[2]

Although the examples given were different, Chambers' presentation in the sixth through tenth editions agreed with that of the early editions in assuming that a special creative fiat for the origin of each species would detract from the power of God. In these editions he scoffed at current definitions of species, assuming that by "taking up the present views of geologists as to species, such an event as the commencement of a certain cephalopod, one with a few new nodulosities and corrugations upon its shell, would, on this theory, require the particular care of that same Almighty who willed at once the whole means by which INFINITY was replenished with its worlds!"[3]

The ideas expressed in the later editions were not new to these editions. But perhaps more than in the early versions Chambers

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[1] CV V:162; VI:155; VIII:95-96; IX:93; X:114.

[2] CV VI:163-64; VIII:100; IX:97-98; X:119-20.

[3] CV VI:155-56; VIII:96; IX:93; X:115.

stressed the ignorance of those who did not accept his view of creation. Although he considered it reasonable for primitive man to accept organic creation by the special interference of God "precisely as, with respect to the motions of the heavenly bodies, the geocentric theory was that which the appearances first suggested, and therefore was first embraced by man," he decried modern man's reluctance to accept the new evidence.[1]

It was in the method of presentation not in the ideas in which the fifth edition differed from both the early and later editions, although elements of both forms were evident in it. Chambers argued against creative fiats in this edition by asking a series of questions, such as, "for, if such fiats were the mode of the Deity's operation, how should there have been oceans existing for unreckonable ages without fish, or dry land without land animals?"[2] As in the other editions he presented the idea of creation by means of natural law as the only reasonable alternative to creation by means of successive fiats, stressing that this view only represented the exchange of one mode of action for another.[3]

Although in the first, third, fourth, and occasionally the fifth editions Chambers discussed the scriptural implications of creation by natural law, he did not in the later editions. In the first four editions he stated that "the ordinary conceptions of Christian nations on this subject are directly derived from Scripture,

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[1]CV VI:156; VIII:97; IX:93-94; X:115-16.

[2]CV V:161-62.

[3]CV V:162.

or, at least, are in conformity with it.[1] Moreover he expressed doubts in the first edition as to how clear the scriptures were on these matters, for he announced that if they were unequivocal on the subject there would be a legitimate objection to the creation of organic beings by natural law. In this edition he continued along these same lines, concluding that not only did the Mosaic record not refute his theory it was actually opposed to special creation. But, he averred that the Mosaic record was not to be used to support or refute any theory of creation, for "there is not the least appearance of an intention in that book to give philosophically exact views of nature."[2] In the third and fourth editions he condensed the first edition discussion into a single sentence, and although the ideas expressed were similar in these editions he did not mention the uncertainties of the scriptural record. Chambers continued in these three editions by insisting that God's procedure was represented as "flowing from commands and expressions of will, not from direct acts," a view consistent with a developmental philosophy rather than with one of special creation.[3]

The fifth edition converged with the first four to quote specific scriptural examples which Chambers considered to be supportive of his theory. He considered statements such as "let there be light . . ." and "let the earth bring forth the living creature after his kind" to be consistent with creation by law, and other statements

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[1] CV I:154; III:159; IV:159.

[2] CV I:156.

[3] CV I:155; III:159; IV:159.

such as "God made the firmament--God made the beasts of the earth . . ." to be subordinate statements which "do not necessarily convey a different idea of the mode of creation, and indeed only appear as alternative phrases, in the usual duplicative manner of Eastern narrative."[1] Chambers concluded in the first four editions that all the scriptures intended to say was that "man was produced in consequence of an expression of the Divine will to that effect." The scriptural objections would, therefore, vanish--the older interpretation being "formed at a time when man's ignorance prevented him from drawing therefore a just conclusion."[2] In the fifth edition, he stated much the same thing although in more temperate language, stating that in the scriptures which form the ideas of most people on creation there is "certainly nothing like the decided affirmation of the doctrine of special exercise which has been assumed."[3]

J. H. Allen, while finding fault with the scientific portions of Chambers' work noted that there was nothing inherently atheistic about assuming that God chose to create by means of natural law. He explained that "the type, both of organic structure and mental character, stamped so plainly on every class of living things, had been regarded as the "image and superscription" of the Maker's hand, denoting unity of design throughout, and marking them as parts of one system, before any theory had appeared connecting them organically. Allen concluded that regarded in this way "we esteem it very far from

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[1] CV I:155; III:159; IV:159; V:166-67.

[2] CV I:156; III:159-60; IV:160.

[3] CV V:167.

irreverent, to trace the successive unfoldings of organic, intellectual and moral life, as portions of one great whole; or to anticipate the time, when the present average advancement of the human race shall seem but the rude beginnings of a glorious and ever widening course."[1]

In the first four but not in the last six editions, Chambers used an example from "a late writer" arguing for the doctrine of more immediate exertions on the part of the Deity in the works of His creation. The argument of this writer was that coral polyps unite to form definite total forms and that whereas instinct might allow each polyp to construct its own cell "there is no superintending one to direct the pattern, nor can the workers unite by consultation for such an end." Therefore, this writer concluded that God alone must be the architect. Chambers included this example because he thought that he could refute it and thereby strengthen his own position. The writer, he explained, was in error, since more recent research has shown "that corals have a general life and sensation throughout the whole mass, residing in the nervous tissue which envelopes them; consequently, there is nothing more wonderful in their determinate general forms than in those of other animals."[2]

Chambers was true to his acceptance of the universality of a common law, stating in all of the editions that not only was it necessary to account for life on our earth, but life on all of the other planets using a common principle. This necessity made the concept of special creation especially ludicrous to Chambers, who found it

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[1] J. H. Allen, Review of Vestiges, pp. 343-44.

[2] CV I:158-59; III:162-63; IV:162-64.

most difficult to believe that God would "be constantly moving from one sphere to another, to form and plant the various species which may be required in each situation at particular times." Such a method would be degrading to God, but "yet such is the notion which we must form, if we adhere to the doctrine of special exercise."[1] How much more reasonable, he concluded, would be an explanation of events by natural law.

If the people of a primitive nation ventured forth to sea in a boat and encountered something which they had not previously seen--a whole fleet of ships, Chambers stated that these people would be justified in concluding that these ships "were occupied, like their own, by human beings possessing hands to row and steer, eyes to watch the signs of the weather, intelligence to guide them from one place to another--in short, beings in all respects like themselves, or only shewing such differences as they knew to be producible by differences of climate and habits of life."[2] Thus, by analogy, he felt qualified to judge the makeup of the other heavenly bodies for since "out of a certain number of the elements of inorganic matter are composed organic bodies, both vegetable and animal: such must be the rule in Jupiter and in Sirius, as it is here."[3]

Since gravity is a universal property in all of the spheres,

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[1]CV I:161; III:163; IV:165-66; V:168-69; VI:164-65; VIII:101-102; IX:98; X:120.

[2]CV I:162; III:166; IV:166-67; V:170; VI:165; VIII:101-102; IX:98-99; X:120-21.

[3]CV I:162; III:166; IV:167; V:170; VI:166; VIII:102; IX:99; X:121.

its relationship to the occupants of the spheres would govern the details of structure and size of the occupants, Chambers argued in all of the editions. In the first four editions, electricity was discussed as another universal characteristic, but it was not considered in the later editions.

Heat and light were postulated as additional universals in all of the editions; Chambers concluded "that, as they bear marked relations to organic life and structure on earth, they may be presumed to do so in other spheres also." Light especially interested Chambers; since light is a universal and since "where there is light there will be eyes," animals with eyes would be found on other spheres "with only such differences as may be necessary to accord with minor peculiarities of conditions and of situation." He extrapolated from this to conclude that there would be a parity of organs in all the globes bearing "not only a general, but a particular resemblance to those of our own." "As one set of laws produced all orbs and their motions and geognostic arrangements, so one set of laws overspread them all with life," concluded Chambers in all of the editions.[1]

Not just once but many different times in each edition, Chambers emphasized how the philosophy of universal natural law exalted rather than diminished the stature of God. Apparently he was experimenting in order to determine the most effective way of presenting this idea in order to curtail the cries of "atheist" hurled at him by certain critics. This experimentation resulted in minor

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[1]CV I:163-64; III:167-68; IV:167-69; V:171-72; VI:166-68; VIII:102-103; IX:99-100; X:121-22.

changes in form and content, but in no place was his basic premise revised.

Chambers' purpose in including the chapter on "General Considerations . . ." was to codify the evidence he had previously presented in order to prepare the reader for acceptance of the theory itself. New examples were included but the ideas were old. Some of the redundant palaeontological survey was omitted from the later editions, but more theological speculation was added to replace it.

Particular Considerations on the Origin of the Animated Tribes

After Chambers had presented his general summary of the facts he had recounted earlier in the text suggesting creation by means of natural law, he proceeded to consider new specific examples to support his contention. He stated his purpose for this chapter in the first four editions by asking "if science has any facts tending to bring the assumption more nearly home to nature," in the fifth edition by inquiring "what organic nature herself says with respect to her origin," in the sixth by asking "how far the notion is countenanced by the constitution of organic bodies," and in the eighth through tenth editions inquiring "how far the notion is countenanced by the constitution of organic bodies, and if any trace is observable in organic nature of such a means and method on the part of its Creator."[1]

Very few of Chambers' specific examples were left unchallenged by the critics. In a desperate attempt to convince, Chambers collected a group of contemporary science's most questionable facts and

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[1] CV I:165; III:169; IV:170; V:173; VI:169; VIII:104; IX:101; X:123.

presented them as supports for his forthcoming hypothesis. Up until this point, although the book was controversial it was still respectable. However, with the appearance of these "particular supports" its respectability vanished, and it was open to the ridicule of Chambers' contemporaries.

The Relationship Between the Inorganic and Organic

Crystallization

The first of the "particular" supports presented by Chambers related to the phenomenon of crystallization. Certain crystalline forms resemble organic forms, he explained in all of the editions, implying, but not explicitly stating, a more fundamental relationship between the organic and inorganic phenomena.

One of these coincidences involved the similarity of the designs left by frost on window panes to the forms of plants. Sedgwick was unimpressed by this resemblance, asking "what child has not . . ." noted "the same thing a hundred times before him?" He explained that although the frost may imitate plant forms it does not have "organic structure or any inner principle of reproduction," for it grows by adding new material on the outside rather than on the inside as do organic beings."[1] The reviewer for the British Quarterly Review was also impressed by the "almost childish method of reasoning" in his description of the mimicry of crystalline forms to living plants.[2] The idea of crystallization as a fundamental link between

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[1]Sedgwick, Review of Vestiges, pp. 8-9.

[2]Review of Vestiges, British Quarterly Review, pp. 499-500.

living and non-living was not original with Chambers, having been espoused in the late eighteenth century by Jean-Claude de Lamétherie. Since this idea supported his theory, he inserted it into his narrative.

Chambers was uncertain in his own mind as to how basic these similarities actually were. Although inconsistent, he apparently was more convinced in the later editions than in the earlier that an integral relationship could be observed between the two types of occurrences. Whereas in the first five editions, he stressed that "crystallization is confessedly a phenomenon of inorganic matter," in the sixth through tenth editions he explained that crystals were considered to "stand between the inorganic and the organic."[1]

Electricity played an important role in this intergradation between the inorganic and organic. Although in the early editions Chambers discussed the effect of electricity upon the form of plants as well as its function in the production of crystals, he did not connect these two facts to explicitly state a relationship between the two types of phenomena.[2] But in the sixth through tenth editions the relationship was clarified; Chambers stated that "it is now incontestable that crystallization is dependent in some degree on an electrical agency, the special forms being the result of the peculiar nature of the constituent substance and the conditions under which the imponderable is applied, . . ." and it is probable that "the electric energies had something to do in determining the forms of plants."[3]

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[1]CV I:165; III:169; IV:170; V:176; VI:173; VIII:106; IX:103; X:123.

[2]CV I:166-67; III:170-71; IV:171; V:176-77.

[3]CV VI:173-74; VIII:106; IX:104; X:125-26.

The "Arbor Dianae," a crystalline formation "precisely resembling a shrub," exemplified this relationship between organic and inorganic. Sedgwick agreed that the arbor dianae resulted from a combination of chemical elements acted upon by electricity, but he was assured that any resemblance to a plant was mere coincidence and to think otherwise was extremely fanciful. "Comparisons of this kind are childish or superstitious--poetical, witty, or absurd--according to the manner in which we use them; but we are certain that they belong not to the stern realities of science," he concluded.[1]

Chambers noted that positive electricity caused a tree-like form as well as the appearance of "individual leaves" in the arbor dianae, whereas negative electricity "recal the bulbous or the spreading root, according as they are clumped or divergent."[2] It was remarkable, he concluded, that this corresponded with the positive charge of the atmosphere and the negative charge of the earth. A plant, he hypothesized in every edition, is "formed on the basis of a natural electrical operation--the brush realized." Thus he assumed that plant forms could be explained by the operation of a law in electricity "variously affecting them according to their organic character, or respective germinal constituents."[3] W. H. Allen was unimpressed. He concluded that Chambers' "long paragraph upon these electrical resemblances does not contain a particle either of scientific

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[1]Sedgwick, Review of Vestiges, pp. 8-9.

[2]CV I:166-68; III:170-71; IV:171; V:177; VI:174; VIII:107; IX:104; X:126-27.

[3]CV I:167-68; III:170-71 IV:171-72; V:177-78; VI:175; VIII: 107; IX:104; X:126-27.

fact or rational argument."[1]

Chambers continued on this questionable path in every edition but the tenth, adding supplementary evidence that electricity is connected with plant life. "Germination, . . ." he explained, "will not proceed in water charged with negative electricity, while water charged positively greatly favours it. . . ."[2] Even more absurd, wrote W. H. Allen, is Chambers' statement that the luxuriance of a garden could be increased "when a number of conducting rods are made to terminate in branches over its beds."[3] Allen was hopeful that "he has learned, ere this, that the conducting wires of whose efficacy he speaks have failed to produce any fertilizing effects in all the experiments which have been made with them throughout Europe and America."[4]

Allen recommended an article in the London Chemist to Chambers in which these experiments were explained. This article reported that

> 'the poles and wires are placed in two very small fields, one of which is in pasture, and the other in a crop of barley. The first had not a living animal upon it; and humane and considerate it certainly was, for the total want of anything in the shape of grass, beyond the roots, would have starved any hill ewe, nibble she ever so eagerly. The devoted field, instead of being electrified, seemed to be paralyzed; and will to all appearances require some 'additional pickles' to revive its sensibilites after the shock it has sustained. Then as to the barley, it seems neither to have suffered nor been ameliorated by the magic wires, for no perceptible difference can be seen over the field.[5]

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[1] W. H. Allen, Review of Vestiges, pp. 310-11.

[2] CV I:167; III:170; IV:171; V:177; VI:174-75; VIII:107; IX:104.

[3] W. H. Allen, Review of Vestiges, p. 310.

[4] Ibid.

[5] Ibid.

God may have established vegetable forms over all of the earth by the use of the same electrical forces that effected the inorganic, suggested Chambers in all of the editions. Aware of his critics' scorn, Chambers, in the sixth through ninth but not the tenth edition, accused them of showing a lack of "philosophical discrimination," for they did not discern that "it is the forms merely, not the internal constitution, of living bodies, which I have suggested to be a result of similar forces to those productive of the forms of crystals."[1]

Identity of Chemical Constituents

Another kind of unity between the inorganic and organic worlds was described by Chambers in all of the editions--the identity of chemical elements forming inorganic and organic bodies. Whereas in the first five editions this discussion followed that of crystallization, in the last five editions it preceded it. Because of this chemical identity between organic and inorganic bodies, Chambers assumed that the organic had arisen from certain combinations of the inorganic elements. In the sixth through ninth editions he aggressively asserted that to argue that the organic and inorganic were subject to different laws was "mere assumption, contrary to the actual state and much more contrary to the tendency of science."[2] That the rise of life out of inorganic elements was "within the scope of the natural operations of deity, albeit we cannot pretend to know much of the absolute character of life itself," was stressed in the tenth edition.[3]

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[1] CV VI:175-76; 497-98; VIII:108; 303; IX:105; 300.

[2] CV VI:170; VIII:104; IX:101.

[3] CV X:123.

In all of the editions, Chambers enumerated the four elements of which organic bodies are composed, explaining that differences between the organic and inorganic was a function of the arrangement of these elements. The combination of these elements in organic bodies results in the formation of the "proximate principles" out of which the living organism is formed, explained Chambers. In the first edition, these proximate principles were listed as "albumen, fibrin, urea, alantoin, and c."[1] In the sixth through tenth editions, Chambers was not specific, but concluded that the combinations of the inorganic substances into the proximate principles was not mysterious but "simply a chemical phenomenon."[2]

Only in the first edition did Chambers mention the laboratory synthesis of urea and alantoin. Since "two of the proximate principles . . ." are "realizable by human care, . . ." he concluded that "the possibility of realizing or forming all is established."[3] A footnote was also included to explain that fatty matter had also been formed in the laboratory.[4] In all of the editions, Chambers cited the authority of an Oxford chemist, Daubeny, to indicate that the proximate principles were combined according to the same rules as the elements of mineral bodies.[5]

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[1]CV I:168; III:171-72; IV:172-73; V:178; VI:170; VIII:105; IX:102; X:123-24.

[2]CV VI:170; VIII:105; IX:102; X:123-24

[3]CV I:168.

[4]CV I:169.

[5]CV I:169; III:172; IV:173; V:178-79; VI:170-71; VIII:105; IX:102; X:124.

Chambers cited another example in all of the editions to support the argument concerning the close relationship between the organic and the inorganic. He explained that "fecula" can be converted into sugar through the action of a secretion diastose. And where diastose (diastase in the fourth through tenth editions) is separately obtained by the chemist "it acts as effectually in his laboratory as in the vegetable organization," he continued. Other chemicals can imitate the same effects.[1] In the sixth through tenth editions, Chambers quoted Carpenter who stated that every new discovery tended to break down the barrier between the organic and inorganic.[2]

What causes the special property called life when the proximate principles become associated within the organism, asked Chambers in each edition. At the present, "no satisfactory answer can be given," he admitted in the first five editions, but in the sixth through tenth he attempted to answer the question on mechanistic lines after remarking that the "mystic something, . . ." the "vital principle . . ." was, quoting from Alison's Principles of Physiology, "'both unsupported by evidence and useless in the explanation of facts.'"[3] To replace the vital principle, Chambers proposed the mechanistic alternative of "natural forces" such as gravity, cohesion, elasticity, the agency of the imponderables, and all other powers which operate both on masses and atoms."[4] The "mechanical principles involved in

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[1]CV I:169-70; III:172-73; IV:173; V:179; VI:171; VIII:105; IX:102; X:124.

[2]CV VI:171-72; VIII:105; IX:102; X:124.

[3]CV I:170; III:173; IV:174; V:180; VI:172; VIII:105-106; IX:103; X:124-25.

[4]CV VI:172; VIII:106; IX:103; X:125.

the bony skeleton, the optical principles in the construction of the eye, or the hydraulic action of the valves of the heart" convinced Chambers that the more basic life-principles would be mechanistic as well.[1]

The Cell

From a discussion of the basic similar constituents between the inorganic and organic, Chambers moved to a description of the basic unit of organized matter, the cell. He explained that the microscopic investigation of the parts of the cell "is of such recent origin, . . . that its results cannot be expected to be very clear." After describing the basic nature of the nucleated cell, he included the comment that "nutriment is converted into these before being assimilated by this system."[2] Huxley, without comment, quoted this sentence among other statements design to show Chambers' lack of physiological knowledge.[3]

The resemblance between the mammalian ovum and the "young of the infusory animalcules" was noted in all of the editions. Chambers explained that "one of the most remarkable of these [infusory animalcules], the volvox globator, can hardly be distinguished from the germ which, after passing through a long foetal progress, becomes a complete mammifer, an animal of the highest class." Another correlation noted by Chambers in each edition was that the globules of the blood also were "distinct organisms multiplied by the same

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[1] CV I:172-73; VIII:106; IX:103; X:125.

[2] CV I:170-71; III:173-74; IV:174; V:180; VI:176; VIII:109; IX:106; X:129.

[3] Huxley, Review of Vestiges, p. 341.

fissiparous generation."[1] Huxley quoted Chambers' statements regarding both the volvox and the blood globules with his own exclamation points to illustrate the ludicrousness of such assertions.[2] Chambers concluded that "all animated nature may be said to be based on this mode of origin; the fundamental form of organic being is a cell, having new cells forming within itself, by which it is in time discharged, and which are again followed by others and others, in endless succession."[3]

The Creation of Organic Globules

The only step missing in the transition between the inorganic and organic is the creation of organic globules, explained Chambers in all of the editions. If this could be done "the possibility of the commencement of animated creation by the ordinary laws of nature might be established."[4] According to Sedgwick, "the if and might of this sentence are words of marvellous import."[5]

Maybe, asserted Chambers in all of the editions but the tenth, the creation of this globule has already been accomplished. "A French physiologist," he wrote in the first edition, has already produced globules in albumen by electricity.[6] The reviewer for the Athenaeum was highly critical of Chambers for building his entire

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[1] CV I:172-73; III:175; IV:176; V:181-82; VI:177-78; VIII:109; IX:106; X:129.

[2] Huxley, Review of Vestiges, p. 341.

[3] CV I:172-73; III:175; IV:176; V:182; VI:178; VIII:109; IX:106; X:129.

[4] CV I:173; III:175-76; IV:176-77; V:182; VI:178; VIII:109; IX:106; X:129.

[5] Sedgwick, Review of Vestiges, p. 7.

[6] CV I:173.

theory on the "precious probability . . ." that "' a French physiologist,' he does not know who, nor when but 'some years ago'" announced that globules could be produced by electricity in albumen. If these globules can not be produced, insisted this reviewer, then all of Chambers' subsequent reasoning is invalid for upon this "obscure fact" rests all subsequent developmental stages.[1]

Although the error of omission was rectified in the third through ninth editions in which he credited Prevost and Dumas with the creation of these globules, a storm of criticism still greeted his discussion.[2] The major point of criticism noted by Sedgwick, the writer of the Expository Outline, W. H. Allen, and the reviewer for the British Quarterly Review was that Chambers had mistaken the inorganic globule of the chemist for the fundamental organic globule.[3] Chambers' interpretation is a "monstrous perversion of sound reason," Sedgwick asserted.[4]

The reviewer for the British Quarterly Review questioned the relevancy of the experiments of Prevost and Dumas for Chambers' purpose. "If his theory had been that the first step in the process of creation was the formation of vesicles by the wind passing over the ocean, then the fact of boys blowing bubbles in soap and water with a tobacco-pipe, and the fable of Venus being born of the froth of

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[1]Review of Vestiges, the Athenaeum, p. 12.

[2]CV III:176; IV:177; V:182-83; VI:178; VIII:109; IX:106.

[3]Sedgwick, Review of Vestiges, p. 7; Expository Outline, p. 50; W. H. Allen, Review of Vestiges, pp. 310-11; Review of Vestiges, British Quarterly Review, p. 500.

[4]Sedgwick, Review of Vestiges, p. 7.

the sea, would have been as much to his purpose."[1] W. H. Allen also denied the applicability of these experiments stating that the globules which were produced were neither living nor organized "What a pity, . . ." he proclaimed, that "the French chemists did not preserve and nourish these precious germs," . . . for "they might have been the basis of a new stirps. . . ."[2]

Chambers' own doubts as to the importance of these experiments to his propositions first appeared in the third edition. The reviewer for Blackwoods noted this change of attitude, explaining that although he was prepared to discuss the "alleged production of animated globules in albumen by electricity, . . ." it would not be necessary, for "we find that, in a note to the third edition, the author virtually relinquishes this ground."[3] Inquiries among scientific men indicated that "no such experiment had been received or accredited amongst them."[4] Sedgwick also noted this third edition defection and criticized Chambers for building his whole theory on a proposition which he himself stated was questionable. These experiments are of critical importance to the theory; Sedgwick insisted that "he cannot desert his fundamental organic globules; and if he cannot create it by purely physical means, his whole system is gone, and he has not so much as a mathematical point to rest his foot upon."[5] He compared

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[1]Review of Vestiges, British Quarterly Review, p. 500.

[2]W. H. Allen, Review of Vestiges, pp. 310-11.

[3]Smith, Review of Vestiges, p. 453.

[4]Ibid.

[5]Sedgwick, Review of Vestiges, p. 7.

Chambers' organic globule to the "petit corps gelatineux" of Lamarck, "without which the authors have not the semblance of a starting-point."[1]

Chambers did not include his doubts as to the applicability of these experiments in the body of the text in the third through ninth editions, but in a footnote grudgingly admitted that new research was likely to lead to new results, for

> I am bound to admit, in the meantime, that the identity of the globules produced in albumen by electricity with living cells, and the fact of the reproduction of living globules, are both doubted by physiologists of high character. In this, as in other instances, particular illustrations may be held in doubt, or may altogether fail, without necessary injury to other arguments.[2]

In the tenth edition, Chambers' doubts concerning the relevance of these experiments mounted, as he stated that the experiments did not appear to have been confirmed. But he was still hopeful even in this edition, stressing that although the actual laboratory connection between the organic and inorganic may not have occurred, such a small distance exists between the two that the probability of the ultimate existence of such a connection must be admitted.[3]

The Artificial Creation of Shell

In the first through fourth edition, Chambers observed that the natural production of shell could take place artificially. Here, therefore, was another example of the similarities between organic and

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[1] Ibid.

[2] CV III:176; IV:177; V:420-21; VI:498; VIII:304; IX:301.

[3] CV X:129.

inorganic phenomena. Although this process of artificial shell production was described in much detail in these editions, it was not mentioned in the later versions.[1] The observation on shell production is of no value, criticized W. H. Allen, since shell is neither a living nor an organized body, but a combination of gelatine with carbonate of lime. This reviewer questioned whether the shell produced the gelatine or whether it came from the animal substance used in dressing the cloth.[2]

This section concerning the fundamental similarities between living and non-living bodies was a preparatory section. It was important for Chambers to establish this similarity before he attempted to prove that the living arose from the non-living. He sought to establish unity of form between the inorganic and organic by means of his illustrations of crystallization, and of substance through his discussion of the similarities of chemical make-up between living and non-living. Electricity was introduced as a possible mechanism for the change from the non-living to the living state. The most controversial statements were removed or modified in the later editions, but the basic position remained unaltered throughout the different versions.

The Spontaneous Generation of Life

From his discussion of the similarities between the inorganic and the organic and the possible laboratory creation of the organic globule, Chambers moved to a consideration of the possibility of the

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[1] CV I:173-74; III:177-78; IX:178-80.

[2] W. H. Allen, Review of Vestiges, p. 310.

spontaneous generation of life in the present. Although he wanted to accept the reality of spontaneous generation, he recognized its controversial nature and did not want his hypothesis bound too closely to this idea. Even if no authentic examples of life-creation in the present could be proved, he explained in the first four editions, this would not disturb his doctrine, for "the conditions necessary for the operation of the supposed life-creating laws may not have existed within record to any great event."[1] This suggestion of a different earlier set of conditions operative at previous times exemplifies the elasticity of Chambers' uniformitarianism.

However, uniformitarianism was one of the arguments used by the foes of spontaneous generation, variously enumerated by Chambers as "the advocates of interference, . . ." in the sixth edition, "the advocates of the anti-natural views, . . ." in the eighth and ninth editions, and "the opponents of the present argument, . . ." in the tenth edition.[2] They argued, Chambers related, that since no passage from inorganic to organic had been observed in recent times, by extrapolation backwards to earlier epochs it was reasonable to assume that the same pattern was present then.[3]

In the fifth edition, Chambers was essentially of the same opinion as he was in the earlier editions regarding the relationship between the doctrine of spontaneous generation and his theory. He reiterated that a "decided negative" to the idea of spontaneous

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[1]CV I:175-76; III:179; IV:180.

[2]CV VI:179; VIII:109-10; IX:106-107; X:129.

[3]CV V:184.

generation would not be critical to his theory but he asserted that he thought it not unlikely "that we should still see some remnants, or partial and occasional workings of the life-creating energy amidst a system of things generally stable and at rest."[1] Chambers agreed in the sixth through tenth editions that it was unimportant to his theory whether or not spontaneous generation could occur in the present.[2]

Chambers, in the sixth through tenth editions, developed a way to free himself from the non-uniformitarian position he had suggested in the first four. Since, he claimed, "the great work of the peopling of this globe" was completed a long time ago, one would not expect many new forms to be created in a relatively full planet, for because of "the occupation of all the great geographical provinces with a more or less full suite of the forms of life, a new development may have hardly any chance of being now drawn forth, and none of being advanced to any extent even though the same life creating laws be still in force."[3] But Chambers concluded that although one would expect the "ordinary means of generation" to be the common one today, this was not an argument against the natural creation of life some time in the past. He also suggested that if life-creating activities do occur at present, they do so rarely enough that "hundreds of human generations may pass without an opportunity of witnessing such effects."[4]

Chambers was convinced that spontaneous generation did

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[1] CV V:184.

[2] CV VI:181; VIII:111; IX:108; X:131.

[3] CV VI:180-81; VIII:110; IX:107; X:130.

[4] CV VI:181; VIII:110-11; IX:107-108; X:130.

occasionally occur in the present, although he realized that this was an unpopular opinion. Most scientists, he explained, held the doctrine in disrepute because in instances claimed as examples of spontaneous generation the conclusions have been after "exhaustive experiments . . ." that there was "no alternative from the conclusion that ordinary generation did take place, albeit in a manner which escapes observations."[1] Chambers admitted that the truth of his examples had not yet been established, and in the tenth edition inserted a statement to protect himself from critics, explaining that since he was forced to rely on the authority of others for data, he did not feel confident that the examples he planned to cite were correct.[2] But it was apparent that he was convinced of the reality of spontaneous generation even if the examples all happened to be wrong. He added in the first nine editions that the opinion of scientists was not monolithic, quoting a Dr. Allen Thomson who felt that the balance of evidence was "in favour of the primitive production of infusoria, the vegetation called mould, and the like."[3]

Some of the examples that Chambers collected to illustrate the possibility of spontaneous generation were found in all editions, others were just in the earlier efforts but omitted from the later ones, while still others were added to the later editions. All of the

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[1] CV I:177; III:180; IV:181; V:185; VI:181-82; VIII:111; IX: 108.

[2] CV X:131.

[3] CV I:179; III:181; IV:182-83; V:185-86; VI:182; VIII:131; IX:110.

editions but the fifth and sixth produced as one possible example of spontaneous generation the appearance of white clover after lime was placed on "waste moss ground" when no seeds were present.[1]

The Spontaneous Generation of White Clover and other Plants

Sedgwick proposed a hypothesis which Chambers had rejected to explain the apparent spontaneous generation of clover. He noted that seeds could remain dormant for centuries and yet germinate as soon as the soil was ploughed. "And is it not well-known that such seeds as have a perfect capsule, and have not been crushed by the gizzard of birds or the teeth of beasts, will pass through them and fall upon the ground with undiminished vitality?" asked Sedgwick.[2] The reviewer for Blackwoods had a similar explanation, remarking that the clover probably arose from seeds already present but which had failed to germinate owing to "ungenial circumstances."[3] Chambers rejected this type of explanation, since in an area in which this had been observed no clover was grown for miles around and pure peat moss was present six feet deep. Since clover seeds were too heavy to be transported by wind, this could not be the explanation.[4]

Newman offered a different kind of objection to the spontaneous generation of clover. He insisted that it was irrelevant as to whether or not clover had arisen spontaneously. What was significant, he

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[1]CV I:178; III:181; IV:182; VIII:112; IX:109; X:131.

[2]Sedgwick, Review of Vestiges, p. 68.

[3][Smith], Review of Vestiges, pp. 452-53.

[4]CV III:181.

concluded, was that if such a creation had actually occurred it would be directly opposed to a theory of progressive development; such a theory "would require that the plant should have been called into existence as a simple cell, that it should then become an alga, subsequently a moss, a fern, or grass, and so upwards, until it arrived at its legitimate place in our system. . . ."[1]

Other examples of spontaneous generation were mentioned in different editions. An example found only in the first edition described the formation of mushrooms by mixing cow and horse dung.[2] According to the eighth through tenth editions, after earth had been thrown up from far below the earth's surface a new set of plants "not always common in the district" appears. These editions produced other examples not included in the earlier efforts, such as the appearance of a plant, sisymbrium iris, in such abundance that "the whole of the rest of Europe could not contain so many plants of it," the appearance of strawberry plants after old beech trees are cleared away, and the appearance of maritime plants in an inland area where a new salt water spring had broken through.[3] Chambers also mentioned that dried-up lakes as well as marshes present a new vegetation.[4] Explaining that certain cryptogams are only found on certain artificial substances (such as white mold on ink), others on animal substances (such as parings of hooves, horn, and bone), some are peculiar to hospitals, and

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[1]Newman, Review of Vestiges, p. 959.

[2]CV I:178.

[3]CV VIII:111-12; IX:108-109; X:132.

[4]CV VIII:123; IX:109; X:132.

others specific to the modelling clay of sculptors, he concluded that these forms had probably been generated spontaneously.[1]

The Spontaneous Generation of Animalcules

Possibly, postulated Chambers, even "animalcules" were generated spontaneously. It is curious, he noted in the first nine editions, that these animals apparently reproduce only by fission. Although ova have been postulated, none have actually been seen. How, if they can indeed only reproduce by fission can they be transmitted to a vegetable infusion?[2]

Chambers has destroyed his own arguments, observed Sedgwick, since "on his own showing, animals which do spring from ova, undergo in the first instance this very process."[3] W. H. Allen quoted Owen's arguments against the spontaneous generation of the infusoria, and concluded that these studies argued against the spontaneous generation of all the minute animals.[4] Ova are very hardy, Bowen contended, and thus can often be found in most unlikely circumstances; inaccurate observations probably explain the instances in which microscopic animals appear to arise spontaneously.[5]

William Henry Smith writing anonymously for Blackwoods had a different view as to the nature of spontaneous generation. He

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[1]CV VIII:113; IX:110; X:132-33.

[2]CV IV:110-11; V:186; VIII:113.

[3]Sedgwick, Review of Vestiges, p. 68.

[4]W. H. Allen, Review of Vestiges, p. 312.

[5][Smith], Review of Vestiges, p. 457.

conceded that life may possibly be produced from the "decay and dissolution of some previous organization" in the animalcules but "here life still produces life, though like does not produce like."[1]

The first edition contained several allusions to animalcules and infusions not found in the other editions. In this edition, Chambers stated that under similar circumstances the same infusoria are always produced without being influenced by exposure to the atmosphere. It also described a progression of animal types in an infusion, remarking that at first the animals were simple, but after a while "become larger and more complicated in their structure."[2] He also speculated that when the quantity of water in an infusion was small the organic material produced was plant but when there was much water the organic forms tended to be animal.[3] Chambers was not convinced by the arguments of the opponents to spontaneous generation who claimed that an infusion must be in contact with the atmosphere in order for organic forms to appear. Although admitting that this possibly was correct, he stated a case for the alternative conclusion that the exclusion of the air prevented occurrence of some other condition necessary for the aboriginal development of life.[4]

Spontaneous Generation of the Entozoa

The minute parasitic "entozoa," able only to exist within

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[1][Smith], Review of Vestiges, p. 457.

[2]CV I:179-80.

[3]CV I:179-80.

[4]CV I:180; III:184-85; IV:184-85; V:187-88; VI:184-85; VIII:114-15; IX:111-12; X:134.

another living being, seemed to Chambers to preclude any possibility other than that they were created spontaneously. Chambers suggested in all of the editions that reproductively mature entozoa originated from particles of organized matter very closely related to the inorganic.[1]

Sedgwick admitted that the entozoa presented some problems difficult to explain, but denied that they offered evidence for the correctness of a theory of transmutation. Arguing from a teleological standpoint, he asked why, since they were provided with a means for continuing their existence in the usual way, is there any need for a different kind of origin.[2] W. H. Allen, as well as Sedgwick, was convinced that rational explanations for their presence would be discovered. Allen suggested that since food is brought from long distances, the entozoa ova could easily be brought with it.[3] Sedgwick stressed the hardiness of the ova and objected to Chambers' contention that they were too heavy to be carried in the air. "Partly on direct proof, and partly on analogy, . . ." he concluded that the "Entozoa were produced in the common way."[4]

William Henry Smith continued his approach that life may be produced from a different kind of living substance. Yeasts, he analogized, reproduce by means of buds sprouting from the parent; therefore, there is nothing inconceivable in the entozoa being produced

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[1]CV I:182-83; III:184-85; IV:184-85; V:187-88; VI:184-85; VIII:114-15; IX:111-12; X:134.

[2]Sedgwick, Review of Vestiges, p. 69.

[3]W. H. Allen, Review of Vestiges, p. 312.

[4]Sedgwick, Review of Vestiges, p. 70.

from the tissues of higher animals.[1] Although Chambers in a footnote in the tenth edition referred to new information about the entozoa which "removes a great deal of the difficulty about the propagation of entozoa & c. which formerly existed," he did not explain how this affected the doctrine of spontaneous generation.[2]

Additional Support for Spontaneous Generation

In all of the editions except the tenth, Chambers discussed other "facts" which would corroborate spontaneous generation. The appearance of organic forms in domesticated animals and on artifacts caused Chambers to conclude that these forms must have originated subsequent to man's appearance. Other examples, hydatids in the muscle of the domestic pig, a moth which attacks only dressed wool, an insect eating only chocolate, and the larva of oinopota cellaris which lives only in wine and beer, corroborated Chambers' belief in the probability of spontaneous generation.[3]

Both Sedgwick and Newman objected to Chambers' example of the hydatid in the muscle of domestic pigs, indicating that such forms had arisen after the domestication of the pig. Sedgwick asked, "has our author a clean bill of health for all the primeval pigs, . . . well attested by good medical naturalists in all ages before pork was eaten?"[4] According to Newman, no evidence was known to indicate that the hydatid did not exist in the wild pig, only that it was more

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[1][Smith]. Review of Vestiges, p. 457.

[2]CV X:134-35.

[3]CV I:183; III:186; IV:186-87; V:189-90; VI:186; VIII:115; IX:112.

[4]Sedgwick, Review of Vestiges, pp. 68-69.

common in the domestic varieties. "The hydatid of the pig, . . ." he concluded, "very probably thrives best on the animal whose flesh may be in an unnatural state from over-feeding. . . ."[1]

The wool moth, tinea, does not exclusively attack dressed wool, insisted both Sedgwick and Newman.[2] Newman reminded the reader "that farmers often hurry the wool into a bad market, to their great loss, rather than incur the greater loss incidental to the attack of these destructive insects."[3] Allen commented on Chambers' other two examples. "How does he know that his chocolate-eater will not thrive upon some of the materials of which chocolate is composed, . . ."he asked, or "that his wine-bibber may not satisfy his intemperate appetite without being immersed, like Clarence, in a 'Malmsey butt.'"[4]

The appearance of a fish found in subterranean cavities dating "from a time posterior to the arrangements of the earth for our species," suggested to Chambers that these fish must have represented a rather late spontaneous creation.[5] Sedgwick stated that these little fishes were "not more difficult to account for than the trout and other fishes found in the mountain lakes of Europe." He explained that subterranean forces, long dormant, occasionally erupt and "the

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[1]Newman, Review of Vestiges, p. 961.

[2]Sedgwick, Review of Vestiges, pp. 68-69; Newman, Review of Vestiges, p. 961.

[3]Newman, Review of Vestiges, p. 961.

[4]W. H. Allen, Review of Vestiges, p. 311.

[5]CV I:183-84; III:186-87; IV:187-88; V:190; VI:186-87; VIII: 115-16; IX:113.

lakes and all their contents are belched out of the craters, and fill the neighbouring valleys with pestilence and ruin."[1] W. H. Allen explained their presence in a different way. He postulated that the fish ova are "conveyed to all places by the birds which feed upon them, and start into life wherever the conditions are favourable to their development."[2]

Newman summarized his inclinations regarding Chambers' examples. "We build houses and towns, . . ." and "we never think of stocking them with rats, or mice, or cockroaches, yet how often do these animals take possession, and divide the tenement with man, even with the 'chivalric upper classes,' without any one attempting to account for their presence by hypothesis: and let us again inquire whether the animals enumerated are of that low rank which is a postulate with our author in new creations."[3]

The Acarus Experiments

Chambers' most notorious example of the production of the organic from the inorganic involved a report of a Mr. Crosse who claimed to have accidentally produced some "insects" in his laboratory while conducting experiments in crystallization. Even though there was almost universal disbelief on the part of most men of science, Chambers continued to include these experiments in all of the editions, blaming the lack of acceptance of scientists on their unfair prejudices. Huxley statedhis view of Chambers' tenacious inclusion of the

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[1] Sedgwick, Review of Vestiges, p. 69.

[2] W. H. Allen, Review of Vestiges, p. 312.

[3] Newman, Review of Vestiges, p. 961-62.

acarus material by the terse statement that "pages 133-138 are occupied by all the old nonsense about the Entozoa and Mr. Crosse's Acarus."[1]

In the first through fifth editions, Chambers considered Crosse's new production to have been hitherto unknown and referred to it as acarus crossii. In the sixth through tenth editions he did not describe it as a new species for by this time acarus crossii had been designated as the well-known acarus horridus, even though Chambers steadfastly continued to refer to it by the former name.

The humor of the history of the acarus-producing experiment impressed Sedgwick as well as Chambers' credulity in accepting it. Sedgwick characterized the creator of the new acarus, Crosse, as "a man of genius and rapid imagination . . ." who has "blundered among new and unlooked-for phenomena; . . . and who has probably "joined most heartily in a laugh against himself."[2] This "new" organism, according to Sedgwick, was a highly complex creature, belonging to the articulata instead of being a monad as would have seemed likely if a case of new generation had occurred.[3]

The reviewer for the British Quarterly Review also noted the exalted position of the new creation. Instead of being single-celled creatures as the developmental hypothesis would dictate, "they belonged to the highest type of the articulata, just where that class is supposed, by some Zoologists, to pass into the Vertebrata."[4]

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[1]Huxley, Review of Vestiges, p. 341.

[2]Sedgwick, Review of Vestiges, p. 70.

[3]Ibid., p. 71.

[4]Newman, Review of Vestiges, pp. 959-61.

Therefore, this reviewer concluded that if Crosse and Weekes had witnessed an act of creation they had observed an act of special creation. But he continued by explaining that Crosse and Weekes were not sophisticated enough scientists for their testimony to be of much value, for there were many possible sources of error in their experimental procedure.[1]

Newman also objected to an act of aboriginal creation producing such a complex organism. After explaining why the acarus was not a laboratory production, Newman argued that if such an animal had been created in the laboratory it would not represent a support for the Developmental Hypothesis. Since these animals are complex "at least as far as the Articulata are concerned; we need not trace our parentage to monads, the relationship might be allowed to cease with mites."[2]

"As men recovered from their first alarms, and were able to look steadily at the wonder, it was found that the Acarus crossii was an old but forgotten acquaintance--the Acarus horridus, which abounds in dirty shops, dusty shelves, and damp out-houses; and having a taste for pure physics, is especially abundant in all laboratories, and among the bottles of a chemists's shop," observed Sedgwick.[3] Miller also referred to the fact that Chambers' acarus crossii was in reality acarus horridus. The laboratory precautions were insufficient, he indicated, because the adult acarus is hardy

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[1] Ibid.

[2] Newman, Review of Vestiges, pp. 959-61.

[3] Sedgwick, Review of Vestiges, p. 71.

enough to withstand the temperature of boiling alcohol and the germs would, no doubt, be even more resistant. Another difficulty was noted by Miller. He explained that in order to rationalize the geographical distribution of the acarus, innumerable spontaneous generations would have had to occur all over the world.[1]

Both W. H. Allen and Bowen referred to the inadequacies of the precautions taken by Crosse and Weekes to eliminate the possibility of contamination. After Allen disclosed the fallacies in these experiments he referred to the experiments of Schulze of Berlin in which adequate precautions were taken and in which no acari were produced.[2] Bowen also referred to the experiments of Shulze in which the results were the opposite of those reported by Crosse and Weekes.[3]

Only two reviewers were disposed to consider the acarus experiments somewhat favorably. The writer of the Expository Outline was willing to admit that all of the evidence was not yet in on acarus crossii, and the reviewer for Blackwoods did not discount the possibility that Crosse and Weekes had produced acari.[4] But the latter reviewer remarked that "it is impossible to say that the germ of life was not previously existing in the fluid through which the electricity passed."[5]

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[1]Miller, Footprints of the Creator, pp. 240-42.

[2]W. H. Allen, Review of Vestiges, pp. 313-15.

[3]Bowen, Review of Vestiges, p. 455.

[4]Expository Outline, p. 48; [Smith], Review of Vestiges, p. 452.

[5][Smith], Review of Vestiges, p. 452.

Sedgwick included another "life-creating" example which summarized his opinion and that of most of the reviewers as to the relevancy of the acarus experiments. He explained that a "new monster, . . ." created in the laboratory, was "carefully packed, sealed, and forwarded to a great anatomist and by him submitted to the Microscopic Society of London." The grand moment of discovery revealed that the new production was nothing less than a carrot seed. Although "it was hard to preserve a becoming gravity, . . . the operators did what prudent men should do . . ." and inquired into the details of the experiment. They learned that the carefully conducted experiment had made use of a common garden pot into which to dip the "creative wires."[1]

Chambers described his version of Crosse's experiment in which the "new species" was produced. He explained that while Crosse was running a current from a voltaic battery through a saturated solution of silicate of potash the insects made their appearance. Chambers bemoaned the fact that Crosse, discouraged by the reception which his experiments received, did not continue his research; however, he was gratified that the effort had not been entirely abandoned but modified and refined by Weekes.[2]

Chambers noted, in the first through fourth editions that near the negative wire of the battery in Weeke's modifications "gathered a quantity of gelatinous matter." Since "gelatin is one of the proximate principles, or first compounds, of which animal bodies

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[1]Sedgwick, Review of Vestiges, pp. 71-72.

[2]CV I:185-86; III:188-89; IV:189-90; V:191-93; VI:187-88; VIII:116-17; IX:113-14; X:135.

are formed," he considered this important.[1] In the third and fourth editions he added a sentence not found in the first, explaining that "of course, we should require a further proof to satisfy us that the matter here concerned was actually gelatin."[2]

Sedgwick considered the illustration of the production of the gelatinous material to be convincing and berated Chambers for following "the lead of some hesitating critic" and adding the qualifying sentence in the third edition. Of course, gelatin was produced, concluded Sedgwick, for "a few drops of acid, properly applied, will gelatinize some of our hardest minerals. . . ." He explained that this "rock jelly" was an excellent food so there was no doubt but that the young acari were feeding upon it.[3] From the fifth through tenth editions, although the gelatinous material was mentioned, no statement was included about gelatin being a "proximate principle" of life.[4]

In all of the editions Chambers discussed the reception of novelties in science and concluded that if a novelty did not agree with the preconceived body of ideas on a subject, the new fact would probably just be dismissed. This is how Chambers explained the ungracious reception of the experiments of Crosse and Weekes. Chambers felt that since "it was held to be impious, even to surmise that animals could have been formed through any instrumentality of an apparatus devised by human skill," these experiments had no chance of

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[1] CV I:186-87; III:189-90; IV:190.

[2] CV I:186; III:189; IV:190.

[3] Sedgwick, Review of Vestiges, pp. 7-8.

[4] CV I:186-87; III:189; IV:190-91; V:193; VI:188-89; VIII:117; IX:114; X:135-36.

being accepted on their merits.[1]

Chambers argued that such charges of impiety were absolutely invalid, arising from "an entire misconception of what is implied by an aboriginal creation of insects." He explained in all of the editions that under no circumstances could one consider the experimenter as the creator of the new insect--he merely set up the conditions which had been preordained by God. He remarked that "on the hypothesis here brought forward, the Acarus crossi was a type of being ordained from the beginning, and destined to be realized under certain physical conditions. . . . The production of the insect, if it did take place as assumed, was as clearly an act of the Almighty himself, as if he had fashioned it with hands."[2]

Chambers closed this chapter in the tenth edition by insisting that "we do not present the Crossian experiment and other alleged cases of primitive generation as undoubted facts, or as indispensable parts of the present hypothesis," adding that although "we do not reject the alleged examples, . . . we do not attach to them a high degree of consequence."[3]

By carefully selected quotations, Sir David Brewster made Chambers' examples appear ridiculous. After quoting from Chambers' illustrations of "arborescent crystallizations on a frosty window, the "Arbor Dianae," the hydatid of the domestic pig, the insect which

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[1]CV I:187-88; III:190-91; IV:191-92; V:193-94; VI:189-90; VIII:117-18; IX:114-15; X:136.

[2]CV I:187-89; III:190-92; IV:191-93; V:195; VI:190-91; VIII:118-19; IX:115; X:136-37.

[3]CV X:138.

"will sip only chocolate," and another which "chooses only wine and beer," the fish pimelodes cyclopum of volcanic cavities, and the supposed laboratory production of acarus crossii, Brewster concluded that "from this indigesta moles, this collection of statements, which no man but our author believes, he proceeds to explain in the subsequent section, the hypothesis of the development of the vegetable and animal kingdoms. . . ."[1]

Since Chambers' examples of the creation of life spontaneously were so unfavorably criticized, he removed some of the examples from the later editions but allowed the most dubious example, the acarus creation, to remain unscathed throughout all of these editions. Never did Chambers address himself to the most potent criticism--that even if all of his examples proved to be correct the results would be opposed to a developmental philosophy, since most of the new organisms alluded to were not especially simple forms.

Chambers' entire chapter on the particular considerations was a disaster as far as the critics were concerned. Most of his facts were questioned and, although he modified the later editions in response to the criticisms, he left the fundamentals unchanged. While it was evident that Chambers did not ignore the reviewers it was equally obvious that he was not going to allow them to upset his initial preconceptions.

The Hypothesis

The reality of progression was now established. The implications from the evidence could no longer be denied, concluded Chambers. To

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[1]Brewster, Review of Vestiges, p. 497.

doubt its existence was to proceed unintelligently; both the general and specific examples suggested the truth of the developmental approach. But the mechanisms involved in the actual process were less easy to isolate. Throughout the various editions, Chambers increasingly recognized the problems involved in considering the organic world in terms of progressive development and modified his ideas accordingly to show how this development had proceeded.

Although even in the first edition Chambers realized that a "chain of being" approach was inadequate to solving the problem, he nevertheless considered development to have proceeded in a linear fashion through the four sub-kingdoms of Cuvier, the radiata, mollusca, articulata, and vertebrata. In this edition he explained that the evolutionary chain may be branched or doubled in some places or possibly "the whole may be in a circle composed of minor circles, as has been recently suggested."[1] But in the third through fifth editions he considered it probable that the two sub-kingdoms, mollusca and articulata, formed two distinct approaches to the vertebrata, indicating that there might be "more than two such great lines at various parts of the animal scale."[2] Even though the articulata might not be linear descendants of the mollusca, Chambers assured his readers that a general advance from the radiates to the vertebrates did occur.[3]

It was increasingly apparent to Chambers that a linear approach

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[1] CV I:191.

[2] CV III:194-95.

[3] CV III:194-95.

to the problem of succession was insufficient to explain the data. An alternative was proposed in Explanations although not incorporated into Vestiges until the later editions. W. H. Allen was critical of the new version in the Explanations and of the inconsistency between this interpretation and that of the Vestiges. Allen explained that "in the Vestiges, he contends for a 'general scale' of animated being; but finding that the vertebrate sub-kingdom descends so low as the cyclostomous fishes which he admits to be inferior to the crustacea and cephalopoda, creatures belonging to the articulata and mollusca, he makes this line so flexible that it can be bent downward into loops, and so slack-twisted that it diverges, in some places, into two or more separate threads." The alternative proposed in the Explanations was little better, for its complex system of stirpes was "fanciful," declared Allen, and was not consistent with the facts.[1]

It was not until the sixth edition of Vestiges that Chambers proposed his alternative to a linear approach to evolution, a system of multiple lines or "stirpes." Although the new system was used in the sixth through ninth editions, only in the tenth edition was it explained in the introduction to the chapter.[2] The deficiencies in the fossil record, reported Chambers in this edition, could be accounted for by discounting the idea that progress represented "a pure, simple series of equal transition, . . ." and replacing it with the concept that there has been "a plurality of lines, in which there have either been some comparatively wide leaps, or else intermediate

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[1] W. H. Allen, Review of Vestiges, pp. 320-21.

[2] CV VI:194-96; VIII:120-21; IX:117-18.

species which have been lost to observation."[1] Two specific lines of progression were mentioned in the sixth, eighth, and ninth editions but omitted from the tenth--the exchange of the trilobite for limulus and that of the brachiopods for the lamellibranchiates.[2]

Although in all of the editions Chambers acknowledged the inadequacy of the fossil record, specific deficiencies were noted only in the third, eighth, and ninth editions. In the third edition he observed that even though the vertebrata possess the highest organization, the lowest vertebrate form, the cyclostome fish, appears more primitive than certain invertebrate articulates and mollusks. He did not attempt to explain this in light of the Developmental Hypothesis for, after mentioning it as a problem, he ignored its implications and concluded that a general progress had occurred.[3]

Chambers did not allude to the example of the cyclostome fish in the eighth and ninth editions, although he referred to different specific inconsistencies of the fossil record. The problems surrounding the early appearance of the complex cephalopods, the doubt as to whether cartilaginous fish were actually primitive or advanced, and the complex teeth of the first saurians were presented as examples of the inadequacies of this record.[4]

Rather than approaching the problem of the unreliability of the known palaeontological evidence by the use of specific examples,

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[1] CV X:140-41.

[2] CV VI:195; VIII:121; IX:118.

[3] CV III:195. See footnote 3, previous page for W. H. Allen's discussion.

[4] CV VIII:121; IX:118.

Chambers' approach in the tenth edition was a more general one with an attempt to explain why certain appearances seemed to be in opposition to an hypothesis of development but in reality were not. One possibilityof error, he observed, related to a mistaken idea of the nature of a primitive organism. He declared that although "the initial genera of the various orders, though always of humble organization comparatively, are not always liable to be described as positively so."[1]

In the sixth through tenth editions, Chambers indicated that the apparent decline in size from certain early forms to their more recent descendants indicated to some that progress had not occurred. However, in the tenth edition, he offered an explanation, as he sought to dispel the idea that "the first animals of all the various orders were very small and ill-fashioned. . . ." Instead, he insisted that these base animals were "always perfect, . . ." and often "are of large bulk as compared with other genera of their own orders. . . ."[2]

Plants and Animals are Constructed According to a Fundamental Unified Plan

After concluding that in spite of limited evidence to the contrary the bulk of the support suggested the occurrence of progressive development, Chambers turned to a comparative anatomical approach for a different kind of evidence. Since it was of basic importance to him to show the underlying uniformity of law behind the operations of both the inorganic and organic at all levels, it was

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[1] CV X:141.

[2] CV X:141.

desirable for him to attempt to demonstrate a fundamental unity of structure and function between divergent members of the animal kingdom. The first unifying factor, explained Chambers, is the "primeval germ" which represents at once the primary and ultimate stage of one group of animals as well as the fundamental stage from which ontogenetic development proceeds in all other forms. The order of the presentation of examples in this discussion varied between the first five and the last five editions, but the significance of this change is only important in illustrating the continued revisions to which the book was submitted.

Rudimentary organs as exemplifying this fundamental unity were described in the first part of the chapter in the first five editions, whereas in the sixth through tenth editions the discussion appeared later in the chapter. A different approach to the problem of apparently useless organs is found in the first five and the last five editions. Whereas in the earlier editions he viewed them as the forerunners of perfect organs in the animal at the next level in the developmental scale, in the last five editions he considered them as the degeneration of organs "when we advance into an adjoining or kindred family. . . ."[1] Although the interpretation changed from the early to late edition types, the examples did not. He used the same examples, the rudimentary limbs of snakes, the useless mammae of males, and, in all editions but the first, the useless pouch of the male marsupial to support both positions.[2] In the tenth edition, Chambers included a footnote which stated that the rudimentary organs of all animals

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[1] CV I:193-94; III:197; IV:196-97; V:198; VI:199; VIII:124; IX:121; X:145.

[2] CV I:193-94; III:197; IV:197; V:199; VI:199-200; VIII:124; IX:121; X:144-45.

probably had functions although they were not obvious to the observer.[1]

The change in view as to the nature of the rudimentary organs may have been encouraged by a statement of the reviewer W. H. Allen who assumed that Chambers considered these organs to have no function. Allen stated that this view of rudimentary organs "is altogether gratuitous," explaining that there were other organs "of which anatomists have not yet discovered the use; but it is not their custom to pronounce them blemishes and blunders on account of their own ignorance."[2]

Even though whale embryos possess rudimentary teeth they are never developed, declared Chambers in all of the editions. Replacing them in function is a new structure, the baleen which is brought forward. The modifications resulting in the baleen of the whale and the lungs of mammals were described.[3] Both Sedgwick and Huxley criticized Chambers' assumption that in mammals both gills and lungs are present at some stage in development with the gills acting in the foetal stage after which they degenerate. The converse situation in the fish with the gills fully developed and the lungs appearing in the rudimentary form of an air bladder, was also incorrectly interpreted, they assumed.[4]

Sedgwick accused Chambers of presenting a statement which "is one mass of gross blunders," in which he misunderstood the nature

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[1]CV X:144.

[2]W. H. Allen, Review of Vestiges, p. 322.

[3]CV I:193; III:196-97; IV:197; V:199; VI:199; VIII:124; IX: 121; X:144.

[4]Sedgwick, Review of Vestiges, p. 77; Huxley, Review of Vestiges, p. 341.

of the air bladder and indicated incorrectly that the mammalian foetus breathes by gills." "It is true," he agreed, that the foetus of a mammal floats during all its progress, in a watery fluid; and at the stage we are here considering, its limbs are ill matured, and a person of lively fancy (like this author) might say that 'they resembled' the fins of a fish; but they are not made up of rays, nor have they the anatomical structure of fins; and the development of the brain is, at this period, absolutely different from that of a fish."[1]

Huxley was equally sharp in his criticism, declaring that Chambers had "absurdly mistaken" the "bronchial clefts" for a "branchial apparatus" in his statement that foetal mammals have a branchial apparatus which recedes, with the lungs developing from a different part of the organism.[2]

Rudimentary organs, stated Chambers in the first five editions, are more evident in groups which are links to other groups. To illustrate this supposition, he first discussed the affinity of the marsupial with the oviparous vertebrates. He explained that this relationship was indicated "by the rudiments of two canals passing from near the anus to the external surfaces of the viscera, which are fully developed in fishes, being required by them for the respiration of aerated waters, but which are not needed by the atmosphere-breathing marsupials."[3] Ostrich-type birds with their rudimentary wings, a diaphragm, urinary sac, and hair-like feathers form a link

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[1] Sedgwick, Review of Vestiges, p. 77.

[2] Huxley, Review of Vestiges, p. 341.

[3] CV I:194; III:198; IV:198-99; V:200-201.

between birds and mammals and represent another example. The duck-billed platypus, at the base of the mammalia, shows its relationship to the birds by the presence of its bill and webbed feet.[1]

Reorganization as an important factor in Chambers' revisions was again apparent. Whereas in the first five editions he presented additional examples of unity of structure after the previously discussed examples, in the sixth through tenth editions he used the same examples to introduce the discussion. All vertebrates, including the long-necked giraffe, he noted, have the same number of cervical vertebrae.[2] The reviewer for Blackwoods objected that whereas those physiologists interested in showing a uniform plan throughout the vertebrates point out that all quadrupeds regardless of the length of their necks have seven cervical vertebrae, they neglect to explain that the number in birds varies from nine to twenty-three and in reptiles from three to eight.[3] Uniformity of structures extends to man. The kinship of man with other quadrupeds, postulated Chambers, is suggested by the os coccygis of human subjects."[4]

The reviewer for Blackwoods objected to Chambers' use of the uniformity of plan throughout the animal kingdom to illustrate transformism. Uniformity, remarked Smith, "is a curious fact" and all that can be concluded from it is "that it appears to hint at the existence of some law," and might "tempt the investigation of the

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[1] CV I:194-95; III:198-99; IV:199; V:201.

[2] CV I:195; III:199; IV:199; V:201; VI:197; VIII:123; IX:120; X:143.

[3] [Smith], Review of Vestiges, p. 458.

[4] Ibid.

physiologist."[1]

Although in all of the editions, Chambers illustrated the fundamental unified plan with the limbs of quadrupeds, reorganization was again apparent, for the position of this material differed in the first through fifth editions and in the sixth through tenth. Many similarities are evident, observed Chambers in each edition, between the leg of the horse, the wing of the bat, and the limbs of a human being. In all of the editions except the third and fourth, he compared the paddles of the whale to the appendages of land vertebrates.[2] Even the apparently limbless snakes do not really form an exception since they possess these structures in a rudimentary form, stressed Chambers in the first and fifth editions.[3] In the sixth through tenth editions, Chambers used the additional analogy between the arm of a man and the wing of a bird.[4] A diagram comparing the anterior limbs of the fish, bird, dolphin, deer, bat, and man was included in the tenth edition.[5]

After discussing the unity of structure in the animal kingdom, Chambers included a short section in each edition indicating that the same unity was also present in the plant kingdom. He concluded that, as in the animal kingdom, when there is a need for a particular

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[1] Ibid., p. 457.

[2] CV I:196; III:199-200; IV:200; V:200-203; VI:196-97; VIII:122-23; IX:119-20; X:142-43.

[3] CV I:197; V:203.

[4] CV VI:197; VIII:122; IX:119; X:142-43.

[5] CV X:143.

structure the usual provision is to modify a structure already present rather than to create a new one.[1]

In all of the editions Chambers summarized the implications of a fundamental unity. This unity exists within the organic world, and would imply the transmutation of one form to another. If rudimentary organs are not explained on the basis of a developmental philosophy then these organs, noted Chambers, "would be regarded in no other light than as blemishes or blunders--the thing of all others most irreconcilable with the idea of Almighty Perfection which a general view of nature so irrestibly conveys."[2] In the sixth through tenth editions he referred back to the macrocosmic unity explaining that the planets "stand in a connexion resembling that in which . . ." [they] "are placed by the third law of Kepler." He also stressed that just as it was inconceivable to imagine a separate creation for each planet it was even more so to imagine such for each species of organism.[3]

The Embryological Evidence for Gradation

Chambers discussed the significance of embryology as evidence for gradation in all of the editions. In the first edition, he stated that "each animal passes, in the course of its germinal history, through a series of changes resembling the permanent forms of the various orders of animals inferior to it in the scale."[4] Although

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[1] CV I:197; III:200]201; IV:201; V:203; VI:200-201; VIII:124-25; IX:121-22; X:145.

[2] CV I:198; III:201.

[3] CV VI:201-202; VIII:125; IX:122-23; X:146.

[4] CV I:198.

he reached approximately the same conclusions in the later editions, his method of approach was changed to that of an historical summary. He explained in the third through ninth editions that the following propositions were the fundamental tenets of embryology: "1. that the embryos of all animals are not distinguishably different from each other; 2. that those of all animals pass through a series of phases of development, each of which is the type or analogue of the permanent configuration of tribes inferior to it in the scale."[1]

Chambers' use of embryology to support his hypothesis was criticized by his reviewers. Sedgwick, although he agreed with Chambers as to the importance of embryological changes, argued that "they affect not our author's argument one jot; unless he can show some want of fixity in the phenomena which flow from them."[2] But, he insisted, such a lack of fixity was impossible since

> parents produce an offspring like themselves. Eagles do not hatch owls; geese do not hatch rats, (whatsoever our author may dream;) and no tropical heat can ever bring a beast from the eggs of a reptile.[3]

Therefore, Sedgwick concluded that no embryological changes could affect the general question.[4]

Sedgwick became more specific in his criticisms of Chambers' embryological arguments. Although he admitted that the early cleavage steps in the embryology of higher vertebrates "do resemble that observed in the fissiparous generation of monads," he asserted that

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[1] CV III:202; IV:203; V:205-206; VI:203; VIII:126; IX:123.

[2] Sedgwick, Review of Vestiges, p. 73.

[3] Ibid.

[4] Ibid.

this was only an analogy and not representative of a fundamental relationship. After this early resemblance the embryo continues to develop but never does it pass through stages resembling the mature radiata, mollusca, or articulata. He triumphantly proclaimed that "thus are three whole classes of the animal kingdom passed over without any corresponding foetal type, and in defiance of the law of development."[1]

Sedgwick further argued that the uniqueness of the embryo at various stages in its development was guaranteed by its special germinal membrane destined to aid in the formation of nascent structures. He concluded that "we cannot hatch a rat from a goose's egg, because all the organic membranes evolved during the process have a prospective reference to the ultimate form of a bird; and it is physically impossible, if they be not fatally interrupted, that they should end in any thing else. . . ."[2]

Other reviewers were equally unconvinced by Chambers' embryological arguments. The reviewer for Fraser's Magazine declined to attack Chambers concerning the details of foetal transformations, but recommended Sedgwick's Discourse on the Studies of the University of Cambridge to dispel the doubts of those "who, having imbibed their opinions from the Vestiges, still retain them."[3] Brewster, by skillfully interspersing Chambers' words with his own, made the theory of recapitulation appear highly improbable without including any specific criticisms.[4] Bowen also considered the recapitulation

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[1] Ibid., pp. 74-75.

[2] Ibid., pp. 75-76.

[3] Review of Vestiges, Fraser's Magazine, p. 371.

[4] Brewster, Review of Vestiges, pp. 497-98.

argument invalid because, he insisted, beneath superficial similarities are underlying basic differences.[1] "If the embryo of one of the mammalia pass through the foetal stages of the fish and the bird, the embryo fish bears the same transitory resemblance to the foetal condition of the bird or the mammal, . . ." proving nothing, asserted Smith in Blackwoods, except that "some deviations of form are in all cases assumed before the final shape is adopted."[2]

In response to these critics, Chambers modified the two embryological propositions of the earlier editions. He added an introductory qualifying statement which explained that "for some years its primary propositions were these. . . ." In the tenth edition, Chambers remarked that whereas the first proposition remained correct the second needed modification. His modification consisted of a statement of von Baer's that "a heterogeneous or special structure arises out of one more homogeneous or general, and this by a gradual change." Therefore, although the embryo generally resembles the groups inferior to it, it does not actually pass through phases identical to the lower animals.[3]

Huxley criticized Chambers' statement which gave credit to the "illustrious Harvey, . . ." Hunter, Tiedemann, St. Hilaire, and Serres for the development of the science of embryology, while he ignored the work of Wolf and von Baer. He also explained that if the "Vestigiarian had ever read a page of Harvey," he would realize that

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[1]Bowen, Review of Vestiges, pp. 458-59.

[2][Smith], Review of Vestiges, p. 456.

[3]CV X:147.

Harvey's source was the carefully executed work of Fabricius.[1]

In all of the editions except the first, Chambers explained that recapitulation tended to be more applicable when individual systems were concerned than when the whole animal was involved.[2] W. H. Allen agreed, but insisted that Chambers attempted to apply the theory to the whole animal. Chambers' assumption "that every human being was once a zoophyte, and that he has passed in succession through every grade of being" was incorrect. All that the recapitulation hypothesis proves, Allen asserted, is that "some parts of a mammal foetus of the highest order do bear some resemblance, in certain stages of their development, to corresponding parts of some of the inferior animals, at some stage of their development."[3]

Even by changing his position Chambers was unable to please the reviewers. Smith, in Blackwoods, took exception to his statement that only parts, not the whole animal undergo embryonic transformations in which, in certain stages, they resemble the adult of more primitive forms.[4] Therefore, he was criticized for both statements that the whole animal undergoes embryonic transformations and that recapitulation is more applicable to individual parts than to the whole.

Chambers used the recapitulation theory in individual systems to explain phylogenetic discrepancies in the third through fifth editions but not in the sixth through ninth. By considering the

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[1] Huxley, Review of Vestiges, p. 341.

[2] CV III:202-203; IV:203; V:206; VI:203-204; VIII:126; IX:123; X:147.

[3] W. H. Allen, Review of Vestiges, p. 323.

[4] [Smith], Review of Vestiges, p. 456.

individual systems, he wrote in the third and fourth editions, "an explanation of such phenomena as the superiority of the highest mollusks to the lowest vertebrates" might be found.[1] In the fifth edition Chambers stated approximately the same thing but in general rather than specific terms, observing "an explanation of the fact that a low class sometimes ascends in its highest forms to a point above the lowest forms of a class held on general grounds to be superior."[2]

In all of the editions Chambers presented examples of recapitulation, although the order of appearance of these illustrations varied from edition to edition. The insect, explained Chambers, "a highly complex articulate," passed through an annelid-like state in its larval form.[3] In the third through fifth editions he added that the worm-like form had previously passed through "the forms of the polype, helioanthois, and arenicola."[4] He compared the larval stages to the mature forms in the fossil record in the tenth edition, thus again attempting to establish in this edition the relationship of the development of the individual to the development of the species.[5]

After discussing the insect, Chambers described the embryology of the crab as a recapitulation of the adult forms of lower animals.

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[1] CV III:202-203; IV:203.

[2] CV V:206.

[3] CV I:198; III:203; IV:204; V:207; VI:204; VIII:127; IX:124; X:148; 152-53.

[4] CV I:198; III:203; IV:204; V:207.

[5] CV X:148.

In the first edition he explained that the crab embryo "resembles the perfect animal of the inferior order myriapoda, and passes through all the forms of transition which characterize the intermediate tribes of crustacea."[1] In the third through tenth editions, Chambers' illustration differed from that of the first as he explained that the crab embryo resembles the "perfect animal of the inferior order entomostraca, and passes through the forms of transition which characterize the intermediate tribe of crustacea."[2] In the tenth edition, he added an additional interpretation stating that the first crustacea were entomostracous with the crab and lobster appearing much later; a diagram depicting the metamorphosis of the crab was also included in this edition.[3]

Sedgwick disapproved of Chambers' inclusion of invertebrates in the embryonic sequence. No vertebrate animal, he explained, after the first rudiments of its structure are laid down, conforms to the type of the invertebrate although in the beginning a vague similarity might be observed.[4] In the tenth edition Chambers modified his earlier statement noting that

> it must be at once admitted, that we do not possess such an intimate and exact knowledge, either of the history of life on the globe or of the embryonic history of an individual organism of the highest rank, as to entitle us to say that there is a perfect resemblance between the two. Nevertheless, although the larva of the insect is not a perfect annelid, or that of a tadpole a perfect fish--there is an embryonic

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[1] CV I:198-99.

[2] CV III:204; IV:204; V:207; VI:204; VIII:127; IX:124; X:152.

[3] CV X:152.

[4] Sedgwick, Review of Vestiges, pp. 83-84.

character about both of them--still they are "essentially" annelid and fish.[1]

Chambers described the fish-like larval form of the frog in all of the editions to further illustrate the doctrine of recapitulation.[2] To refer to the frog tadpole as a fish because it possesses gills is objectionable, complained Sedgwick. The "branchial fissures" are present in all of the vertebrates at some stage in their development but are different in each vertebrate class; an anatomist can easily distinguish the gills of a mammalian embryo from those of a fish.[3]

Owen, noted Sedgwick, agreed with his statement that various vertebrate groups possess different respiratory apparatuses. While frogs and fish breathe by branchial tufts and gills, wrote Sedgwick of Owen's views, "other amphibia and birds are breathing by allantois; and never, for an instant breathe by gills."[4] He continued by asserting that at the same period when most mammals were respiring by means of both allantois and placenta, man breathes by the placenta alone.[5]

Only in the tenth edition did Chambers decline to describe the steps through which man would ontogenetically pass in recapitulating the phylogenetic succession. From his first form, "that which is permanent in the animalcule" through the various intermediate stages including a later phase in which "he exhibits an intermaxillary bone,

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[1]CV X:150-53.

[2]CV I:198; III:204; IV:204-205; V:207-208; VI:205; VIII:127; IX:124; X:153.

[3]Sedgwick, Review of Vestiges, pp. 76-77.

[4]Ibid., pp. 78-79.

[5]Ibid.

which is characteristic of the perfect ape" he eventually becomes "a true human creature."[1]

Sedgwick disagreed with Chambers' first supposition that all ova were the same.[2] His quarrel continued as he quoted Dr. Clark's Memoir on Foetal Development which asked "with what shadow of reason can any school of anatomists pretend to say, that one order of animals can pass into another order in the way of ordinary gestation, seeing that the indispensable respiratory foetal organs are so different in each?"[3] Although Sedgwick admitted that all of the vertebrates were constructed on a similar general plan, he insisted, however, that foetal differences were just as real as adult differences. He explained that "the parts laid down may be so ill defined that a fanciful person might call them, while in early progress, by some name suggested by his imagination; but he has no right to overlook the inseparable organic appendages, which have all a reference to the perfection of the animal form; are all prospective contrivances, and imply, by anatomical necessity, the subsequent and more perfect conditions of existence."[4]

But these subtleties escaped Chambers. He was not even content to allow embryological progress to halt at the appearance of man but followed it throughout the races of man to reach its culmination in "the adult Caucasian, the highest point yet attained in the animal

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[1]CV I:199; III:204-205; IV:205; V:208; VI:205; VIII:127-28; IX:124-25.

[2]Sedgwick, Review of Vestiges, p. 74.

[3]Ibid., pp. 78-79.

[4]Ibid., p. 77.

scale."[1]

Although the order of the presentation of the illustrative material varied in the different editions, a discussion of embryonic development as related to two specific organs, the brain and the heart was included in all editions. The comparative anatomy of these structures was discussed in all the editions except the tenth. Instead, in this edition, Chambers compared these structures in the various vertebrate classes by means of diagrams. These organs, concluded Chambers, in the adult forms pass through the stages which are permanent in the adults of the lower groups.[2] He included a footnote in the third edition which indicated that the phylogenetic development of systems from the primary phase of a simple cellular substance was also recapitulated in the development of the embryo.[3]

Sedgwick disagreed with Chambers' conclusions regarding the developmental implications of the embryological stages in the formation of the heart. Paraphrasing Chambers' contention that the heart of a mammal first represents the single tube heart of an insect, advancing to a two-chambered condition in the fish, through a three-chambered amphibian-like stage, finally arriving at a mammalian four-chambered heart, Sedgwick concluded that although these statements contained "some positive truth," the conclusions were basically false. He explained that when the development of the human heart was studied in detail, it was evident that it does not pass through the form which

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[1]CV I:199; III:204-205; IV:205; V:208; VI:205; VIII:128; IX:125.

[2]CV I:200-201; III:205-206; IV:205-206; V:208-209; VI:206-207; VIII:128-29; IX:125-26; X:149.

[3]CV III:207.

is permanent in the amphibia but through a form which is not permanent in any known creature.[1] "Neither let it be said, . . ." insisted Sedgwick, "that the heart of birds and mammals, when in the condition of a single tube, is identical with a corresponding condition of the heart of fishes; for in the former case there are no aortic valves, while in the latter they are essential."[2]

As he had previously alleged was the case with the heart, Sedgwick claimed that the brains of the different vertebrate classes were more alike than different. He accused Chambers of using for his sources "one or two superficial works" on this subject while ignoring the many standard productions. Inaccuracy and "a most ignorant representation of facts" characterized Chambers' discussion of the embryology of the brain, claimed Sedgwick. He alluded to Chambers' statement that "ventricles and corpora striata are only found in mammals." These structures, he asserted, are found in lower classes as well. Chambers' statement that during the nine-month gestation period of the human foetus its brain resembles successively that of an insect, a fish, a turtle, a bird, a rodent, a ruminant, a wolf, and a monkey, showed that Chambers was again befuddled by his tendency to consider appearances reality.[3]

After discussing the relationship between ontogenetic and phylogenetic development, Chambers attempted to correlate embryological development with the fossil record. In the first edition he explained

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[1] Sedgwick, Review of Vestiges, pp. 79-81.

[2] Ibid., p. 81.

[3] Ibid., pp. 81-82.

that embryonic stages of the modern fish resemble the mature fish of the old red sandstone. This comparison had been made previously in the chapter on the old red sandstone, and he only repeated the example in the first edition. In this edition he stated that a geologist had inquired "if the fish which existed before the Old Red Sandstone had any peculiarities assimilating them to the foetal condition of existing fish, and particularly if they were small."[1] Chambers agreed with this unnamed geologist in indicating that the discovery of a small ancestor was important, a position inconsistent with his later views that many of the ancestral forms were large. But in the first edition he was pleased to note that some of the early fish "are so extremely minute as only to be distinguishable by the microscope."[2]

An additional example of the correlation between ontogenetic and phylogenetic development was included in the third through tenth editions. The free-swimming starfish, comatula, at one stage was attached by a stalk to the sea bottom and it was, at this point, essentially a crinoid. Turning to global history, Chambers then indicated that the crinoids of the early fossil record had been replaced in the oolite by "animals of the form of the mature comatula."[3]

In the third through ninth editions, Chambers mentioned that the salmon embryologically passed through phases characteristic of mature cartilaginous fish.[4] Instead of the salmon, Chambers used

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[1] CV I:202.

[2] CV I:202.

[3] CV III:203; IV:204; V:206-207; VI:204; VIII:127; IX:124; X:151.

[4] CV III:204; IV:204; V:207; VI:204-205; VIII:127; IX:124.

the white-fish as an example in the tenth edition, writing that it is "one of the most highly organized of its class."[1] In this edition, the examples were arranged phylogenetically with the illustrations of the whitefish and frog presented at the end of the discussion.

In attempting to correlate the history of the embryo with the history of the globe, Chambers admitted, in the tenth edition, that the data did not indicate a "perfect" resemblance between the two, but stressed that "there is a striking resemblance, and every addition to our knowledge helps towards establishing a complete one."[2] Chambers' revised views as to the method of the developmental progression were apparent in the tenth edition discussion of embryonic and phylogenetic parity. In this edition he noted, besides the vertical "a kind of lateral advance from the more general to the more special."[3] Applying this position to geological history, he concluded that the early vertebrates such as the fish should be very general in form. This was in fact the case, he asserted, since these early forms had characteristics of both invertebrates and of the highest vertebrates. Chambers concluded that since the appearance of similarity between ontogenetic development and occurrence in the fossil record did occur, the same cause was no doubt in effect in both instances.[4]

The Principle of Progressive Development

Chambers had finally arrived at the point where he was willing

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[1] CV X:248.

[2] CV X:249.

[3] CV X:153.

[4] CV X:154.

to formally present his hypothesis. Although he presented it in each edition, his own evolving ideas concerning progressive development were apparent from his changes in presentation from the first four to the last three editions. The fifth and sixth editions were intermediate between the two edition types. The developmental principle as stated in the first four editions was that of an uncomplicated series of forms each giving rise to a slightly more advanced type. In these editions Chambers stated that "the whole train of animated beings, from the simplest and oldest up to the highest and most recent, are, then, to be regarded as a series of advances of the principle of development, which have depended upon external physical circumstances, to which the resulting animals are appropriate."[1]

In the first edition alone, Chambers speculated on the question of whether the whole of a given species was moved forward at once or whether only a chosen few organisms of a series were destined to become the progenitors of the next higher group. If the first method were correct, Chambers explained, it would involve simultaneous moves all up and down the line "so that the place vacated by one species was immediately taken by the next in succession, and so back to the first. . . ."[2]

The more complicated view proposed by Chambers in the fifth through tenth editions illustrates his new approach to progression. In these editions he noted two types of developmental advances. The first was the gradual advance from one grade to the next through

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[1] CV I:203; III:208; IV:208.

[2] CV I:222.

an "impulse" by the ordinary means of generation. These "grade" advances, which reached their apex in the dicotyledons in the plant kingdom and the vertebrates in the animal, were few. Although grade advances are independent of physical conditions, environmental conditions are responsible for the adaptations that occur within the grades. This two-strand idea was first tentatively proposed in the fifth edition.[1]

In the eighth through tenth editions, Chambers stated the hypothesis with a measured emphasis not found in the other editions. It was in order to present the simplest explanation, he noted, one "appealing to and allying itself with science, instead of resting on a dogmatic assumption of ignorance, that I bring forward on this momentous occasion the principle of PROGRESSIVE DEVELOPMENT."[2] Although in the fifth and sixth editions he did not present such a pompous statement of the principle, the explanation of the mechanics of the system was similar to that in the eighth through tenth editions.[3]

The simplicity of the developmental approach was one of its characteristics which made it so appealing to Chambers. In the first edition he praised it as an

> idea more marked by simplicity than perhaps any other of those which have explained the great secrets of nature. But in this lies, perhaps, one of its strongest claims to the faith of mankind.[4]

Chambers recognized the strength of a simple approach in the later

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[1] CV V:211; VI:209; VIII:131; IX:128; X:155-56.

[2] CV VIII:130; IX:127; X:155.

[3] CV V:211-13; VI:209-11.

[4] CV I:203.

editions as well, asking "would not a well-supported hypothesis as to the deposition of seed, the penetration of sap, the expansion and bursting of the germ, and the sprouting forth of the stalk, be greatly preferable to remaining under some hazy, unsupported hypothesis as to a miracle being required for every individual plant."[1]

The Developmental Hypothesis was desirable to Chambers, not only because of its simplicity but also because of its Platonic implications. Chambers included in the first through fourth editions a footnote which made it evident that he was aware of the Platonic emphasis of his theory. "When I formed this idea, . . ." he wrote, "I was not aware of one which seems faintly to foreshadow it--namely, Socrates's doctrine afterwards dilated on by Plato, that "previous to the existence of the world, and beyond its present limits, there existed certain archetypes, the embodiment (if we may use such a word) of general ideas; and that these archetypes were models in imitation of which all particular beings were created."[2]

In all of the editions Chambers summarized development throughout the animal kingdom with an explanation of his concept of the mechanism involved in the advance. The more simplistic concept of the earlier editions was apparent in this discussion.

The Nucleated Vesicle

The "nucleated vesicle," Chambers explained in every edition, is the fundamental form of life, i.e. the meeting place between the inorganic and organic. This nucleated vesicle is both an independent

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[1] CV III:208; IV:208; V:211; VI:208; VIII:130; IX:127; X:155.

[2] CV I:204; III:209; IV:209.

organism and the starting point of the embryonic processes in higher animals.[1]

How, asked Chambers in each edition, was this nucleated vesicle originally formed? The chemicals comprising these vesicles can be produced in the laboratory. In the first edition, Chambers explained, as he had earlier in the text, that a compound similar to albumen, urea, had been created in the laboratory. Albumen is important, Chambers stressed in the first through ninth editions, because it is possible that an actual nucleated vesicle can be produced in it by an "electric agent." But after the first edition, Chambers eliminated the reference to the creation of urea, and in the tenth edition omitted any reference to the possibility that a nucleated vesicle had actually been produced.[2] In the tenth edition Chambers cautiously explained that the proximate principles were theoretically, or in some cases actually, producible in the chemical laboratory. In this edition he noted that after the production of the proximate principles only the production of the "nucleated vesicle" was necessary to bridge the gap between the inorganic and organic.[3]

The bridging of this gap is not such an impossible supposition. It is probable that the living was produced from the non-living by means of a "chemico-electric" operation.[4] Although in the first

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[1]CV I:204; III:209; IV:209; V:212; VI:209-10; VIII:131; IX:128; X:156.

[2]CV I:204-205; III:209-10; IV:209-10; V:212; VI:210; VIII:131; IX:128; X:156.

[3]CV X:156.

[4]CV I:204-205; III:209-10; IV:210; V:213; VI:210; VIII:131; IX:128; X:156-57.

through fifth editions Chambers inquired as to what followed the creation of the nucleated vesicle, only in the first edition did he attempt an answer.

The Transmutation of Living Forms

In a vegetable infusion it is possible to observe the process of development in progress. "Simple forms are produced at first, but afterwards they become more complicated, until at length the life-producing powers of the infusion are exhausted." An advance from the simple to the complex occurs in the infusion, analagous to that which occurred throughout the entire creation.[1] After the illustration of the infusion, the third through fifth editions joined the first to suggest that after the first living thing came "an advance under favour of peculiar conditions from the simplest forms of being, to the next more complicated, and this through the medium of the ordinary process of generation."[2]

Sedgwick was highly critical of Chambers' statement that he had taken existing natural means and shown them to have been capable of producing all the existing organisms. "He has not shown this; and we affirm that he cannot show it; and to prove his point, he has taken the unnatural means of falsifying the documents of nature."[3] Sedgwick was unimpressed by Chambers' assertion that even though no definite proof might be adduced for his hypothesis he was certain that it was correct. Chambers had nothing, he objected, but "bare assertions"

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[1] CV I:205.

[2] CV I:205; III:210; IV:210; V:213.

[3] Sedgwick, Review of Vestiges, pp. 31-32.

to support his hypothesis.[1]

The writer of the Expository Outline, while not noting anything in the Developmental Hypothesis which was impious or hostile to the moral and social interests of the community, observed that the law of development merely evaded the question "by the substitution of one mystery for another."[2]

Chambers' theory differed from those of Lamarck and St. Hilaire, stated W. H. Allen. Chambers attempted to reconcile "the doctrine of final causes with transmutation of species and unity of plan in organized bodies," while they did not. Allen was willing to credit Chambers with originality here in trying "to make out a logical impossibility, and to balance himself securely upon both horns of a dilemma."[3] This originality resulted, continued Allen, in his ability to substitute an "unintelligible for an intelligible cause of the supposed transmutations."[4]

In the sixth through tenth editions, Chambers was also concerned with what occurred after the creation of the nucleated vesicle; the more complex approach of these editions to the problem of development was obvious. The two-thread approach was again presented. There are two phenomena to be accounted for, explained Chambers, "first, grade; and second, external peculiarities." The first approach, he insisted, involved accepting the possibility

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[1] Ibid., p. 31.

[2] Expository Outline, pp. 50-51.

[3] W. H. Allen, Review of Vestiges, pp. 318-19.

[4] Ibid.

that a fish could advance to be a reptile and a reptile a bird. Even though such a grade transition has never been seen by man, it is likely that such advances had occurred in the many years before the appearance of man. According to Chambers, only three grade transitions would have occurred before the production of the vertebrates. He assumed that "such a leap in organic progress has, therefore, only taken place once in many millions of millions of years."[1]

Illustrations of the Developmental Hypothesis

Appearances may be deceiving, advised Chambers, for even though grade transformations may have never been observed by man, it is probable that they occurred before man's appearance on earth. He assumed that if the totality of existence could be reviewed, forms could be observed being transformed into the next more advanced group. Chambers proposed hypothetical solutions for transitions from one group to the next.

Mr. Babbage's Calculating Machine

An example taken from Babbage in the Ninth Bridgewater Treatise provided an illustration outside of the fields of geology and zoology to testify to Chambers' assumption that appearances might be misleading. In all of the editions, Chambers described Babbage's calculating machine and noted how a series of numbers was repeated predictably until one hundred million and one. At this point it seemed reasonable to assume that the next number would be one hundred million and two; however, this was not the case--the next number was one hundred

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[1]CV VI:211-12; VIII:131-32; IX:128-29; X:157.

million ten thousand and two.

The machine continued to operate predictably until it seemed apparent that a law was involved and then switched to another predictable series of numbers. The new law was again superseded by another.

Chambers then applied this illustration to the transmutation of forms, and insisted that since the gestation of an entire creation took such a long time it was most probable that translations from one form to the next would not be seen. To further illustrate this idea, Chambers described a hypothetical ephemeron "hovering over a pool for its one April day of life" observing the young tadpoles in the water. Since no change would be observed in the tadpole's form during that afternoon the ephemeron would be incapable of imagining that a frog would be the end result. Chambers explained that "precisely such may be our difficulty in conceiving that the advance of plants and animals by generation to a higher type of being is a possibility of nature." "Mr. Babbage's illustration, . . ." he concluded, enables us to understand how this ordinary procedure may be subordinate to a higher law which in proper season interrupts and changes it."[1]

Writing of Chambers' use of Babbage's calculating machine as a support for his theory, Sedgwick asserted that "we think this, perhaps, the most unspeakably preposterous instance of bad reasoning in the whole volume"[2] Trying to apply mathematics "where life, imagination, and mind are the subjects of our thoughts, is rank folly, . . ." he

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[1]CV I:206-11; III:210-16; IV:210-16; V:213-18; VI:212-18; VIII:135; IX:129-32; X:158-61.

[2]Sedgwick, Review of Vestiges, p. 66.

contended. Sedgwick did not quarrel with the use of the machine within the context for which it was intended, but for it to be "dragged before the public (we doubt not to the inexpressible disgust of Mr. Babbage) only to cast light upon the precious philosophy of resemblances," is inexcusable.[1]

Smith agreed with Sedgwick, arguing that "it is absurd to talk about "the law of Babbage's calculating machine, since "his machine partakes only of the laws of mechanics, which, we presume, are as constant there as elsewhere."[2] This reviewer defined a law as an invariable, therefore, "deny its constancy, and you deny it to be a law; it is a mere contradiction in terms to speak of a law that changes." By applying this definition to "a law of animal life which changes of itself from time to time," this reviewer concluded that Chambers had departed "from the fundamental principle of all science."[3]

Brewster, however, was not unimpressed with Chambers' illustrative use of Babbage's calculating machine which he considered an admirable device, and agreed that "we cannot tell what changes of law are to appear in the future." But he disagreed with Chambers' conclusion that scientists were unaware of what preceded us in the geological past. Brewster was assured that "the chronicle of geological events is now so complete, that we do know what has happened in preceeding ages," and averred that if the Developmental Hypothesis was correct there would be ample fossil evidence to corroborate it.[4]

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[1] Ibid.

[2] [Smith], Review of Vestiges, pp. 455-56.

[3] Ibid.

[4] Brewster, Review of Vestiges, pp. 498-99.

Newman also admitted that the work of Babbage was an ingenious undertaking but agreed with Brewster that "we totally deny its applicability to the purely physiological question; and this on the simple ground, that Mr. Babbage's machine, however wonderful, is under his own control. . . ."[1]

The Mechanism of Progression

After having presented evidence for the feasibility of translations from one group to the next higher group, Chambers attempted to explain how such changes might occur. In the first through ninth editions, he reviewed the embryological evidence that indicated that the embryos of the higher groups passed through successive stages which were permanent in the lower groups. In these editions, Chambers included a chart to illustrate how these embryological data could relate to the transmutation of forms. As indicated by this illustration, the foetuses of the four vertebrate classes proceeded identically to the first level of the chart at which place the fish foetus diverged, passing along its own individual line to its culminating point. The other classes proceeded upwards along the line until the reptile diverged, followed by the bird and mammal.[2] Although Chambers did not include the chart in the tenth edition, he concluded that "it becomes very clear, that the protraction of the more general condition, at some given stage, till a higher special point was reached--overleaping, as it were, the intermediate space--

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[1]Newman, Review of Vestiges, p. 956.

[2]CV I:212-13; III:217-18; IV:216-18; V:219-21; VI:218-19; VIII:136; IX:133.

is all that is necessary for an advance from one grade of being to another."[1]

The idea that a germ destined to become one of a different race advances along the usual line and then diverges and follows a different path up to the period of its birth into a new creature is ridiculous, insisted Bowen. Why don't fish generate reptiles today, he questioned? It is most unlikely that nature today is judicious and reasoning while at first it was blind, absolute, and invariable.[2]

Chambers was inconsistent in his discussion of the nature of the germ between the first edition of Vestiges and Explanations, noted W. H. Allen. Whereas, Allen indicated, Chambers did not explicitly state in Vestiges that all germs were identical, he certainly implied it; in Explanations "he denies that he has asserted their identity but still is careful not to assert the contrary."[3]

A search for the possible mechanism for such a transition caused Chambers to speculate in all of the editions. The only condition necessary for the advance from one grade to the next, he stated in all of the editions but the tenth, is that the fish embryo not diverge at its customary place but continue on to the next level. A reptile rather than a fish then results. But this is not an explanation of cause. Although he avoided discussing cause in the sixth through tenth editions, he attempted an explanation in the earlier ones. In the first and third editions, Chambers speculated

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[1]CV X:162.

[2]Bowen, Review of Vestiges, p. 463.

[3]W. H. Allen, Review of Vestiges, pp. 318-19.

that the cause might be "certain external conditions operating upon the parturient system," and in the fourth and fifth that some "impulse, natural, though perhaps inscrutable," is responsible for the advance.[1]

Smith, in Blackwoods, explained that physiologists who had made microscopic studies of the embryo were convinced that "the embryo of the higher animals pursues a different course of development, from the very earliest stages, to that of the lower animals."[2] Therefore, he concluded, a mammal is destined from the very beginning to become a mammal not a reptile or bird. "It cannot be, therefore, . . . that the same germ which is nourished up to a certain point to be a fish, would, if transferred to other care and a better system of nutrition, be nourished into a bird or mammal," stated this reviewer.[3]

Chambers in the first and third editions stressed that even though the actual mechanism for the grade transitions may not be known, the fact that certain modifying effects "only somewhat short of a transition from species to species" indicate strongly that such transitions probably did occur at some time. In the fourth and fifth editions, he explained that the hypothesis was the guide, indicating as he had in the first and third editions that many modifications almost as radical as transformations from species to species had occurred.[4]

This Platonic procedure annoyed Sedgwick. "I have, says he

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[1]CV I:213; III:218; IV:218-19; V:221-22; VI:219; VIII:136; IX:133; X:157.

[2][Smith], Review of Vestiges, pp. 82-83.

[3]Ibid.

[4]CV I:214; III:218-19; IV:219; V:222.

to himself, an hypothesis with which my mind is satisfied; and there must therefore be something within the natural range of things for my hypothesis to rest upon," concluded Sedgwick concerning Chambers' mental processes.[1] That Chambers was beginning to question the force of physical events in influencing progression as early as the fourth edition was apparent from his stated inability to decide in this edition whether the "universal gestation of nature" was merely the result of time as in individual development or whether it involved specific associated conditions to cause the advance.[2]

Illustrations of Development

Chambers presented an illustration in all of the editions to show that "development is still daily seen at work to certain effects, only somewhat short of a transition from species to species."[3] Sex, he explained, is a developmental phenomenon. All individuals are at one stage in the embryonic process female and progress toward the more perfect male form. Although in the first edition he did not discuss the previous proposition, in the tenth edition he stated that they passed from a neuter stage to "the more powerful sex."[4]

Chambers was incorrect, insisted Sedgwick. He ignored the best authorities for even though they agreed that at an early stage it was impossible to distinguish one sex from the other this did not

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[1]Sedgwick, Review of Vestiges, p. 65.

[2]CV IV:219.

[3]CV I:214; III:218-19; IV:219; V:222; VI:219; VIII:136; IX:133-34; X:162.

[4]CV III:219; IV:219; V:222; VI:219; VIII:136-37; IX:133-34; X:162.

imply that such a distinction was not there. At a certain early developmental stage it was even impossible to tell the lungs from the liver, he noted.[1]

W. H. Allen also disagreed with Chambers' view of sex as a developmental phenomenon. He argued that "everybody knows that gestation is not more protracted when a male is produced than when a female is."[2]

Bees were described by Chambers in all of the editions as being illustrative of sex as a developmental phenomenon. In every edition except the first, he credited a contemporary physiologist, Huber, with research on sex determination in bees.[3]

Although Sedgwick admitted that Huber's work on bees had value as a physiological effort, he denied that it had any relevance to Chambers' developmental scheme. There would be value in this kind of speculation only if "he can show that the sex of a lamb, a calf, or a foal depends upon a longer or shorted period of gestation." Slashing again at Chambers' undocumented theorizing, Sedgwick suggested that "if his mind is troubled with any doubts upon this subject, (but it is not much its nature to let doubts stand in the way of theory,)" he should close Huber's book and "consult some honest British cattle-breeder who will tell him all about the matter."[4]

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[1]Sedgwick, Review of Vestiges, pp. 82-83.

[2]W. H. Allen, Review of Vestiges, p. 325.

[3]CV I:214-16; III:219-22; V:222-25; VI:220-22; VIII:137; IX: 134-35; X:162-63.

[4]Sedgwick, Review of Vestiges, p. 83.

Time, Chambers explained, is the important factor in determining which sex will be produced--a female bee develops for sixteen days, a neuter twenty, and a male twenty-four. In all of the editions but the tenth, he stated that "these changes may be produced by a mere modification of the embryotic process, which it is within the power of the adult animals to effect."[1]

Chambers had misinterpreted Huber, stated W. H. Allen, for Huber did not indicate that the bees could adjust their sex themselves. Neither are the worker bees neuters, but females. "Bees, . . ." he concluded, "will do nothing for our author, except to convict him of distorting facts and misquoting authorities."[2]

Bosanquet disagreed with Chambers' assumption that sex was a matter of development. There is no evidence, he asserted, for believing that neuter larvae could by any prolongation of their gestation period become males.[3]

Changes in external conditions function "merely to accelerate the period of the insect's perfection" not to work a direct change on the embryo, explained Chambers in the first four editions. From the time of oviposition there is a distinction between the sexes of young bees because the queen lays all of the eggs which are destined to become workers before those which will become males. This results from the condition of the queen's reproductive system for "when her impregnation is delayed beyond the twenty-eighth day

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[1]CV I:215-16; III:220-21; IV:221; V:224; VI:221; VIII:138; IX:135.

[2]W. H. Allen, Review of Vestiges, p. 325.

of her entire existence, she lays only eggs which become males."[1]

An additional support for sex as a developmental phenomenon was included in the fifth through tenth edition footnotes. In the creeping willow, twigs above the water blossom as females whereas those which have been in the water and subsequently bloom after the water has dried up blossom as males.[2]

The bee example is very important as an illustration of the principle of development, stressed Chambers, even though it is confined to the production of sex. Since there is a unity throughout nature, an extrapolation can be made from development in the production of sex and development as a more universal phenomenon.[3]

The production of variety in species is also explained by the Developmental Hypothesis.[4] It is fully established, stated Chambers in all of the editions, that a human family, tribe, or nation can be advanced from a lower form to a higher or degraded from a higher to a lower in response to external conditions. When negroes lived in a state of barbarism they possessed "coarse features, and other structural peculiarities" but these features became more refined when they moved to a more temperate climate. Conversely, "well-formed and good-looking" people under "miserable conditions" would eventually show "an unequivocal retrogression towards the types of the lower

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[1]CV I:216; III:221; IV:222; V:224-25; VI:222; VIII:138; IX:135; X:163.

[2]CV V:225; VI:504-505; VIII:308; IX:306; X:163.

[3]CV I:216-17; III:222; IV:223; V:225; VI:222; 504-505; VIII:138; IX:306; X:163.

[4]CV I:217; III:222; IV:223; V:225; VI:223; VIII:138; IX:135; X:163-64.

animals. He concluded in all of the editions that "both effects are simply the result of the operation of the law of development in the generative system."[1] Reflecting his early view as to the importance of external conditions in producing change in organisms, Chambers stated in the first through fourth editions that given favorable conditions an organism advances, but given unfavorable ones it regresses. In these three editions he speculated that the reason changes of species no longer seem to occur is that the external conditions necessary for the advance are no longer present.[2]

"Monstrosities" also furnish evidence for development. Sometimes the heart of a human proceeds no "farther than the three-chambered form, so that it is the heart of a reptile."[3] The cause of such defects, he explained in the first through fourth editions, is "nothing more than a failure of development in the system of the mother, occasioned by weak health or misery."[4] In each edition he interpreted this as a "realization of the converse of those conditions which carry on species to species, so far, at least as one organ is concerned." Chambers found it easy to imagine the converse of this situation--a condition which well could result in transitions from one species to the next.[5]

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[1] CV I:218; III:223; IV:224; V:225-26; VI:223-24; VIII:139; IX:135-36; X:164.

[2] CV I:218; III:223; IV:224.

[3] CV I:218; III:223-24; IV:224; V:227; VI:224-25; VIII:139; IX:136; X:164.

[4] CV I:219; III:224; IV:224-25.

[5] CV I:219; III:224; IV:225; V:227; VI:224; VIII:139; IX:136; X:164-65.

It is "no great boldness" to conjecture, reported Chambers in the first three editions, that a "super-adequacy" of such a force "would suffice in a goose to give its progeny the body of a rat, and produce the ornithorhynuchus, or might give the progeny of an ornithorhynchus the mouth and feet of a true rodent, and thus complete at two stages the passage from the aves to the mammalia."[1]

Among other absurdities, stated Sedgwick with disgust, Chambers believes that "by a double process of incubation he can hatch a rat from a goose's egg." This example illustrates beyond a doubt that Chambers' "credulity is quite on a level with his rashness."[2] In the fourth edition, Chambers modified his statement to say that this super-adequacy would suffice to accomplish the purpose of "carrying forward the last of the reptilia into--we shall say hypothetically--the first of the mammalia."[3] But the more colorful first edition language reappeared in the fifth and remained throughout the rest of the editions.[4]

In the sixth through tenth editions, Chambers explained that what really disturbed scientific men about his theory was "in conceiving the particulars of such a process as would be required to advance a fish into a reptile."[5] However, he could not understand why this should be a great difficulty--the metamorphosis of the

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[1] CV I:219; III:224-25.

[2] Sedgwick, Review of Vestiges, p. 11.

[3] CV IV:225.

[4] CV V:227-28; VI:224-25; VIII:139-40; IX:136-37; X:165.

[5] CV VI:225; VIII:140; IX:137; X:165.

tadpole into the frog seemed to represent an excellent example as to how a fish could turn into a reptile. He saw this transformation as being hypothetically the same as a grade advance even though in the case of the frog it was only a process in ordinary generation. The retrogressive example of batrachians which never undergo metamorphoses but merely grow into gigantic tadpoles was mentioned, for "here the progeny of a reptile literally becomes a fish, and transition of species as thoroughly realized, although in retrogression."[1] This example was especially impressive to Chambers since it involved the whole animal. He concluded that "that which we see nature undo she is able to do, and might be seen doing, if the proper occasion were to occur, or were the requisite attendant conditions realized."[2]

Chambers included a section of his "two-thread" approach to development. This discussion was omitted from the earlier editions, although certain of the examples were included, since Chambers had not yet arrived at this view of the Developmental Hypothesis.

After announcing that he had completed his discussion concerning grade transitions, in the later editions Chambers proposed to consider "that part of the hypothesis to which we are to look for an account of the external variations and adaptations of animals."[3] The prevalent doctrine--that like produces only like with only a small amount of allowable individual variability leading to a fixed and immutable species--ignores facts which would weaken its acceptance.

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[1] CV VI:225-26; VIII:140; IX:137; X;165.

[2] CV VI:226; VIII:140; IX:137; X:165.

[3] CV VI:226; VIII:140; IX:137; X:165.

Only those ideas were allowed which would bolster its preconceptions. Chambers proposed to show that "this doctrine is in such a condition with regard to facts, and has of late been obliged by facts to make so many shifts in its assumptions, that it is not entitled to the respect usually assigned to it."[1]

Why, asked Chambers, does a germ usually develop into a form resembling its parents? Is there anything innate in it which predestines it to follow this usual course? There is no reason to assume, he concluded, that it possesses "a certain capacity of development peculiar to itself."[2] It might only be "bound down to the attainment of the parental form by being kept and nourished by the parent." Huxley, in answer to this assertion asked whether "this profound naturalist ever heard of a cuckoo, or of an ichneumon fly. . . ."[3]

"Species," wrote Chambers in the sixth through tenth editions, is a term with a variety of meanings. The proponents of fixity attach "the term species to every organism which manifests the same peculiarities throughout a series of generations."[4] He criticized the readiness of naturalists to apply a specific determination on any animal population which varies, however slightly, from another. "An extra-plication in the enamel of a fossil pachiderm's tooth, is, . . ." for example, "sufficient to obtain a specific name for that animal,

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[1] CV VI:226-27; VIII:141; IX:137-38; X:166.

[2] CV VI:226-27; VIII:141; IX:137-38; X:166.

[3] Huxley, Review of Vestiges, p. 341.

[4] CV VI:227; VIII:141; IX:138; X:166.

and constitute its origin a separate miracle."[1] Chambers was convinced that if the doctrine was really considered with the species as previously defined, "we should possess a fact speaking strongly against fixity of species."[2] It would mean that one species has been replaced by another in comparatively recent times, for in the case of certain of the latest fossil plants such as poplars, pines, and birches, some exist today which are almost the same but yet variable enough to be considered specifically different.

Although Chambers admitted that the descriptions of ancient botanists were not exact enough to allow of a specific comparison with existing forms, current examples of new species being found in districts previously thoroughly described by modern botanists indicated to him that speciation might have occurred. He used an article from Gardner's Chronicle as his source and accepted its conclusion that it was unlikely "that botanists were so mole-eyed thirty years ago, that their quick sighted successors have been able to add twenty-five per cent. to the number of ascertained species growing at their own doors."[3]

Many examples can be collected, wrote Chambers in the sixth through tenth editions, to show that forms which have been named as species are not absolute. One example, described in detail in these editions and mentioned in the third edition, was the illustration that in the thallogen group "it is even uncertain whether this matter will reproduce its like, and whether it is not a mere representation

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[1]CV VI:228; VIII:141; IX:138; X:167.

[2]CV VI:228; VIII:141; IX:138; X:167.

[3]CV VI:228; VIII:142; IX:139; X:167.

of the vital principle of vegetation, capable of being called into action either as a Fungus, and Alga, or a Lichen, according to the particular conditions of heat, light, moisture, and medium, in which it is placed; producing Fungi upon dead and putrid organic beings, Lichens upon living vegetables, earth, or stones; and Algae, where water is the medium in which they are developed."[1]

In the fifth edition, Chambers asked if "after such an array of facts, can it reasonably be said that specific distinction is rigidly maintained in the current era?"[2] He was even more definite in the sixth through tenth editions, questioning with "what respect, it may be asked, can we attach to the doctrine of intransibility of species, when we find its adherents wrong in so many instances."[3] In the fifth edition he evaded the problem by stating that varieties, not species, were involved in the contradictory examples. But, wrote Chambers in the sixth through tenth editions, even if this assumption were granted it would not be significant to the species problem. "What <u>is</u> species, . . ." he asked, "if it cannot be fixed upon such a vast assemblage as the Thallogens, or even the progeny of the Thelophora sulphurea?" In the tenth edition he stated categorically that those who considered species a fixed thing knew nothing at all about the question.[4]

W. H. Allen was willing to admit that a species could be modified in a limited manner in response to environmental conditions.

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[1]CV III:227-28; VI:230-31; VIII:142-43; IX:139; X:168.

[2]CV V:230.

[3]CV VI:233-34; VIII:145; IX:142; X:171.

[4]CV V:228-29; VI:229-30; VIII:142-43; IX:139; X:171.

But he insisted that these variations were within very strict limits and that by reverting to the original conditions the original type would reappear.[1]

Many of the examples were common to the different editions. In the third through tenth editions Chambers explained that cowslip, primrose, oxlip, and polyanthus, formerly regarded as different species were found to develop from one set of seeds under differing environmental circumstances.[2] He explained in the sixth through tenth editions that the clove, pink, and carnation were currently considered to be merely new varieties, not new species.[3] In the fifth through tenth editions, he wrote that the artichoke and cardoon are in reality a single species as are ranunculus aquatilis and ranunculus hederaceus.[4]

In the first four editions, Chambers mentioned that even though science has no such facts on record, the transition from one species to another may occur in the "obscurer fields of creation." Even if data confirming transformism were presented to the scientific community there would be little chance that they would be accepted, since the doctrine of life producing life is so strongly entrenched.

A credible example of one species being transformed into another in present times would strengthen Chambers' case for the Developmental Hypothesis. He was convinced that he had found such an example in the transformation of one species of grain into a different

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[1] W. H. Allen, Review of Vestiges, p. 324.

[2] CV III:227; IV:227; V:338; VI:231; VIII:143; IX:140; X:169.

[3] CV VI:231; VIII:143; IX:140; X:169.

[4] CV V:228; VI:231; VIII:143-44; IX:140; X:169.

form. In the first through fourth editions, he mentioned it as "one direct case of a translation of species, which has been presented with a respectable amount of authority," citing an article by a Dr. Weissenborn, in the Magazine of Natural History, as the source. In the first through fifth editions, Chambers explained that oats which were kept cropped down during the summer and autumn and allowed to remain over the winter would produce a thick crop of rye at the next harvest.[1]

Although never accepting the report that oats had been transformed into rye, Newman was willing to acquiesce for the sake of argument. But even accepting this transformation as a premise, he found it difficult to reconcile this transition with Chambers' proposal of small advances from one species to the next. Newman objected, asking "whether the author is aware that, in a natural series hundreds certainly, and thousands probably of species intervene between the two plants which he has named as belonging to separate natural families of plants: if the oat of agriculture were to indulge in metamorphotic vagary from one species to another, it would, at the lowest possible estimate, have to take hundreds of simple and modest stages from species to species, before it became rye."[2]

W. H. Allen suggested a possible explantation for the supposed transformation of the grains. He postulated that seeds too heavy to be carried by air might be transported from one place to another

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[1] CV I:221; III:225-26; IV:226-27; V:229.

[2] Newman, Review of Vestiges, p. 962.

in the alimentary canals of birds and subsequently germinate.[1]

According to Sedgwick, the transmutation of oats to rye was probably a fable. But he contended that even if this transmutation were proved to have actually occurred it "makes nothing (as he himself indeed allows) for his general argument."[2]

The reviewer for the Athenaeum did not speculate as to whether or not this transformation had actually occurred. But, he concluded, if it had occurred, it would only emphasize that "the botanical characters of the genus and species in this instance have not been accurately understood."[3]

In the third and fourth editions Chambers speculated about the importance of the examples of transmutation within the cereal groups. The change of oats into rye represented an especially impressive example of transformation since botanists had often ranked oats and rye in different genera, he wrote in the third edition. Even if one insisted on maintaining that variation stopped short at the present of forming new species it shows very concretely how changing environmental conditions can effect an organism. Thus, it is easy to conceive that in the geological past only a slight bit more power would have been needed to effect a transformation from one species to another. Chambers found confirmation in the fossil record, explaining that species did "follow each other in an order at once of

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[1] W. H. Allen, Review of Vestiges, p. 322.

[2] Sedgwick, Review of Vestiges, p. 68.

[3] Review of Vestiges, Athenaeum, p. 12.

development and of time."[1]

Although Chambers also used the example of the transmutation of one grain form into another in the sixth through tenth editions, he broadened the scope to include more grains, stating that "wheat, barley, oats, and rye, are found to be resolvable into one."[2] In these editions it was stated that wheat which was mown down so that it would not fruit until the next season would produce partly rye or some other cereal. He also explained that oats would be transformed into rye, barley, and even wheat. Although formerly this evidence had not been verified, recently "it has been tested by experiment, and reported on by so many credible persons, that it can no longer be rejected."[3]

In the tenth edition Chambers included a footnote which qualified the acceptance of the grain transformation. It was a quotation from a manuscript--Notes of a Physiologist, in which the author declared that upon examination of the corn grains he found them to differ so much one from another that he found it difficult to believe in their mutual convertibility. However, this question was not included in the text.[4]

In the first four editions, Chambers mentioned that the succession of different trees in the forest might represent transformation.[5] Newman insisted that even if one accepted that forests of a different kind succeeded those which were burned because the burned

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[1]CV III:229; IV:228; V:226-27.

[2]CV VI:232; VIII:144; IX:141; X:169.

[3]CV VI:232; VIII:144; IX:141; X:169.

[4]CV X:169-70.

[5]CV I:221; III:226; IV:227.

specimens were transformed into the new form, "it were introducing a second hypothesis more startling than the first, to suggest that the new species had sprung from the ashes of the old."[1]

Poorness of the soil has the same effect as mowing down in causing transformations from one type of grain to another, wrote Chambers in the sixth through tenth editions. In a wheat field near Lucerne a crop was found with "ears resembling barley but with grains similar to rye, growing from the same stem with ears of wheat."[2] In these editions, Chambers cited Dr. Lindley as not considering this transformation from one cereal form to another unlikely. In the tenth edition only, Chambers added a new confirmatory fact in a footnote, explaining that "after these facts had been presented in several editions of the present work, challenged on merely speculative grounds, but never truly shaken, botanists were astonished, in 1852, by the announcement of M. Fabre, that an experiment conducted by him during twelve years with the wild grass, Aegilops ovata, had resulted in its transition into true wheat. . . ."[3] Lindley's commentary on this transformation was also discussed in the footnote; he concluded that the grain transformation was very probable.[4]

In the fourth through ninth editions, Chambers presented another example which challenged the idea of the fixity of species. He explained that cabbage, savoy, broccoli, and cauliflower are all

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[1]Newman, Review of Vestiges, pp. 962-63.

[2]CV VI:232; VIII:144; IX:141; X:170.

[3]CV X:170-71.

[4]CV X:171.

descendants of a wild sea-shore plant, brassica cleracea.[1]

W. H. Allen agreed with Chambers' assessment of the relationship between the cabbage, savoy, broccoli, and cauliflower. But he did not note a conflict between this fact and the idea of the fixity of species, since all of these forms would, under suitable circumstances revert to their type form.[2]

After completing his illustrations of transformation within the plant kingdom, Chambers in the sixth through tenth editions considered examples of transition within the animal kingdom. Although he stated his intention to pass over the succession of forms found in infusions discussed in earlier editions he mentioned a new discovery concerning alternation of generations; he remarked that "such matters are as yet obscure, however highly they may promise in time to illustrate this question.[3]

Huxley did not accept Chambers' statement that alternation of generations was an obscure topic. He wrote that

> this ignorance is the more unpardonable, as though the author of the Vestiges is totally unacquainted with foreign literature, the perusal of Professor Owen's 'Parthenogenesis,' published years ago, would have been amply sufficient to give him more just ideas. But we suppose it was pleasanter to generalize than to learn.[4]

Fresh water mollusks if they survive when placed in salt water assume a form of shell typical to marine forms. This involves a very radical departure from the shell of the parent mollusk.

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[1]CV IV:229; V:229-30; VI:233; VIII:144-45; IX:141.

[2]W. H. Allen, Review of Vestiges, p. 324.

[3]CV VI:234-35; VIII:145; IX:142; X:171.

[4]Huxley, Review of Vestiges, p. 341.

These differences are certainly marked enough to cause them to be specifically unique and Chambers conjectured that they might even be placed in a separate tribe or family. He also explained that the modification of the stomach of a shell-fish-eating trout, the thickened parietes of the stomach of a corn-fed common gull, and the peculiar form of mandibles of many birds are now found to be externally modifiable.[1]

Domestication can produce startling changes in the varieties of animals, reported Chambers in the sixth through tenth editions. The goose, cow, and hog especially reflect the results of domestication, he stated.

In the third edition he described the lengthening of the legs of the domestic pig turned out in the wilderness, the "change from the lean, bare dog of Turkey, to the short, thick, well-furred dog of Siberia" as illustrations of results of environmental conditions on so-called species. He again expressed dissatisfaction with the species concept in the sixth through tenth editions when he stated that the term species is "merely applicable to certain appearances presented, perhaps transiently, to our notice."[2]

The tenacity of scientists in holding to an accepted theory even when new facts make it necessary to modify it considerably, was apparent in the history of the problem of fixity of species, wrote Chambers in the sixth through tenth editions. Scientists, he explained, began with the observation that like usually produces like and from this basis postulated that species is determinate. But, he added, as

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[1] CV VI:235-38; VIII:145-46; IX:142-43; X:172.

[2] CV VI:238; VIII:146-47; IX:143-44; X:173.

new facts were acquired it became necessary to invent "varieties" in order to keep the axiom intact. And when more contradictory data were acquired it became necessary either to change the classification so that only varieties were involved or to impugn the veracity of the examples.[1]

Chambers was highly critical of both of these procedures, claiming that it was "a process the reverse of philosophical: it is to start with a theory, and then make facts succumb to it;" his very procedure in writing the Vestiges! If the facts were examined without reference to preconceived ideas, it would be apparent "that a great modifiability exists in organic nature, especially in the humbler departments of the two kingdoms."[2]

Chambers noted in the tenth edition only, in a footnote from Carpenter's General Physiology, that the lower groups were more sensitive to environmental changes than the higher and responded to these environmental stimuli by modifying their development. He also concluded that the same principle applied to the early conditions of the higher organisms; their embryos, "like those beings of permanently-low type which they resemble in degree of development, being liable to be affected by modifying causes, which the perfect beings of the same kind are able to resist."[3] He concluded that the reason for the greater variability of the lower forms is their short gestation period.[4]

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[1] CV VI:238-39; VIII:147; IX:144; X:173-74.

[2] CV VI:238; VIII:147-48; IX:144-45; X:174.

[3] CV X:174.

[4] CV X:175.

Man's view of the fixity of species can be compared, wrote Chambers in the sixth through tenth editions, to his former view of the fixity of the sun's position in the universe. Just as the solar system is now known to be slowly changing its position in the universe, if we consider a large enough span of time species will also be seen to be changing.[1]

What is necessary, asked Chambers in the sixth through tenth editions, to keep variants from reverting back to their original types? An animal with a peculiarity of form must unite with a creature with a similar variation in order for the peculiarity to be preserved, he concluded.

In order to answer those individuals who asked why, if speciation had happened in the past it was not still occurring, Chambers explained that during the time of most of the speciation many of the available niches were unfilled. To judge the geological past in terms of a "fully-peopled" modern world would be engaging in a terminal fallacy, for in the past new fields of existence were constantly being opened up by new environmental opportunities. Chambers assumed that since organisms tended to be "pressing" upon the verge of the local means of subsistence, new environmental possibilities may have been explored by individuals. For example, "it might be that individual wading birds began to advance into dry grounds and woods, elected to the new life by some of those varieties of appetency which occur in all tribes; thus exposing themselves to new influences, and ceasing to experience those formerly operating, until, by slow degrees, in

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[1]CV VI:240-41; VIII:148-49; IX:145-46; X:175-76.

the course of a vast space of time, the characters of the pheasant tribe were evoked."[1] The isolation of the variants from the rest of the population made their absorption back into the original population less likely in the past than it would be in the present with most of the niches filled. When these animals were isolated, the probabilities of reunion were less, although depending on the degree of variation recombination could still occur.[2]

But Recombination could occur only between members of the same stirps, stated Chambers in the sixth through tenth editions. Plants, he explained, which "in different soils and climates have diverged from the original form of the first created individual, . . ." would "refuse to bear seed by the one which has departed most widely, and yet produce it readily by another, which still agrees with it in some important points."[3]

If one admits, reported Chambers in the sixth through tenth editions, that certain plants varied enough so that they would not interbreed, "the grand basis of specific distinction, the possibility of intermixture, can no longer be laid hold of."[4] For "plants and animals of one line are only to be expected to unite, which being of one grade of organization, are also sufficiently near to each other in those peculiarities liable to modifications from external causes, on which the so-called distinctions of species are grounded."[5]

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[1]CV VI:242-43; VIII:150; IX:147; X:176-77.

[2]CV VI:242-43; VIII:150; IX:147; X:176-77.

[3]CV VI:244; VIII:150-51; IX:147-48; X:177.

[4]CV VI:244; VIII:151; IX:148; X:177-78.

[5]CV VI:244; VIII:151; IX:148; X:177-78.

With these statements, Chambers announced in the sixth through tenth editions that the illustrations of his hypothesis were closed and in the succeeding sentence summarized the evidence for his theory. Although he admitted that rigid proof had not been attained, the consistency of the totality of the evidence pointed to the impression that "VESTIGES, at least, are seen of the manner and method of the Creator in this part of his work."[1] Science does not have "one positive affirmation on the other side," claimed Chambers in the eighth through tenth editions. Immutability of species "appears as merely one of the prejudices formed in the non-age of our race, and which it becomes the manhood of humanity to discuss."[2]

Chambers presented a chart of animal relationships taken from Fletcher's Rudiments of Physiology in the first through fourth editions. This scale corroborated his early Developmental Hypothesis; it was formed independently and without knowledge of that hypothesis and yet it agreed with it.[3] However, in the fourth edition he stressed that the chart was merely a rough approximation, since no really natural system existed.[4] He mentioned specific objections, particularly the placing of the articulata in a straight line continuing from the mollusca.[5] He also stressed that the mammalia advanced in several lines rather than one, illustrating his development

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[1]CV VI:246; VIII:151-52; IX:149; X:178.

[2]CV VIII:152; IX:149; X:178-79.

[3]CV I:223-27; III:232-35; IV:232-35.

[4]CV IV:232.

[5]CV IV:232-33.

towards the later multiline concepts. He justified his continued inclusion of the scale by stating that it was the best availabe; however, he omitted it altogether from the later editions.[1]

Sedgwick could countenance many of Chambers' other blunders more easily than he could the inclusion of this "grand creative scale arranged in four parallel columns." While acknowledging that it was impossible to produce an accurate scale, Sedgwick assailed Chambers for not using the best material available but instead, "without giving his readers any notice of his artifice, he arranged the palaeontological forms in accordance with his own hypothesis."[2] "The whole pretended order, . . ." complained Sedgwick, "is one mass of error."[3] The fish were in the wrong place, birds placed six steps above their rightful position in the geological scale, and monkeys four steps above where they should be so "that they may claim parentage with the human family."[4]

Summary of the Hypothesis

In the first four editions, Chambers reiterated the importance of physical conditions in governing the progress of development. Air and light are prime physical factors, he noted; their importance can be illustrated with the example of batrachians which when kept away from light never metamorphose. He proposed that the earth may have been under different conditions of light and air in its

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[1] CV IV:233.

[2] Sedgwick, Review of Vestiges, p. 82.

[3] Ibid.

[4] Ibid.

early days. Chambers again mentioned his assertions that the carbonic acid gas content of the atmosphere was higher in the carboniferous than at the present. An additional physical factor might be important. Perhaps, he speculated, the residue of zodiacal light around the sun was denser in the past than in the present. Although these factors are possible causes for development, he asserted that he did not consider them the total explanation. They do, however, represent a possibility.[1]

The idea of progressive development was presented in the sixth through tenth editions not as a proved fact but as a rational interpretation of the facts. In all of the editions, even the later ones in which he had advocated the two-strand approach to development, he stated that the production of the total creation involved a progress from the simplest to the most complex, "in short, a universal gestation of nature, analogous to that of the individual being."[2]

In the sixth through tenth editions Chambers explained that only in certain areas of the world has development reached its highest stage. Although he had previously underplayed the importance of physical conditions in regulating development, in the fifth through tenth editions he discussed certain zoogeographical areas such as Australia and the island of the Pacific where development has been retarded presumably because of the late uprise of the land.[3] Perhaps,

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[1]CV I:228-30; III:236-38; IV:238-40.

[2]CV VI:246-47; VIII:152; IX:149; X:179.

[3]CV V:232-33; VI:247; VIII:152-53; IX:149; X:179.

he suggested, the developmental process might be starting every hour in infusions and, given the proper conditions, would continue to advance.[1]

But after the statement of a general advance, Chambers remarked in the sixth through tenth editions that the course of organic development was not invariably forward. The young of certain marine mollusks are free swimming while as adults they are sessile, he explained in the eighth through tenth editions. However, in the tenth edition he presented a footnote indicating that locomotion is not of necessity in itself an advanced condition. In the eighth through tenth editions, he noted that the situation in mollusks "throws an interesting light on some of the objections which have been urged against the present hypothesis, showing, for instance, how a grade transition in that general gestation of nature which has been spoken of, might, in some of the series of beings, present us with animals comparatively high in some respects, to be followed by species in which, owing to the adaptive process, some of the higher features were reduced or erased."[2] The correlation between a regression from the young to the mature individual and the regression of animals in the geological series were considered by Chambers to support instead of establishing a difficulty to the theory of Progressive Development.[3]

Lamarck's Hypothesis

All of the editions converged again as Chambers

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[1] CV V:233; VI:247; VIII:152-53; IX:150; X:179.

[2] CV VIII:153; IX:150-51; X:180.

[3] CV VIII:153; IX:150-51; X:180.

discussed Lamarck's theory. The explanations in the first four editions were slightly different from those in the sixth through tenth editions. In the later edition types, he stated that Lamarck's conception of use and disuse with the addition of time is insufficient to cause progression. In the early editions he also remarked on the inadequacy of Lamarck's conception. In fact, in the first edition he was ready to place it "with pity among the follies of the wise." His language was more moderate in subsequent editions. In the fourth edition, he remarked that Lamarck would have been acceptable if only he had understood that advance took place through the ordinary medium of generation "to modifications of external structure fitting the progeny for new conditions, and if, to these ideas, he had added a more explicit acknowledgment of the whole being the evolution of a divine will, which was present in it all. . . ."[1] In the first through third editions he admitted that it was on the ideas of Lamarck that the current hypothesis was based, going beyond him in using the ordinary means of gestation and by attributing it all to the pre-planned action of God. Only in the first edition did he mention how the theories of Macleay, Vigors, and Swainson supported his contentions.[2]

Although Newman agreed that many of Chambers' ideas were appropriated from Lamarck, he insisted that Chambers had omitted Lamarck's "brightest thought of all, that progressive development arose from the wants of the individual. . . ." Chambers was proud of

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[1] CV I:230-32; III:238-40; IV:240-41; V:233-35; VI:248-50; VIII:153-54; IX:151-52; X:180-82.

[2] CV I:230-32; III:238-41.

this omission, whereas Newman considered it one item which made his theory inferior to that of Lamarck.[1]

Lamarck's mistake, explained Chambers in the fifth through tenth editions, was in giving the adaptive principle too much to do. For "what undoubtedly is effectual in modifying the exterior peculiarities of animals, was obviously insufficient to account for the great grades of organization."[2] Chambers' solution in these later editions was similar to that presented in the earlier, a process analogous to ordinary gestation for advancing life through the major grades with external conditioners to modify exterior characters. In these editions he also acknowledged Lamarck as the source of his theory.[3]

In the first edition Chambers criticized Lamarck by insisting that the regularity in the structure of the classification of animals was "irreconcilable with the idea of form going on to form merely as needs and wishes in the animals themselves dictated."[4] If this had been the case, then all development would have been irregular, he explained.

The Developmental Hypothesis as Exalting Rather than Degrading Man

Is it degrading, asked Chambers, to have lower animals involved in the production of man? Only a prejudiced mind could object to a

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[1] Newman, Review of Vestiges, pp. 957-58.

[2] CV V:235; VI:249; VIII:154-55; IX:151-52; X:181-82.

[3] CV V:235; VI:250; VIII:155; IX:152; X:182.

[4] CV I:232.

simian descent, he concluded. Newman averred that he would "prefer being considered the children of prejudice to the children of monkeys, and cling to the lesser reproach, in order to avoid the greater."[1]

How, since this method was conceived by God, could it possibly be degrading, asked Chambers in the first four editions?[2] In the eighth through tenth editions he compared it to a full-grown individual contemplating himself as a baby and even as an embryo. It would not be any more degrading to consider one's ancestors as being lower animals, he stated. The source of our prejudice, hypothesized Chambers in the fifth through tenth editions, is the veneration everyone has been taught for his ancestors. This veneration makes it difficult to imagine our ancestors as humble animals. This is the wrong approach, he contended; in our world, "the elder people of the earth are in reality its children, and we are its true senate."[3]

Chambers concluded in all of the editions that man had a moral responsibility to be kind to the lower animals because of his relationship to them. In the fifth through tenth editions, he reminded the reader of the noble qualities of animals which are in many respects superior to man, explaining "alas for man's boasted superiority--in how many respects does it fail beside the unassuming merits of the mere commonality of nature."[4]

A new urgency to convince not noted in the previous chapters

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[1] Newman, Review of Vestiges, p. 957.

[2] CV I:233-34; III:241; IX:241-43.

[3] CV V:236-38; VI:251-52; VIII:155-56; IX:152-53; X:183.

[4] CV I:235; III:242-43; IV:243; V:238-39; VI:253; VIII:156-57; IX:154; X:183-84.

is encountered in Chambers' three chapters on the Developmental Hypothesis. It is as if he is almost desperate in his efforts to convince the readers of the acceptability of his position. This attitude drove him to include many examples which his contemporaries considered absurd, thus providing them with additional ammunition with which to demolish his arguments. These examples were included both before and after the actual presentation of the hypothesis. Although changes were made in subsequent editions the spirit remained the same and any hope that he may have had of placating his critics by correcting erroneous facts and adding new corroborating instances was thwarted. It was the examples that were ridiculed by the critics. Often ill-chosen, they offered a tangible basis for rebuttal, whereas the hypothesis itself was more difficult to attack.

But the hypothesis itself was troublesome to Chambers as was evidenced by his continuous revisions. Although the two-strand approach to development of the later editions explained more of the phenomena than did his earlier theories, his distinctions between grade transitions and environmentally modified transitions are never absolutely clear. As is apparent from the remarks of the critics, all of the ramifications of this approach are not presented. Whether Chambers himself was aware of the way in which the two strands interacted is not obvious. Nevertheless, although modifying the mechanisms, Chambers, true to his Platonic convictions, never wavered from his original postulate of a general progress throughout the organic kingdom.

CHAPTER V

APPLICATIONS OF THE HYPOTHESIS TO THE CLASSIFICATION AND DISTRIBUTION OF ANIMALS

Nowhere in the text did Chambers respond to adverse criticism of an application of his hypothesis as decisively as he did in his discussion of the affinities and geographical relationships of organisms. In the first edition, he accepted the controversial Macleay system of classification, a system which, with its emphasis on an ideal arrangement based on a circular and numerical basis, was compatible with his Platonic-Pythagorean biases. But in using the Macleay system he found himself open to much criticism, and in the third edition began a process of major modification that continued through the eighth edition. Macleay's theory occupied a decreasingly important place in his considerations in each subsequent edition until eventually it was just barely mentioned as an interesting but quaint curiosity.

Even the title of the chapter changed from the first to the third edition. The complete domination of Chambers by Macleay's system of thought was apparent in the first edition title, "Macleay System of Animated Nature, This System Considered in Connexion with the Progress of Organic Creation and as Indicating the Natural Status of Man." By the writing of the third edition, Chambers' confidence in Macleay's correctness had diminished and, accordingly,

the title of the chapter was changed to "The Hypothesis Considered in Connexion with the Classification and Geographical Distribution of Organisms."[1]

Chambers' disenchantment with the Macleay system resulted more from the unfavorable criticism of the hypothesis itself than from direct censure of his use of it in Vestiges. Most of the critics of Vestiges chose to ignore this section in their reviews.

Sir David Brewster, however, did call attention to Chambers' changed emphasis. He explained that Chambers in the first edition gave "a full notice of that wild hypothesis, and expressed his highest approbation of it, as furnishing a powerful additional proof of the hypothesis of organic progress by virtue of law."[2] After briefly explaining the Quinary System of Macleay, Brewster concluded that it would be an "unprofitable task" to enter into any examination of this system. Brewster recognized Chambers' own misgivings in the later editions stating that

> the author of the Vestiges, repenting, we hope, of his adhesion to it, and of the wild notions of which he has made it the foundation, had himself condemned it. He has actually omitted from his 4th edition the whole section on the Macleay system; and though he persists in saying that it 'possesses a basis in truth,' he yet acknowledges that it 'has been latterly abandoned by many who at one time embraced it, in consequence of its being found to involve so many difficulties.'[3]

This change in Chambers' ideas was not especially laudable, noted Brewster, for "this little incident points out in a striking manner the constitution of our author's mind--a mind without fixed principles,

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[1] CV I:236; III:244.

[2] Brewster, Review of Vestiges, pp. 499-500.

[3] Ibid.

and as ready to abandon an old position as it is willing to assume a new one."[1]

Smith, in Blackwoods, also mentioned Chambers' use of the Macleay system, which he regarded "as confused as it is fantastic. . . ."[2] Macleay's hypothesis might be applicable to gradations between lower animals, suggested this reviewer, "but when he ascends to the higher and larger animals, whose forms and habits are well known to us--when he has to find a father for the horse, the lion, the rhinoceros, the elephant--his phenomenon, we are sure, will no longer retain its 'simple and modest character.'"[3] These large differences, he noted, were not compatible with Chambers' expressed hypothesis "that the simplest and most primitive type gave birth to the type next above it, and this again produced the next higher, and so on to the very highest, the stages of advance being in all cases very small. . . ."[4]

The Macleay Hypothesis

Parallelism Between the Plant and Animal Kingdoms

Since most of Chambers' illustrations of his hypothesis were taken from the animal kingdom, it was important for him to demonstrate that the same system was applicable to the plant kingdom in order to confirm a fundamental unity throughout the organic world. He postulated in the first through third editions that there existed a

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[1] Ibid.

[2] [Smith], Review of Vestiges, p. 457.

[3] Ibid.

[4] Ibid.

point near the base of both plant and animal kingdoms where it was impossible to say that one began and the other left off. The two kingdoms then diverged, he explained, and thereafter a general parallelism could be observed at all levels.[1]

Chambers was more convinced of his system of parallels in the first edition than in the third. Confidently he stated in the first edition that the analogy between the two kingdoms at various levels is so striking "that I fully expect in a few years to see the animal and vegetable kingdoms duly ranked up against each other in a system of parallels, which will admit of our assigning to each species in the former the particular shrub or tree corresponding to it in the latter, all marked by unmistakable analogies of the most interesting kind."[2] Skepticism intruded on the third edition for he had realized the difficulty in applying this idealistic system.

Characteristics of the Macleay System

"Beautiful analogies" formed the basis of the "natural" classificatory scheme which Chambers proposed to describe.[3] Circularity characterized this system. When the animal kingdom was considered either in its entirety or in any one of its subdivisions, Macleay, observed Chambers, had found the components to be arranged according to a series of affinities into a circle--"that is to say, starting from any one portion of the group, when it is properly arranged, we can proceed from one to another by minute gradations,

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[1] CV I:236-37; III:244-45.

[2] CV I:237.

[3] CV I:237-38.

till at length, having run through the whole, we return to the point whence we set out."[1] The ultimate test of the correctness of any level of classification, "be it a tribe, order, or class depends on it being so arranged; thus, each circle is composed of a set of inferior circles."[2]

The second major characteristic of the Macleay system, according to Chambers, is its quinary nature. In the first edition his Platonic-Pythagorean biases were dominant; he found this numerical uniformity, which goes down to the lowest modifications of the system, there would be something very remarkable, as arguing a definitive and preconceived arrangement. . . ."[3] The entire animal kingdom is divided, according to the quinary hypothesis, into five sub-kingdoms, vertebrata, annulosa, radiata, acrita, and mollusca. Each of these sub-divisions is then divided into five more sections. For example, he explained that the sub-kingdom vertebrata is composed of five classes, each of which can be divided into five orders.[4]

As he wrote the third edition Chambers was doubtful of the correctness of the quinary approach. Unfortunately, he explained in this edition, the quinary aspect of the theory had "given a fanciful air to their other views. . . ."[5] However, he proposed in this edition to overlook the quinarian part of the theory and to consider the system

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[1] CV I:238; III:245.

[2] CV I:238; III:245.

[3] CV I:239.

[4] CV I:239.

[5] CV III:246.

of analogies or "representation, which these naturalists claim to have discovered in the animal kingdom."[1]

The treatment of the theory was even more sketchy in the fourth edition and was relegated to a later part of the chapter. Chambers summarized the theory in this edition by declaring that it had only been a few years since "an eminent naturalist" announced the discovery of certain analogies in the animal kingdom which led him to believe that all natural groups could be divided into fives, in each part "of which there is a certain character, repeated in the corresponding portions of all others groups."[2]

In the fifth edition, Chambers left out any mention of Macleay's theory altogether. But in the sixth through tenth editions, a short discussion was again included near the end of the chapter.[3]

In the last five editions, Chambers summarized the quinary aspects of the theory, making it evident that he was describing someone else's interesting ideas--nothing to which he himself would subscribe! He explained that "there were striking appearances of a basis of truth in theory, though in the excessive ardour of its first advocates, it was carried to a pitch of refinement in which nature was lost sight of, and the whole was greatly marred by the notion that all the groups arranged themselves in circles."[4]

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[1] CV III:246.

[2] CV IV:274-75.

[3] CV VI:346; VIII:211; IX:208; X:245.

[4] CV VI:347; VIII:211; IX:208; X:246.

After passing from total acceptance to total rejection, Chambers was prepared, in the sixth through tenth editions, to accept the theory as "a great step in philosophical zoology" since it attempted, however inadequately to present a natural system of classification. But, in these editions, he presented it as an interesting theory, not the truth.[1]

The Class Aves as Illustrating the Macleay Hypothesis

In all of the editions except the fifth, which omitted any reference to it, Chambers described the class Aves as illustrative of the Macleay Hypothesis. This class, he explained in the first three editions, is subdivided into five orders--incessores, raptores, natatores, grallatores, and rasores. The sequence of these orders relates to their "different degrees of perfectness, the first being the most perfect with regard to the general character of the class, and therefore the best representative of the class; whence it was called the typical order."[2]

> The second or sub-typical is less perfect, observed Chambers,
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> comprehending the chief noxious and destructive animals of the circle to which it belongs. The other three groups were called aberrant as exhibiting a much wider departure from the typical standard, although the last of the three is observed to make a certain recovery, and join on to the typical group, so as to complete the circle.[3]

These aberrant groups--the natatores, or swimmers, the grallatores, or waders, and the rasores, or scrapers--were described in the first

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[1] CV VI:347; VIII:211; IX:208-209; X:246.

[2] CV I:240; III:246.

[3] CV I:240-41; III:246-48.

and third editions.[1]

Although in the fourth edition, Chambers mentioned the same five divisions of the Aves, he did so in a developmental sequence, rather than one based on degrees of perfection. He briefly characterized the avian orders in this sequence: natatores, grallatores, rasores, incessores, and raptores, but criticized the circular arrangement indicating that this had caused many to abandon the theory.[2]

Since Chambers had abandoned the quinary approach altogether in the last four editions, instead of the original five divisions he substituted three; "first, birds of solitary, predaceous, carnivorous habits; second, birds of gregarious habits, accustomed to walking on the ground, slow of movement, large of bulk, generally granivorous and harmless; third, birds which are, generally speaking, omnivorous, rapid of movement, comparatively of small bulk, not merely gregarious, but social, often marked by garrulity, imitative power, cunning and mischievousness."[3]

Additional Applications of the Macleay Hypothesis

In the first edition alone, Chambers included additional examples from the work of Swainson which ascribed moral characteristics to each of the five sub-divisions. He explained that the "leading animal of a typical circle" is characterized by a balance of qualities, in which one character does not predominate over the others. However, he

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[1] CV I:240-41; III:246-48.

[2] CV IV:275-76.

[3] CV VI:347-38; VIII:212; IX:209-10; X:246.

noted that the sub-typical group was not so well balanced. It was characterized as being "most powerfully armed, either for inflicting injury on their own class, for exciting terror, producing injury, or creating annoyance to man. . . . They are, in short, symbolicaly types of evil."[1]

In the genus equus, the zebra was described as the sub-typical animal, "which actually shews the stripes of the tiger, and is as remarkable for its wildness as its congeners, the horse and ass, are for their docility and usefulness."[2] Swainson, Chambers declared, found such moral delineations in the order of butterflies. Caterpillars armed with prickly or poisonous spines reflected the sub-typical "evil." In this edition, he appeared to accept Swainson's conclusions that these moral divisions represented a primary law since they could be found throughout the animal kingdom. The evil nature of this sub-typical group was symbolized by the "impure black and lurid beetles forming the saprophagous petalocera of Mr. Macleay;" the entomologists who so described them had no "suspicion, that, by the filthy habits and repulsive forms of these beetles, nature had intended that they should be emblems of hundreds of other groups, distinguished by peculiarities equally indicative of evil."[3] The evil subtypical animal can be contrasted with the typical division of the beetles which "live upon fresh vegetables; . . . are diurnal, and sport in the glare of day, pure in their food, elegant in their

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[1] CV I:242-43.

[2] CV I:243-44.

[3] CV I:244-45.

shapes, and beautiful in their colours."[1]

The three aberrant groups--the natatores, suctores, and rasores were also described along with Swainson's examples in the first edition. The natatores are "remarkable for their bulk, the disproportionate size of the head, and the absence, or slight development of the feet;" they tend to partake of the predaceous and destructive character of the adjoining sub-typical group.[2] Examples were given in the radiata, the fish, and the cetacea.[3]

The suctorial group also represents aberrant animals and is named for the characteristic of "drawing sustenance by suction."[4] Chambers gave examples of this group and described it as basically having negative qualities including an "indisposition to domestication, and an unsuitableness to serve as human food." The last example was of the rasorial group which "comprehends most of the animals which become domesticated and useful to man, as, first, the fowls, which give a name to the type, the ungulata, and more particularly the ruminantia, among quadrupeds, and the dogs among the ferae."[5]

The Macleay Hypothesis, reported Chambers, applies to the evolution of life. The lowly acrita are the basis of the process; they consist "like the rest, of five groups, (classes) and these are respectively representations of the acrita itself, and the other four

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[1] CV I:245-46.

[2] CV I:246.

[3] CV I:246-47.

[4] CV I:247.

[5] CV I:248.

sub-kingdoms, which had not come into existence when the acrita were formed."[1] He was convinced that the acrita prophesied the future and higher events of animal development and that Macleay's whole system of representation could be regarded as "a powerful additional proof of the hypothesis of organic progress by virtue of law."[2]

Since by the writing of the third edition Chambers had rejected the quinary approach of the first, he did not include the detailed examples of this edition and was contented to state that although certain characteristics were repeated over and over throughout different parts of the animal kingdom, the presumptions of the quinarians were "claiming too much."[3] His concern with a developmental sequence from the sea to the land was first apparent in this edition. The typical groups were chiefly aquatic, he noted, with the land forms developing subsequently.[4]

The Demise of the Quinarian Approach

Chambers was still not prepared in the third edition to reject all of the implications of the quinarian approach. He explained that the rasorial birds and ruminant quadrupeds "seem respectively to have arisen from the preceding type, as creatures qualified to subsist by immediate connexion with the ground; and it is curious to find that many such birds have a regurgitating power like the ruminant quadrupeds, as if common circumstances had led to common

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[1] CV I:249-50.

[2] CV I:250.

[3] CV III:248-49.

[4] CV III:249.

organization."[1]

But rather than accepting these relationships as generic connections as he apparently did in the first edition, Chambers in this edition and in the fourth considered that "there representations appear, primarily at least, as a result of physical conditions for animal existence operating in various departments of the animal kingdom."[2] Since, for example, when woods first appeared only animals which had proper adaptations to the woods would survive; those animals from different parts of the animal kingdom with similar adaptations tended to be successful; thus "it is not surprising to find the perching birds and squirrels, and the quadrumana hands and feet, suitable for grasping branches and climbing among them. . . ."[3] This, stressed Chambers, did not imply representation as the quinarian school had indicated. Even so, in this edition he was unwilling to completely discard it, and indicated, as in the first edition, that the acrita prophesied the later groups and that the fishes contain a family prefiguring the scraping birds. Rather than, as in the first edition, describing how this theory supported the developmental hypothesis, in the third he stated that it "would present no objection to our hypothesis of organic development; and this is all that I am at present concerned to shew."[4]

Chambers explained in the fourth edition as he had in the

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[1] CV III:250..

[2] CV III:250.

[3] CV III:250-51.

[4] CV III:251.

third that the ocean was the starting point in the developmental sequence. But in this edition he described the evolutionary order in more detail; the ocean, he noted, was the starting point of the process and contained the basis of a set of lines equivalent to those which Macleay would call natatorial. From these natatorial trunk lines, branches arose to form the wading birds, grallatorial or suctorial types, which in turn gave rise to more terrestrial forms.[1]

Cuvier's classificatory system was objectionable to Chambers because it was unnatural, and to replace it he suggested a possible scheme based on the series of analogous forms. This idea appeared to foreshadow his multiline scheme of both vertical and horizontal affinities hinted at in the fifth edition and expanded in the sixth through tenth editions.[2]

After a brief absence, Chambers' Pythagorean preoccupation with numerical relationships reappeared in the sixth edition. It was apparent in the first edition in his fascination with the quinary nature of Macleay's Hypothesis but was not evident in the third and fourth editions in which he tended to dismiss quinarianism as artifice. But he returned to numeralogy with enthusiasm in the later editions using a base of three to replace that of five. Truth, he was convinced is to be found in "the idea of three great strands of organic being, each composed of three inferior strands, respectively representing the principal lines, and which probably were the true genealogical series of our system."[3] Such a concept

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[1] CV IV:255-56; 276.

[2] CV IV:277-78.

[3] CV VI:350; VIII:213; IX:210; X:247.

was pleasing to Chambers' mind. "It would give us a curious conception of organic nature, . . ." he reported, "if we could satisfy ourselves that, like chemistry it had a mysterious foundation in mathematical proportions. Threes under threes, each subordinate three reflecting the ternity to which it belongs, and all others."[1]

Chambers did not ignore the implications of Macleay's hypothesis in the sixth through tenth editions but instead incorporated certain of these ideas into his newly contrived system of relationships of stirpes. By merging these ideas into his preconceptions of the composition of the major divisions or stirpes of the animal kingdom, he was able to postulate a vertical evolutionary sequence.[2]

Certain characters are universal, reported Chambers in the sixth through tenth editions; for example, there is a balance between herbivores, carnivores, and scavengers throughout the different grades of animals. In the tenth edition he described the similar adaptations of the tongue and lip of the Iguanodon of the Wealden and modern herbivorous mammalia for an herbivorous existence. Apparently he saw a real genetic link between animals with similar life styles. For example, he found that the parrots among the birds and the monkeys among the primates had many traits in common. "The explanation is easy: . . ." he concluded, "the monkeys either are the descendants of the line which at an earlier period gave parrots, or the parrots come from a sub-line representing the monkeys in their greater

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[1] CV VI:350; VIII:213; IX:210; X:247-48.

[2] CV VI:350; VIII:213; IX:210; X:247-48.

line."[1] He produced other examples of a continuity of characteristics--the cephalopod foreshadowing the shark, the shark, the saurian, and the saurian, the vulture and mammalian carnivores.[2] "It is curious to observe in each line through all grades a continuity of character," wrote Chambers in the eighth through tenth editions.[3]

"Some curious inferences" can be drawn from the preceding examples. According to Chambers, the stirpes culminating in the primates was central between the other two, combining their characteristics with some of its own. Man represents the "crowning species" in the primate. The other lines also had crowning species, with the herbivorous stirpes topped by the pig in the sub-carnivorous line, the sheep in the sub-herbivorous, and the horse in the sub-central.

Examples were also given in the carnivorous stirpes. But man was the very top animal mainly because of his general characteristics--a "universality of characters."[4] "We see that an intensity of it marks all the greatest individuals of our species, such as Shakespeare and Scott, of whom it has been observed that they must have possessed within themselves, not only the poet, but the warrior, the statesman, the philosopher, and the man of affairs, and who, moreover, appear to have had the mild and manly, the moral and impulsive parts of our nature, in the finest balance," concluded Chambers.[5]

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[1] CV VI:352-53; VIII:214-16; IX:212; X:249.

[2] CV VI:353; VIII:215; IX:212; X:250.

[3] CV VIII:215; IX:212; X:250.

[4] CV VI:355-57; VIII:216; IX:213-14; X:251-52.

[5] CV VI:356-57; VIII:217; IX:213-14; X:252.

Order Underlying Apparent Chaos

Chambers sought to rationalize his numeralogical approach in the first and in the sixth through tenth editions with an analogy "more apt than dignified."[1] Imagine, he requested of the reader, an insect perceiving a formal garden. Because of its limited perspective it observes only a small part of the whole and, therefore, envisions irregularities and arbitrary arrangements. However, he explained, as the view becomes more comprehensive, order becomes apparent. He drew a Platonic conclusion, insisting that "it can scarcely be necessary to point to the inference hence arising with regard to the origination of Nature in some Power, of which Man's mind is a humble and faint representation."[2] The insects in the garden would, after understanding the artificiality of the whole garden, be bound to conclude that a higher power had constructed it, likewise, man when given a glimpse of the artificiality which is the basis of nature would conclude that the whole production is the result "of a Being resembling, but infinitely greater than ourselves."[3]

Geographical Distribution of Plants and Animals

Although Chambers in all of the editions discussed the geographical distribution of organisms, in the first through fourth editions he considered distribution in relationship to the Macleay Hypothesis. In these editions he first discussed the vegetation in areas of similar climate but separated by strong barriers. He noted

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[1] CV I:250; VI:350-51; VIII:213-14; IX:210-11.

[2] CV I:251; VI:351; VIII:214; IX:210-11; X:248.

[3] CV I:251; VI:351; VIII:214; IX:210-11; X:248.

that although the vegetation in these similar areas bears a general resemblance, "the species are nearly all different, and there is even, in a considerable measure, a diversity of families."[1] The intertropical vegetation of Asia, Africa, and America, for example, while generically similar is specifically different. There are twenty such botanically separated provinces, using De Candolle's figures, declared Chambers.[2]

The same conclusion is as applicable to animals as to plants. Those in divergent geographical areas although under similar environmental conditions would be specifically different. Dr. Prichard was cited as the authority and his conclusion that no individual species were common to distant geographical regions accepted. Only the ubiquitous man, bear, and dog represent rare exceptions to this rule. The larger, stronger, and swifter animals are native to the elder continents, hypothesized Chambers in the first through fourth editions, while the less advanced forms are found in the New World, with "a much greater recession . . . in both the botany and zoology of Australia."[3]

Australia, concluded Chambers in the first four editions, conveys "the impression of an early system of things, such as might be displayed in other parts of the earth at about the time of the oolite;" from unknown causes it has "been belated in its physical

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[1]CV I:252; III:252-53; IV:279.

[2]CV I:254; III:254; IV:280.

[3]CV I:255-56; III:254-56; IV:280-82.

and organic development."[1] Chambers suggested, in the first edition alone, that this land might evolve in the future so that higher forms might develop.[2]

From the previously stated data, Chambers concluded in the first four editions that life originated in "numerous distinct foci" and that these original creations progressed according to the local climate "as far as at least the class and order are concerned, a diversity taking place in the minor gradations."[3] This diversity in the lower divisions, he wrote in the first three editions, was due to "the result of minute and inappreciable causes."[4] Although in the fourth edition he did not include this speculation, he stated, as he had in the first and third editions, that development did not reach the same level in the different continents and indicated that the probable cause was the relative antiquity of the continents. In the fourth edition he continued with a discussion not found in the first and third, explaining why the developmental hypothesis was the best theory to explain the observable facts of geographic distribution.[5]

In the first and third editions, Chambers noted that the facts of distribution would not allow whole families to be advanced to a superior state since the different families were often found on different continents. To illustrate this, he explained that one

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[1] CV I:256-58; III:257-58; IV:284.

[2] CV I:258-59.

[3] CV I:259; III:258-59; IV:285.

[4] CV I:259; III:259.

[5] CV IV:285.

family of the quadrumana, the cebidae, was exclusively American, while the second, the simiadae, was entirely Old World. He explained that because of their wide separation it would be unlikely for their evolutionary histories to be intertwined. In the third edition he concluded "that the entire system has been produced in lines geographically detached and accordingly in separate genealogies, the general types being everywhere regular in succession, by virtue, we may suppose, of conditions so far uniform, but afterwards branching out in ramifications of a diverse character, under the influence of circumstances the nature of which we can imagine, but of which we might vainly endeavour to ascertain the particulars."[1]

In attempting in the first edition to make the facts of distribution conform to the circular quinarian hypothesis, Chambers envisioned an awkward arrangement in order to complete the circles which involved taking subdivisions from various continents. Although the whole system is remarkable for its unity, it had been produced in geographically detached lines "consisting of particular typical groups placed in an independent succession, or of two or more of these groups," wrote Chambers in the first three editions. For example, he explained, the birds of Australia are mainly suctorial and mammals of the Old World chiefly rasorial. This concept was not inconsistent with the Macleay Hypothesis, rationalized Chambers in the first edition, although he admitted that there was still much obscurity on this point.[2]

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[1]CV I:259-60; III:260.

[2]CV I:260-61.

The Distribution of Plants and Animals in the Past

The distribution of plants and animals in the past was different from that of today, explained Chambers in the first three editions. Both plants and animals were more uniform throughout the globe than they are at present. The effect of the "yet unexhausted effect of the internal heat of the earth upon its surface," might explain the uniformity, suggested Chambers, evoking Brongniart's hypothesis.[1] The distribution of plants and animals has been basically the same since the close of the geological eras; Chambers both denied that the present forms had migrated from a common center and that they were newly created after the geological eras.[2] The situation can be explained, he noted, by supposing that a considerable variety of species had appeared towards the close of the geological eras and that the greater variety of climate in subsequent ages could account for the variations.[3]

Swainson's System of Classification

In the first edition, Chambers presented the nine grades of classification used by Swainson. Although Swainson did not list variety Chambers wanted to include it, and to subject it to the same system of representation found in the higher categories.[4] Unfortunately, regretted Chambers, not every organism can be classified into all nine

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[1] CV I:261; III:260-61.

[2] CV I:261-62; III:260-61.

[3] CV I:262; III:261.

[4] CV I:261-68.

grades; this presented a difficulty to his Pythagorean mind, "as it introduces an irregularity into the natural system, and consequently throws a difficulty and doubt in the way of our investigating it."[1]

After these interjections, Chambers proceeded in the first edition to consider the status of man. He was critical of Swainson because he considered the simiadae to comprise a complete circle without room for man.

Swainson arranged the simiadae as follows:

typical . . . . . simiadae
sub-typical . . . . . cebidae
natatorial . . . . . unknown
suctorial . . . . . vespertilionidae
rasorial . . . . . lemuridae

Chambers could not accept Swainson's view that man was distinct, representing a link between unintelligent being and the angels. An arrangement in which man is "allowed the place to which he is zoologically entitled," was proposed to supplant Swainson's unacceptable arrangement. His proposal suggested the following arrangement:

typical . . . . . bimana
sub-typical . . . . . simiadae
natatorial . . . . . vespertilionidae
suctorial . . . . . lemuridae
rasorial . . . . . cebidae

"Here man is put into the typical place, as the genuine head, not only of this order, but of the whole animal world," reported Chambers. A discussion followed in which he rationalized his system, explaining that just as the corvids occupy the typical place among the incessores, man occupies a similar place in his group. Man's qualifications for

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[1]CV I:264.

the leading position, he explained, were numerous, for "considered zoologically, and without regard to the distinct character assigned to him by theology, simply takes his place as the type of all types of the animal kingdom, the true and unmistakable head of animated nature upon this earth."[1]

Single vs. Multiple Origins of Life

As in the early editions, Chambers concluded in the fifth through tenth editions that the facts of distribution made it unlikely that life had a common origin and had been dispersed from a common center. In these editions, as in the earlier ones, he noted the effect of barriers upon the distribution of plants, but accepted Professor Henslow's number of forty-five distinct botanical provinces rather than De Candolle's twenty, cited in the first four editions. Zoological observations, reported Chambers, even more than botanical ones made multiple origin a necessity.[2]

Although general parities between geographically isolated areas of similar climate were noted, Chambers explained that isolated forms were always specifically and often generically different when no chance of intercommunication occurred. Even though a similar idea had been previously proposed in the earlier editions, in these later forms Chambers included examples. As one illustration he explained that whereas in Asia the lion and tiger occur, in Africa a different lion and the leopard occur, in South America, the jaguar, and from Brazil

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[1] CV I:265-68.

[2] CV V:282; VI:357; VIII:217; IX:214-15; X:252.

to Canada, the puma.[1]

An error in the fifth through ninth editions was apparently corrected in the tenth. In the four earlier editions, Chambers had stated that "Asia and Africa have elephants, to which the extinct mastodon of Northern Europe and the extinct mammoth of North America are parallels; . . ." whereas in the tenth he did not differentiate between the ranges of the mammoth and mastodon; he merely stated that "the extinct mammoth and mastodon of Northern Europe and North America, . . ." parallel modern elephants.[2]

Whereas in the fifth edition, Chambers stated that Australia had no indigenous mammalian animals, in the sixth through tenth editions he stated that it "has only a few very unimportant mammalian animals of her own."[3] In the first through fourth editions he had stated that it was well known that no animals above the marsupials were native to Australia.[4]

General Principles Regarding Geographical Distribution

Chambers in the fifth through tenth editions stated several principles concerning geographical distribution. There is more uniformity, he concluded, in organic life between two land masses in either the northern or southern hemispheres even though they are divided by wide oceans than in two portions of the same continent

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[1]CV V:284-85; VI:357-58; VIII:218-20; IX:215-16; X:252-53.

[2]CV V:284-85; VI:359-60; VIII:219; IX:216; X:253.

[3]CV V:285; VI:360; VIII:219; IX:216; X:254.

[4]CV I:257; III:257; IX:216.

extending into both hemispheres; an island usually shows zoological features reminiscent of those of the nearest continent; two countries divided only by a narrow sea usually have the same flora.[1]

Chambers also reached a more major conclusion in these editions. Since the first appearance of land he assumed that Europe, Asia, and Africa had been one theatre of organic being thus, "there has been, on one part or another of this geographical area, an uninterrupted chain of living forms from an early period in the secondary formation."[2] Some isolated island regions are known to have a shorter history as dry land as, for example, the Isle of Bourbon and the Gallapagoes. These areas as well as the continent of Australia either lack mammals entirely or possess a small number of primitive kinds. These regions with an incomplete fauna also are primitive botanically, indicating a less remote origin than most of the other regions.[3]

The "facts" of geographical distribution suggest certain theological implications, noted Chambers in the fifth through tenth editions. Specific differences in parts of the world with similar climates would be unlikely in a system of special creation; in such a system it seemed far more likely that God would have created the same species in diverse geographical areas. The facts of distribution make it far more likely "that organisms took their rise in germs springing from inorganic elements; which germs being different in accordance with such slight local differences in the combination of

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[1]CV V:285-86; VI:361; VIII:219-20; IX:217; X:254.

[2]CV V:286; VI:261-62; VIII:220; IX:217; X:254.

[3]CV V:286-87; VI:362; VIII:220; IX:217; X:255.

the elements as physical studies inform us of, and the external conditions attending their development being also locally different, the resulting vessels of life were various accordingly."[1]

If plants had originated in the sea and then spread to the surrounding lands we would expect a similar flora in all of the adjacent land areas. This did, in fact, occur in the Mediterranean and its surrounding land. This hypothesis would explain why islands have similar floras and faunas to their neighboring continents. However, it would also explain why the organisms of areas remote from each other vary specifically, for they would represent different foci of origination of life.[2]

Since Chambers represented marine forms as primitive, he decided that the land animals developed from the sea animals in close proximity. Thus he saw the seal group as ancestral to the polar bear which was in turn ancestral to the brown bear, black bear, wolf, fox, and dog. Amid other examples he noted that the herbivorous cetes gave rise to the moose, deer, and musk ox which were the progenitors of the goat and sheep. Rodents presumably were descendants of aquatic birds.

By supposing the sea to be the birth place of the land groups, it is possible to explain why the fauna of the northern hemisphere has more in common with other northern hemisphere forms than with the southern and vice versa. The hypothesis of an incompletely evolved land mass such as Australia and the Gallapagoes correlating with

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[1] CV V:288-89.

[2] CV V:290; VIII:222; IX:219; X:257.

"imperfectly" developed life forms seemed to Chambers to explain the phenomena. "Development is a matter of time, and in the case of these regions, the full time has not yet elapsed," he concluded. In the fifth edition alone, he mentioned again the inadequacy of special creation to explain these data. He was even more positive in the eighth through tenth editions, stating that "no rational cause for this imperfect zoological show can be presented in consonance with the plan of special exertions."[1]

Relationships Between Plants and Animals

By the writing of the fourth edition, Chambers had essentially abandoned the Macleay Hypothesis as a natural classificatory scheme but had not replaced it with another system. Although he realized that appearances could be deceiving, he was convinced that within various families it was possible to discern genetic affiliations which "have come into existence in succession, conformably to the coming into existence of fields of life suitable for them, and to which they bear a reference to their organization."[2]

The Problems with Systems of Classification

All previous systems of classification have failed, wrote Chambers in the fifth edition, because they are artificial. Only when a natural classificatory scheme has been devised will success result. A linear scale will not explain succession, he decided. He was apparently moving towards the two-strand approach of stirpes

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[1] CV V:292-93.

[2] CV IV:246.

and environmental modifications of the later editions and away from the linear approach of the earlier editions. "The gradations extend along several lines, or chains, . . ." he explained, "each comprehending a succession of organisms of one comprehensively peculiar character, and each possessing ramifications, the extremities of which have, as a matter of course, no affinity towards any other group."[1]

After discussing classificatory schemes in the sixth through tenth editions, Chambers suggested that it would be instructive to subject the developmental hypothesis to a test to see if it would agree with a system of classification. But since no natural system of classification has been devised this was clearly impossible. Nevertheless, he proposed to discuss his hypothesis with regard to a general order of classification, writing in the sixth edition that this order must "either agree with a genealogical system, or become its condemnation," and in the eighth through tenth editions that this order must be examined "with a view to ascertaining how far any such order agrees with a genealogical system."[2]

As in the fifth edition, Chambers was critical of a linear succession, stressing that it was not the idea of development that was in error, but the original concept of a chain of being. He advanced a substitute for this concept--the consideration of each kingdom "as consisting of a plurality of series going on side by side with

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[1] CV V:240-42.

[2] CV VI:254; VIII:158; IX:155; X:185.

each other, but not all to the same point in the scale."[1] He hastened to add that this view was not merely hypothetical but based on embryology, paleontology, and the "general character of particular series."[2] He was certain that this system was more acceptable since it focused on essential characters and overlooked "external and comparatively accidental characters."[3] While his system might be too futuristic for contemporary naturalists, he was convinced that it would represent the direction which they would eventually take.[4]

A Substitute for the Traditional Classificatory Scheme

Although in order to be understood Chambers proposed to use Cuvier's terminology, he introduced a substitute for the traditional classificatory system. He suggested that the animal kingdom, and, by analogy the plant kingdom, could be divided into a series of longitudinal divisions which represented the natural divisions. These divisions, called grades or stirpes, were few; for example, the divisions of the vertebrata, the fish, reptiles, birds, and mammals were the only natural subdivisions into which the sub-kingdom could be divided.[5] Chambers recognized, however, that a wide diversity exists within each grade, and concluded that within an individual grade a lateral breakdown into "groups or series" yields animals generally

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[1] CV VI:255-56; VIII:159; IX:155-56; X:186.

[2] CV VI:256; VIII:159; IX:156; X:186.

[3] CV VI:256; VIII:159; IX:156; X:186.

[4] CV VI:256-57; VIII:159; IX:156; X:186.

[5] CV VI:257-58; VIII:159-60; IX:156-57; X:186.

alike. These types of segregations did not represent natural stages, insisted Chambers, but "are only the marks of stages which the true divisions, the Stirpes of being, have reached in their respective courses."[1]

Chambers' view of the relationships between animals was more simplified in the fourth and fifth editions than in the later editions. In both of these editions two major evolutionary lines were mentioned. The first, characterized by a symmetrical structure, is the articulata-vertebrata line and the second unsymmetrical line is the mollusk line. There are other less important lines such as that which passes from the sponges through the polyps and the entozoa.[2]

The radiata, stated Chambers in the fifth edition, represent the base form of the higher groups; animals pass "rapidly through this division, most of the lines . . ." advancing "into one or other of the higher sub-kingdoms."[3] The entozoa were cited as an exception. The radiates represented an ideal primary group for Chambers, since most of them are marine. His theory that the sea was the original matrix of life would be consistent with the acceptance of the radiates as a base stock.[4]

Chambers continued to regard the radiates as a base group in the sixth through tenth editions. Certain of these animals such as the internal parasites never progress up the evolutionary scale,

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[1]CV VI:257-58; VIII:160; IX:157; X:186-87.

[2]CV IV:246-47; V:243-44.

[3]CV V:244.

[4]CV V:243.

explained Chambers, whereas others progress into higher groups.[1]

After describing the radiates, Chambers continued in the sixth through tenth editions by stating that there are two possible ways of investigating the affinities of organisms; the first is to observe the similarities and differences in adult organisms and the second is to observe the succession of embryological forms. In describing the embryological method of investigating the relationships between organisms, Chambers reflected a more sophisticated view of recapitulation than he had expressed in the earlier editions. No animal, he explained, passes in the embryological process through the stages of all animals simpler than it in the zoological scale. The two investigatory techniques were briefly mentioned in the fourth and fifth editions.

In order to illustrate this selective recapitulation, Chambers explained that the sea-nettle is at one time like a monad and then like the polyp, whereas the mollusk is like the monad and polyp but never like the sea nettle. Chambers remarked that although this had been considered a difficulty to the doctrine of unity, there is no problem if one classifies animals in stirpes according to their affinities.[2] Each stirps would have a self-contained unity of organization and would not have to correlate with the stages of another stirps.[3]

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[1]CV IV:254; V:243; VI:258; VIII:160; IX:157; X:187.

[2]CV VI:259; VIII:161; IX:157-58; X:188.

[3]CV VI:259; VIII:160-61; IX:157-58; X:188.

Evolution of the Echinoderm

Chambers presented a representative evolutionary series within the echinodermata to illustrate a genealogical series. Since some of the lower echinoderms resemble the polyps, Chambers concluded that they probably originated from some part of this order.

From this polyp-like ancestor, Chambers postulated that a form resembling ecrinus or the stone lily evolved. He described this stalked form in the fifth through tenth editions with diagrams included in the tenth.[1]

Preceeding from the stalked encrinus, the path of echinoderm evolution passed through a form in which the body and legs left the stalk and became free swimming. However, in this stage, which was represented by the comatula, the young lived on a stalk for a time like an encrinus.

The next stage in the evolutionary process after the comatula was the slender armed ophiurae followed by the asteriadae or true starfish in which the central part dialates until it fills up the space between the arms. From the starfish the echinoderms passed to the sea urchin and then to the fistularidae, "animals externally worm-like and possessing the rudiment of a heart, with red blood in the arteries."[2] Chambers added in the fifth through eighth editions that in the fistularidae "we may be said to have come nearly if not fully abreast with the annelides, and to be approximating to

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[1]CV IV:252-53; V:257-60; VI:260-63; VIII:161-63; IX:158-60; X:188-89.

[2]CV V:258-59; VI:261-62; VIII:162-63; IX:159-60; X:187-91.

some of the humbler fishes."[1]

In the fourth edition, Chambers noted a problem not mentioned in the later editions as he explained that "for, while there are many reasons for placing them [echinoderms] at the bottom of the Articulata, they also connect beyond doubtwith a low grade of fishes." But Chambers did not see this as a real difficulty unless it was insisted that only the highest form of an animal can form a juncture with the lowest form of the next.[2]

Chambers mentioned the great number of forms through which the echinoderms passed before leaving the radiata, but explained this by remarking on the superiority of the echinoderms to the rest of the radiates.[3] The fossil record of the appearance of echinoderm groups correlated with this hypothesis. The polypiarians and encrinites appeared in the silurian and the echinidae not until the oolite. He explained that since the more complex forms are soft bodied, there is, as would be expected, no evidence of their appearance.[4]

The Evolution of the Articulata

Chambers in the fourth through tenth editions described "the two grand series" of invertebrates, the articulata and the mollusca. The first of these lines to be discussed in the sixth through tenth editions was the articulata but in the fourth and fifth

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[1]CV V:259; VI:263; VIII:162-63.

[2]CV IV:254-55.

[3]CV IX:160.

[4]CV V:259-60; VI:262-63; VIII:163; IX:160; X:191-92.

editions this discussion followed that of the mollusca.[1]

The articulates, explained Chambers in the sixth through tenth editions, passed through few evolutionary phases--from monad, to worm form, and then to the articulate. This group did not pass through the radiate group and there is some reason to assume "that the great classes of the Articulata are distinct stirpes, the commencement of each of which is little more than a step from the inorganic form of matter."[2]

The treatment of the articulata and of the general problems of succession were considered quite differently in the fourth edition than in any other. In this edition, Chambers surmised that since an insect emerges from an egg "in the form of an annelidan (the larva)," or if it has limbs as a myriapod, that the "Annelides, Myriapoda, and Insecta, form parts of one line, in that order of succession." The crustacea and arachnida represent side lines, he postulated, "apparently branching from the same vermiform root."[3]

Chambers noted in the fourth edition that the most primitive members of all of the subkingdoms were aquatic, explaining that "the ocean has all along formed the medium in which the grand or main line of animal life was conducted through the successive stages of development, while only branches or lateral extensions went off towards the land."[4] Accordingly, he reported, the groups mollusca and

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[1] CV IV:248-50; V:252-57; VI:263-72; VIII:163-68; IX:160-65; X:192.

[2] CV VI:263-64; VIII:163-64; IX:160-61; X:192.

[3] CV IX:255.

[4] CV IV:256.

articulata, the first to contain land genera, evolved from marine forms. He explained that in the articulata the burrowing annelid, naidea, was an offshoot of a marine form and was adapted to burrowing in the sand on the sea shore; from these burrowing forms sprang the earthworms as well as the insects.

He added that two other articulate groups, the crustacea and the arachnida also had a marine origin.[1] "There is a progressive development or improvement of structure as we advance from the marine families to those of the land," concluded Chambers of the articulata in the fourth edition.[2]

The conclusions as to the marine origin of the articulates and their evolutionary pattern is similar in the fifth through tenth editions. As in the fourth edition, Chambers hinted, although less explicitly, that the articulates may have had their origin in inorganic material. He noted the approach which the entozoa made to this group and reported that he was unable to locate any zoophytic predecessor for this group.[3] The fifth edition was similar to the last five editions in much of the discussion of the articulata.[4]

The annelids, remarked Chambers in the fifth through ninth editions, are somewhat of an anomaly. Although they are supposedly the lowest of the articulates, they possess red blood like the vertebrates. However, by the tenth edition he found that this was

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[1]CV IV:257.

[2]CV IV:257.

[3]CV VI:264; VIII:164; IX:161; X:192.

[4]CV V:252.

no longer a problem, for he had learned that the so-called red blood is "merely a hue possessed by the fluid element of the blood, and not due to red corpuscles, as in the vertebrata."[1]

Several groups of annelids were described in the fifth through tenth editions--the tube-inhabiting tubicolidae, the leech group (suctoria), the earth-worm group, and the sea-mouse group. Although he considered it possible that the nereis worm was the progenitor of the myriapods, he also thought it conceivable that the two families of myriapods, the julidae and scolopendridae may have represented more than one line of passage, particularly since the first animals are herbivorous and the second carnivorous "and it appears as a rule in the genetic system, that true carnivores are always apart."[2]

The simpler aquatic crustaceans, the entomostraca, precede the more complex malacostraca in the fossil record; the trilobites may be intermediate between the two, observed Chambers. In the sixth through tenth editions, he explained that the macruri appear in the triassic and continue to the present, and the brachyura appear in the tertiary and continue to the present.[3] He only noted the significance of this geological distribution in the tenth edition, explaining that the brachyura (crabs), possess embryos that are macrural (lobster-like) in shape.[4] He was aware of another evolutionarily significant fact as he stated in the fifth through

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[1] CV V:253.

[2] CV V:253-54; VI:264-66; VIII:164-65; IX:161-62; X:193-94.

[3] CV V:256; VI:267-68; VIII:165-66; IX:162-63; X:195.

[4] CV X:195.

tenth editions that the young of the lobster and crab are entomostracous in form and represent the passage to the malacostracous form.[1]

In the sixth through tenth editions, Chambers discussed the hermit crabs as illustrating the history of the species. Because of their adaptations to the shells of mollusks, he concluded that these mollusks must have existed before the crabs. Here he pokes fun at the special creationists, saying that

> they must believe that the Creator, having a particular regard to the fact of molluscan shells lying useless on the shore, formed, by special care or fiat, a family of crabs to occupy them. . . . Surely the Deus ex machina was never more remarkably exemplified.[2]

On the other hand, he explained, the phenomenon of the hermit crabs could be well understood by the use of the developmental hypothesis.[3]

Since, postulated Chambers in the fifth through tenth editions, in their larval state many insects pass through either an annelidan or myriapodous state, these groups may be ancestral to the insects, although it is not established.[4] But it is impossible, according to Chambers, to locate predecessors for the next group, the arachnida.

He tentatively suggested that both the arachnids and the insects may "have sprung almost or wholly at once from inorganic elements."[5] In the fifth and sixth editions he added that this

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[1] CV V:256; VI:268; VIII:166; IX:163; X:195.

[2] CV VI:268-70; VIII:167; IX:163-64; X:196-97.

[3] CV VI:270-71; VIII:167-68; IX:163-64; X:197.

[4] CV V:256-57; VI:271; VIII:168; IX:164; X:198.

occurred "under the proper electric influences." Although he refused to make a definite pronouncement regarding this primeval generation, his experience with the acarus certainly prejudiced him towards this view.[1]

Evolution of the Mollusca

After having discussed the evolution of the articulata, in the sixth through tenth editions Chambers discussed that of the mollusca. In the fourth and fifth editions this discussion preceded that of the articulata.

In all of the editions, Chambers traced the origin of the mollusks to the radiata, with the fourth and fifth editions being more specific, noting an evolutionary sequence from the "infusorial animalcules, the Monads, or Vibriones, the Polygastria, and the Rotifers, . . ." through the bryozoa which develops into the molluscan order of tunicates.[2] In the sixth through tenth editions, he briefly noted that the genesis of this group was in the radiata and that from an infusorial type it passed into the polyp and subsequently into the molluscan form.[3] The mollusks are traditionally classified into three groups: one group of headless mollusks in bivalve shells and two groups of headed mollusks in univalve shells (with some in all three divisions being naked).

The first of these groups discussed in the fifth through tenth

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[1] CV V:257.

[2] CV IV:247-48; V:244.

[3] CV VI:272-73; VIII:168-69; IX:165-66; X:198.

[4] CV VI:272-73; VIII:168-69; IX:165-66; X:198.

editions was the headless group, subdivided into the tunicata, brachiopoda, and lamellibranchiata.[1] Although the discussion was more detailed in the sixth through tenth editions the presentation was basically similar in all of these editions. The brachiopods, related Chambers, were the first mollusks having hard parts capable of being preserved, and represent the dominant fossil of the lower silurian era.

Chambers, in the sixth through tenth editions, stated that the lamellibranchiates were the first hinged bivalves and that as the brachiopods declined in number they made their appearance in the fossil record. The more primitive division of the lamellibranchiates, the monomyaria, appeared, he explained, before the more complex dimyaria.[2] He remarked that Agassiz was aware of "this beautiful harmony between the fossil history of the acephalous mollusks and their order in progressive organization."[3]

The fifth edition rejoined the sixth through tenth editions in a discussion of the three higher molluscan classes. Although the organization of these groups is superior to the headless forms they are not, cautioned Chambers, "on that account to be held as an advanced form in the same genealogy." The fourth edition converged with the fifth through tenth in describing the lowest univalve class, the pteropoda; Chambers in the fifth through tenth editions was more detailed in his description of the pteropoda than he was in the fourth.[4]

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[1]CV VI:273-74; VIII:169; IX:166; X:198-99.

[2]CV V:245-46; VI:274; VIII:169; IX:166; X:200.

[3]CV VI:274; VIII:170; IX:167; X:200.

[4]CV V:246-47; VI:274-75; VIII:170; IX:167; X:200-201.

Gasteropods as the descendants of the pteropods were discussed in the fourth edition as well as the later ones, although the descriptions were more detailed in the later editions.[1] In the fifth through tenth editions Chambers noted a gradation of form in some of the groups passing "from the simple cone of the limpet to the spiral of the snail."[2] At an early developmental stage, he noted in the fourth through tenth editions, the gasteropods correspond to the permanent state of a pteropod.[3]

Before completing his survey of the mollusca, Chambers digressed in the fifth through tenth editions to discuss the evolutionary significance of certain characteristics. He stressed that the humbler forms of both plants and animals are confined to a fixed place in the bottom of the ocean, and as they become increasingly complex they advance from these depths to the surface of the ocean, to fresh water, and even to dry land. In the fifth through ninth editions he explained that the division of the sexes into separate individuals was an advance, but in the tenth edition he omitted any reference to this.[4]

The highest mollusks, the cephalopods, were discussed in the fourth through tenth editions.[5] A pteropodan ancestry was postulated for this group; he was quite specific in the fifth through tenth editions, explaining that "their descent is probably from the

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[1]CV IV:249; V:247-48; VI:275-76; VIII:170-71; IX:167; X:200-201.

[2]CV V:247; VI:275-76; VIII:170-71; IX:167; X:202.

[3]CV IV:249; V:248; VI:276; VIII:171; IX:168; X:202.

[4]CV V:248; VI:276-77; VIII:171; IX:168; X:202-203.

[5]CV IV:250-51; V:248-51; VI:277-80; VIII:171-72; IX:168-70; X:204-206.

carnivorous families of the pteropoda."[1]

It was important for Chambers to establish the pteropodan ancestry for the cephalopods. Often he had been criticized because it was claimed that the highly organized cephalopods appeared in the fossil record before some of the lower forms. A pteropodan ancestry would show that "cephalopoda might be expected to make their appearance as early in the rock series as any other mollusks possessing parts equally fitted to commemorate their existence."[2] A contemporaneity of the cephalopods with the gasteropods and brachiopods is to be expected, noted Chambers, since cephalopods are carnivorous and need something upon which to prey. This corresponded with his idea that carnivores and herbivores are developed along separate lines.

In the fourth through tenth editions, Chambers remarked that the cephalopods had a remarkably developed nervous system, reaching the ultimate level of development possible within the molluscan framework.[3] The cephalopod mollusks, speculated Chambers in the fifth through tenth editions, are probably ancestral to the vertebrates because of this advanced nervous system. Whereas, he explained, in the lower mollusks the nervous centers are only protected by coverings which also cover the rest of the body, cephalopods possess special cartilaginous plates to protect these centers and "which naturalists

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[1] CV IV:250-51; V:249; VI:277; VIII:171; IX:168; X:204.

[2] CV V:250; VI:278; VIII:172; IX:169; X:204.

[3] CV IV:251-52; V:251; VI:280; VIII:173; IX:170; X:206.

interpret as the rudiment of an internal skeleton."[1]

In the fourth edition Chambers quoted John Hunter who reported that the nervous system of the cephalopods was advanced over that of the gasteropods and that the nautilus was a connecting link between the two groups.[2] In this edition, Chambers considered the pteropods, gasteropods, and cephalopods to be upon one genealogical line--a view, as was previously mentioned, that was considerably modified by the writing of the fifth edition. He was unwilling to speculate in this edition as to the connections between the tunicates, lamellibranchiates, and brachiopods.[3] Chambers defined a genealogical line in the fourth edition, stating that "it is to be kept in mind that each class ascend to characters superior to the lowest forms of the next above it; a fact which entirely ceases to be a puzzle when we come to regard the classes as branches arising in succession from one trunk line of development."[4]

Since, in the fourth edition, Chambers had not rationalized the early appearance of the complex cephalopods, he was anxious to understate their importance. He explained that the mollusk is chiefly an "eating" animal--a characteristic not carried over into the vertebrates where the emphasis is on the nervous system. Even

> the organization . . . of the Cephalopoda, high as it is, after all, [was] devoted only to the service of a voracious stomach. Are not, then these destructives of

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[1]CV V:251; VI:280; VIII:173; IX:170; X:206.

[2]CV IV:250.

[3]CV IV:250.

[4]CV IV:250-51.

> the primeval seas treated somewhat more respectfully, by geologists especially, than they deserve to be?[1]

In the sixth through tenth editions, Chambers explained the early appearance of the exalted cephalopods by indicating that they changed more abruptly and developed more rapidly than did the lower mollusks. This idea, he explained, would not contradict a theory of law, for in such a theory each organism would undergo the modifications appropriate to its own constitution.

A chart was included in the sixth through tenth editions illustrating the genealogy of several of the important invertebrate groups. Many times a lower form of a group is ancestral to a form of the next higher group, for often these higher forms are branches which are evolutionary dead ends. "And this is the more worthy of being pointed out, as the supposition of something different has supplied one of the stumbling-blocks of the development theory," asserted Chambers. In classes which have marine and terrestrial members, the marine forms are invariably inferior to the terrestrial and are just as invariably ancestral to higher forms. None of the grade transitions, he concluded took place out of an aquatic medium.[2]

Chambers' own developing concept of the vertical grades of development was apparent from his conclusion to the discussion of invertebrate evolution in the fifth edition. Although he was progressing towards the ideas of the sixth through tenth editions, his presentation was more tentative. He concluded that Cuvier's divisions represented grades and that genetic lines passed vertically through

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[1] CV IV:252.

[2] CV VI:280-81; VIII:174; IX:170-72; X:206-207.

the whole or a portion of the grade classification.[1] He also explained that the grades were reached by steps of different lengths, "denoting that the advances have followed no uniform rule, but have been in some measure obedient to external and incidental conditions."[2]

The Passage from the Invertebrates to the Vertebrates

The most significant evolutionary advance involves the passage of the invertebrates to the lowest vertebrate class, the fish. Although he discussed the general subject in the fourth through the tenth editions, his method of description as well as his proposed pedigrees varied from one edition to the next.

In the fourth edition, Chambers refused to designate the animals involved in the transition, although he suggested a transformation from the red-blooded annelids into cyclostome fishes. But he expressed doubts as to whether these fish were the first of this class in respect to time. He suggested the possibility of another line originating in the upper silurian or old red sandstone. It would have progressed from crustaceans to crustacean-like fish such as cephalaspis and coccosteus, to the sauroid family of ganoid fish in the carbonigenous with reptilian affinities.[3] Although Agassiz implied distinct pedigrees for the other three orders of fish, Chambers said that he did not "feel bound to follow him in so obscure a walk since his classification is not yet approved as a natural one."[4]

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[1] CV V:260-61.

[2] CV V:260-61.

[3] CV IV:258.

[4] CV IV:259.

Chambers proposed a different pedigree in the fifth edition. He called upon the authority of Owen to indicate the affiliation of the cephalopod dibranchiata to the cyclostomes. The correspondence between the eight arms of these animals and the eight filaments surrounding the mouth of the cyclostomes appeared to establish this relationship. This seemed to be more reasonable to Chambers since the cyclostomes appeared in the upper silurian and devonian eras immediately following the time when the cephalopods were the chief carnivorous marine forms.[1]

Chambers prefaced his discussion of the transition from the invertebrates to the vertebrates in the sixth through tenth editions by a description of the new structures first evidenced in this group--a skeleton and a two-chambered heart. But the fish, he explained, still retained certain invertebrate characteristics such as cold-bloodedness and branchiae for respiration.[2]

The most radical transformations were involved in the passage from the invertebrates to the fish, from the fish to the reptiles, and from the reptiles to the highest classes. But this was to be expected, he averred, since the changes represented here were changes in grade, not merely the environmentally wrought lesser changes. Thus, he concluded that we would expect to find less clear evidence for transformation than at lesser junctures.[3]

But the passage between the invertebrates and fish is clear

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[1]CV V:261-62.

[2]CV VI:283; VIII:175; IX:172; X:208.

[3]CV VI:283; VIII:175; IX:172; X:208.

on at least one point, the connection of the cephalopod mollusks with the cyclostome fish, stressed Chambers. Although he had mentioned this relationship in the fourth and fifth editions, he elaborated on it more fully in the sixth through tenth editions.[1] He explained that there are four ways in which these cephalopods show a relationship to the cyclostomes: "in the nature of the skeleton, in the character of the investing skin which ejects a copious secretion whenever the animal considers itself in danger, in the power of respiring through the gill apertures without any dependence for that function on the mouth, and in the eight free filaments seen in some species extending forward from around the mouth. . . ."[2]

To illustrate how a bag-like mollusk could resemble an elongated fish, Chambers explained that in the mollusk the alimentary canal doubled back, since the mouth and anus were in such close proximity in these animals. He concluded that "the inversion reversed or undone, makes the fish."[3] Although these fishes have not been found in the fossil record, Chambers did not observe any difficulty in this lack, because he postulated that they would not have been preserved because of their lack of hard parts. A progress from entirely soft animals, to those having rudimentary cartilaginous plates to protect the brain, to those having a skull and vertebral parts made of cartilage is evident from the fossil record, explained Chambers in the fifth through tenth editions.[4]

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[1] CV VI:283-84; VIII:175; IX:172; X:207-208.

[2] CV VI:284; VIII:175; IX:172-73; X:208-209.

[3] CV VI:285; VIII:176; IX:173; X:209.

[4] CV V:262-63; VI:285; VIII:176; IX:173; X:209.

In the fifth through the tenth editions, Chambers, in discussing the origin of the cyclostome fish, returned to his often stated view that the carnivorous line gives rise to other carnivores. Whereas the cephalopods had once been the most important carnivores of the early seas, they were replaced in later times by the cartilaginous fish.[1]

Chambers mentioned a possible annelid origin for the fish in the fifth through tenth editions as he had suggested earlier, without conviction, in the fourth. In these later editions he suggested that some of the less carnivorous of the early fish may have had such an annelid origin.[2]

An echinoderm origin was also possible, conjectured Chambers in the fifth through tenth editions. Perhaps, he suggested, the fistularidae represent such a connection, for the geological record is compatible with such a view. Although he suggested that two groups of primitive osseous fish might have had an echinodermal origin as he had previously stated in the fourth edition, he realized that any conjectures on the origin of the fish would be premature and would need revision as new facts appeared. He concluded that it is probable that "we find, . . . three advances made to its lower confines from the invertebrata--namely, by the cephalopodous mollusks, by the annulose animals (annelides), and by the echinodermata."[3]

In the fourth edition after he had discussed the possible

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[1]CV V:262; VI:286; VIII:176; IX:173; X:210.

[2]CV V:263; VI:286; VIII:177; IX:173-74; X:210.

[3]CV V:265; VI:288; VIII:178; IX:175; X:211.

relationships of the sauroid fish, Chambers discussed criticism from those who were unable to understand why a fish with so many reptilian characteristics appeared so early in the fossil record. This difficulty was not insurmountable to Chambers. Since a considerable amount of time had elapsed between the time fish first appeared and the time when fish with reptilian characteristics appeared, there is no contradiction to the Developmental Hypothesis, he assured his readers.[1] In one sentence he argued that the reptilian adaptations were minor "compared with the development of the grand features of internal organization" implying that these adaptations were of no evolutionary significance. But in the next sentence he indicated that these features might be important when he stated that the subsequent rise of new fish without reptilian characteristics presents no difficulty when "we understand the main line of animal development to be, as many facts seem to imply, not singular, but plural--a rope of several strands."[2]

In the sixth through tenth editions, Chambers discussed the correlation between the geological succession of fish with the embryonic development of an individual fish of a higher group. He recognized that there was opposition to this view, but announced that he would rely on the authority of Agassiz. He noted that there appeared to be remains of cartilaginous structures in the devonian osseous fish, a condition present in adult sturgeon and in all fish embryos.[3]

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[1] CV IV:260.

[2] CV IV:260.

[3] CV VI:289; VIII:178; IX:175; X:211-12.

The Passage of the Fish to the Reptiles

Although Chambers discussed the transition from the fish to the reptiles in the fourth through tenth editions, in the fourth edition he used the designation, "amphibia," for one order, but in the fifth through tenth editions used "batrachia" to designate this same group.[1] In the sixth through tenth editions, he divided the reptiles into three rather than into the traditional four orders, for he had decided to accept the classification of those who regarded the snakes as a reduction from the lacertine sauria rather than as a distinct order as in the traditional classification of Cuvier.

By virtue of their embryonic history, the batrachians exhibited a relationship to the fish. In the fourth edition, Chambers postulated that they were direct descendants of the fish; the same relationship was implied in the fifth edition. Their embryonic history, he stressed, furnished "an illustration of the transmutation theory which has never been sufficiently regarded."[2] These animals in their individual development realize "before our eyes, one of the grade transitions presumed by the development theory," declared Chambers in the sixth through tenth editions.[3] There are certain species of amphibians, he wrote in the fourth through tenth editions, in which development becomes arrested at the fish stage and never

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[1] CV IV:260-61; V:266-67; VI:289; VIII:179; IX:175-76; X:219.

[2] CV IV:261; V:266.

[3] CV VI:302; VIII:186; IX:183; X:223.

proceeds to the reptilian.[1]

In the sixth through tenth editions, Chambers described groups of batrachians, including frogs and toads, salamanders, and blind worms. The evolutionary importance of this group is undeniable, asserted Chambers, for "they present unequivocal affinities to the grade below them, and also striking affinities amongst themselves, while their reproduction supplies a faithful picture of the principal phenomenon concerned in the developmental theory."[2]

The chelonia are important evolutionarily since it is possible to find within this group marine forms, fresh water forms, and finally land forms. Chambers' account in the sixth through tenth editions contained a more detailed characterization of the chelonia than that in the fourth and fifth. After noting in these descriptions that some of the chelonia are carnivorous whereas others are herbivorous, Chambers concluded that two or more stirpes exist within this group. He was convinced that the herbivorous marine turtles are related to the herbivorous land tortoises with rather minor changes attending the conversion. A second line may have begun, he suggested, with the coriaceous marine turtles and evolved into the river-dwelling soft tortoises. A third line is apparent in the emydes and terminates in certain land species. Although he was unwilling to speculate on the genealogy of the chelydes, he assumed that they represented primitive forms.[3]

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[1]CV IV:266; V:266-67; VI:302, 306; VIII:189; IX:183; X:223.

[2]CV VI:307-308; VIII:189; IX:183-87; X:220.

[3]CV IV:261; V:266-67; VI:290-96; VIII:179-82; IX:176-79; X:212-16.

The snakes and lizards presented more of a developmental problem to Chambers than did the other groups. In the fourth edition he explained that the genealogy of the small lizards as well as the snakes must be considered when more data are available. Although it seemed apparent that the snakes evolved from the lizards by a loss of limbs, Chambers found this difficult to accept because of a seeming connection between the amphibians and snakes.[1]

Although the snakes and lizards were not described in detail in the fifth edition, Chambers included a detailed characterization in the sixth through tenth editions. The first group to be described, the crocodilian saurians, are carnivorous and river dwelling. According to Chambers, the origin of these animals is to be found among the squamatic saurians of the secondary formation--probably from the ichthyosaur with its fish-like organization and crocodile-like head. Other connecting links, he explained, are found in the teleosaur and stenosaur.[2]

The lizard as a typical lacertine saurian was discussed in the tenth edition. After the description, Chambers noted a transition from the sauria to the ophidia. Although in the fourth edition he had questioned this relationship, by this edition it was obvious to him that the ophidia should not be in a separate order. Evolution can be retrogressive as well as progressive. Since snakes appeared late in the fossil record, geology seemed to agree with

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[1] CV IV:262.

[2] CV V:266-67; VI:296-302; VIII:182-86; IX:179-82; X:217.

this view of the origin of the ophidia, he claimed.[1]

After discussing the affinities of the reptiles, Chambers concluded in the sixth through tenth editions that geological history again proved itself in accord with the developmental hypothesis. Reptiles occur after the fish in time and also stand after them in organization.[2] In certain cases the transition with the fish is obvious as in the case of the sauroid fishes with reptilian teeth. The lacertilians of the keuper also represent a transitional line, he declared. Although in the fifth and sixth editions Chambers reported that the labyrinthodons represented another transitional line, this connection was not mentioned in the eighth through tenth editions, for labyrinthodons were no longer considered to be batrachians.[3] In the majority of the cases Chambers admitted that the records were meagre and "it is therefore not surprising that specimens uniting the fish with the reptiles, as is done by the enaliosauria, are not as yet found." But still the general affinity of reptiles to fish was evident.[4]

The Affinities of the Birds

What reptiles, asked Chambers in the fourth through tenth editions, could possibly have been ancestral to the birds? Although, in the fourth and fifth editions, he admitted certain similarities between the crocodiles and birds, he explained, in the fourth edition,

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[1] CV VI:300; VIII:184-85; IX:181-82; X:216-18.

[2] CV VI:308-309; VIII:190; IX:187; X:223-24.

[3] CV V:267; VI:309.

[4] CV V:267; VI:311-12; VIII:190; IX:187; X:224.

that he did not interpret this similarity as a genetic connection but rather as "a high degree of organization in an independent line, coming to a point abreast with certain characters in a superior class."[1]

In the fourth edition, Chambers suggested that certain groups of birds may have had a piscine rather than a reptilian origin. The primitive character of the penguins and of the diving birds suggested to Chambers an origin from the fish. This hypothesis would have the advantage of explaining a hitherto unexplained phenomenon. If birds originated from fish, the existence of bird fossils as early as the new red sandstone before the reptiles had reached their height could be explained.[2]

By the fifth edition Chambers had abandoned the idea of a piscine origin for the birds and was concentrating on the location of reptilian antecedents. But, as he reported in the sixth through tenth editions, it was likely that the birds were derived from only one order of reptiles. Although he admitted that the transition from the reptiles to the birds was not as clear as the transitions within the birds themselves, he was not concerned since he recognized that the intermediate forms might not be preserved.[3]

In the fifth through tenth editions, Chambers had decided that the chelonia, of all of the reptilian groups, represented a posibility of being the lone ancestor to the birds. In the fifth edition, he was not yet entirely convinced of the single group

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[1]CV IV:262-63; V:268.

[2]CV IV:263.

[3]CV V:269; VI:311-12; VIII:191; IX:188; X:225.

ancestry and was still considering other possible reptilian ancestors. However, he was basically convinced of the ancestral nature of the chelonia, for this group contains "families of various habits answering to the leading distinctions in the class of birds."[1]

Chambers was concerned with developing an evolutionary sequence within the aves in the fourth through tenth editions. As he explained in the sixth through tenth editions, "unusually clear chains of affinity run through the class."[2] Avian evolution began in the ocean and proceeded to the land, Chambers explained using examples to support his hypothesis.[3] In the fourth and fifth editions he explained that the wading birds proceeded from the swimmers and were succeeded by the perching birds.[4] The raptors, suggested Chambers in the fourth edition, had a separate origin from a different group of swimming birds.[5] In this edition he postulated that the scansores or climbing birds were probably composed of four distinct genetic lines having only climbing in common.[6] He described five groups of birds based on adaptation in the fifth edition, the natatores, grallatores, rasores, incessores, and raptores; the scansores of the fourth edition

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[1]CV V:269-70; VI312; VIII:191; IX:188; X:225.

[2]CV IV:263-65; V:270-73; VI:310; VIII:190-91; IX:187-88; X:224-25.

[3]CV IV:263; V:270-71; VI:313-14; VIII:191-92; IX:189-90; X:226-27.

[4]CV IV:263; V:270-74.

[5]CV IV:264.

[6]CV IV:265.

was not included.[1]

In the sixth through tenth editions Chambers proposed that the first division of the birds should be into three stirpes according to eating habits, the herbivorous forms in one, the carnivorous in a second, and the omnivorous in a third. In the sixth edition alone Chambers explained that a true classification of the birds would present them in the order in which they came into being.[2]

The description of bird affinities was presented in much more detail in the sixth through tenth editions than in the fourth and fifth editions. In these editions he discussed the first of the major avian stirpes--that which resulted in domestic poultry. The root of this stirpes, he explained, was in certain of the natatorial families such as the divers and grebes, residents of the Arctic Ocean. They were succeeded by the mergansers, ducks, geese, swans, phalleropes, gallinules, and coots. Although these animals are still mainly aquatic and have webbed or lobated feet, they tend to live more in rivers and other inland waters.[3] But at this point Chambers noted a tripartite division based on food habits. The mergansers and ducks are chiefly carnivorous, the geese and swans, herbivorous, and the gallinules and coots, omnivorous. As he continued a hypothetical history of these animals, he postulated that they moved along rivers in search of food and landed either on sandy beaches or upon low shores where everything was marshy.

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[1] CV V:270-73.

[2] CV VI:310-11; VIII:191; IX:188; X:225.

[3] CV VI:312-13; VIII:191; IX:189; X:225-26.

As "on came the tide of population behind; it behooves them to spread landward for subsistence."[1] The result was a modification of the natatorial form to a wading form. Following with a Lamarckian touch, Chambers wrote that "the webbing of the toes shrunk, being no longer required for swimming; the toes were elongated, so as to give support upon a yielding ground or bottom; the tarsi were also lengthened to raise the body of the bird above the shallow water in which it walked: at the same time the animal acquired a greater length of neck and of bill to enable it to feed in these waters."[2] In the fifth edition, Chambers also mentioned the transformation of the natatorial into the grallatorial forms and although the description of the anatomical changes was similar to that of the later editions, the account was more abbreviated.[3]

The first stirpes that passed into the waders could be, claimed Chambers, divided into a carnivorous group--descendants of the anatine birds which gave rise to the ardeidae, herons, spoonbills, and storks--and the herbivorous anserine birds--predecessors of the rails, bustards, plovers, snipes, sandpipers, and curlews.[4] As more land appeared and the bird populations expanded, it spread first along rivers and eventually arrived at "elevated, dry, and sylvan grounds."[5] The modified habitat necessitated other modifications.

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[1]CV VI:313-14; VIII:192; IX:189-90; X:226-27.

[2]CV VI:313; VIII:192; IX:189-90; X:226.

[3]CV V:270-71.

[4]CV VI:314-16; VIII:193; IX:190-91; X:227.

[5]CV VI:316; VIII:194; IX:191; X:228.

The crane group (herbivorous line) gave rise to the pheasant family, containing such animals as the peacock, jungle-fowl, domestic poultry, turkeys, and currassows; the pigeon group came from this group. The rails and bustards (omnivorous line) gave rise to the game birds such as the grouse, partridge, and quail.[1]

In the sixth through tenth editions, Chambers stressed several general principles to be drawn from the genealogy of these birds. Each subdivision, he emphasized again, carries on the same food habits throughout all of its transformations. A second principle is that there is always a diminution in size from the marine original to the subsequent land forms. The third principle is that intelligence and a tendency to domestication increases from the marine to the land forms.[2]

The primary avian stirpes could take a second path, Chambers explained in the fifth through tenth editions. Since not all of the land next to the sea was marshy--some of it was composed of extensive sandy plains--the result instead of wading birds was a form with a series of adaptations for living in this type of environment. The running birds, the cursores, such as the ostrich in Africa, the Emu and Cassowary of Australia, the Rhea of America and the Apteryx of New Zealand represent this path of development.[3]

In the sixth through tenth editions, Chambers wrote of a second stirpes--one which was destined to be destructive over the

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[1] CV V:271-72; VI:316-17; VIII:194-95; IX:191-92; X:228-29.

[2] CV VI:318; VIII:195; IX:192; X:229.

[3] CV VI:314; VIII:193; IX:190; X:227.

rest. As in the fifth edition, he had this line arising from the family of the albatross. He explained that because of the habits of this family in frequenting cliffy wildernesses rather than low shores, there were no intermediate wading forms unless the secretary bird could be considered one. The secretary bird as a possible intermediate form was stressed more in the fifth edition; the albatross and petrel passed through such grallatorial forms as the secretary bird to the true raptors, speculated Chambers.[1]

The third avian stirpes to be discussed in the sixth through tenth editions was the universally distributed omnivorous stirpes. These birds usually progress by hopping, and the land species have a foot adapted for grasping or perching. Wary and vivaceous, these birds are noted for chattering and imitativeness; in some advanced genera they have beautiful songs. This stirpes originated in the gull family, the laridae. Defending the gulls against charges of stupidity, Chambers suggested that the reason for this appearance is that they are unused to living near humans, thus their reactions to them are inappropriate. He described various gulls both as to habit and appearance. Since not all gulls are white, he suggested that those with some black may have led to the descendants of the gulls, the crows, "more especially as one of the family, the pie, is chequered, and white crows sometimes occur as exceptions to the rule."[2] But he cautioned that plumage color may be dependent upon external conditions.

Since it produces such a vast and varied progeny, the crow

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[1] CV V:271-72.

[2] CV VI:319-21; VIII:197-98; IX:193-94; X:230-31.

family is extremely important. The carnivorous corvids originated from the raven in the old world; in Europe the hooded crow is the descendant of the raven. Although the crows are characterized as conirostres, having a conical beak, in the predaceous species the beak is hooked resembling that of the raptors. Another series of beaks of birds descending from crows possess a modified raptorial beak, the dentirostres, such as the shrikes and butcher birds (Laniadae).[1] Chambers provided a detailed descriptive genealogy of the descendants of the crows in these later editions.

Chambers noted with satisfaction in the fifth through the tenth editions the correspondence between the fossil history of the birds and his proposed system of relationships. In the fifth edition he stated that those birds which were placed at the bottom of their class also appeared first in the fossil record. The Connecticut footprints supported him in this viewpoint, he noted, for they were made by grallatorial, cursorial, and rasorial birds. He noted that the bird found by Dr. Mantell in the wealden was grallatorial with higher birds coming later; the raptores, for example, did not appear before the eocene tertiary.[2]

As in the fifth edition Chambers noted that the Connecticut footsteps represented primitive birds but admitted that some doubt was attached to those footsteps ascribed to rasorial birds. He did not find the absence of early fossils of swimming birds disconcerting even though they were supposed to be ancestral to the whole class.

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[1] CV VI:323; VIII:198; IX:195; X:232.

[2] CV V:273-74.

He gave two reasons for this; it could "be considered that the phenomena are extremely local and limited; also, that the spot investigated is a portion of an ancient shore, a haunt of wading rather than of swimming birds."[1] Chambers pounced on a recent announcement that a footprint of a swimming bird, a coot, had been found in the Connecticut footprints but he mentioned that this could not be relied upon "especially as a footprint, resembling that of a finch was spoken of at the same time."[2] The three bird fossils found prior to the Connecticut footprints but still in the secondary formation were a snipe, an albatross, and a swallow, "the majority being thus applicable to early portions of the genealogy."[3]

The Evolution of the Mammalia

Although in the fourth edition Chambers suggested that all mammals may have evolved from the reptiles, by the sixth through tenth editions he suspected that even though most mammals had had a reptilian origin the lowest forms came through the birds. He admitted that the intermediate forms in the class transition were missing, but suggested that a few facts might help to illuminate the obscurity. Enough evidence was available, he asserted, to show that both birds and reptiles connect with the mammals.[4] Perhaps the fossil blank at the cretaceous is responsible for some of the obscurity.[5] This discussion

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[1] CV VI:332-33; VIII:203; IX:200-201; X:237.

[2] CV VI:332-33; VIII:203; IX:200-201; X:237.

[3] CV VI:332-33; VIII:203; IX:200-201; X:237.

[4] CV IV:265; V:274; VI:332; XIII:204; IX:201; X:237-38.

[5] CV VI:332; VIII:204; IX:201; X:238.

was not included in the fifth edition.

The first mammal-like reptile was the oolitic cetiosaur, suggested Chambers in the fourth through tenth editions. Although in the fourth edition he stated that this animal was a crocodilian, in the fifth through tenth editions he merely described it as being related to the marine sauria.[1] In all of these editions he noted its affinities to the cetaceans. In order to emphasize the reptilian origin of the cetacea, he stressed, in the sixth through tenth editions, certain reptilian characteristics of this group.

The cetacea represented an ideal primitive mammal for Chambers since these animals were both marine and large. In the fourth through tenth editions he suggested that these aquatic mammals arose from the marine saurians.[2]

In the fifth through the tenth editions, Chambers discussed the passage of the birds to the mammals. The description in the fifth edition was more abbreviated than that in the later editions. Although he considered the evidence of relationship to be clearer than in the case of the reptilian passage, he found it strange that the "humbler" mammals such as the edentates, insectivores, and rodents came through this channel. As a developmentalist he would have preferred for the birds to have given rise to higher mammals.[3] But, he explained, an intermediate connecting group, the implacental mammals (monotremes and marsupials) are hardly mammalian in character at all. A clear gradation

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[1]CV IV:265; V:274; VI:334-35; VIII:204; IX:201; X:238.

[2]CV IV:265; V:274; VI:332-35; VIII:205-206; IX:201-202; X:238.

[3]CV V:276; VI:235-36; VIII:205; IX:202; X:238-39.

between the birds and the mammals is evidenced in these animals. The ornithorhynchus appeared to be a "semi-rodent" and the echidna a "semi-insectivore."[1] The marsupials also seemed to divide into these two forms as if "these were only further advances along similar lines."[2]

In the fourth edition Chambers was inclined to disregard a bird ancestry for any of the mammals, although he admitted that certain bird-like affinities were to be noted in the insectivores, edentates, monotremes, and marsupials. In this edition all that Chambers suggested was that rodents and insectivores had their origin in aquatic mammals.[3]

In the sixth through tenth editions, Chambers returned to the main mammalian line which had proceeded from the cetiosaur to the cetacea. He noted that the marine mammals were extremely varied, explaining that "the whale, the dolphin, the seal, are animals fully as different from each other as the panther and the elephant, the deer and monkey."[4] Still using some of the Macleay terminology, he sought to explain the relationships within the mammalia by stating that the carnivora are "represented" in the seals, the great pachyderms in the whales, and the ruminants in the manatus and dugong. Chambers discussed the obscurity surrounding the aquatic mammals but asserted that they do not represent one or even two orders. He stated that "they merely form the initiatory stages of

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[1]CV V:275-76; VI:336; VIII:205; IX:202; X:239.

[2]CV V:275-76; VI:336; VIII:205; IX:202; X:239.

[3]CV IV:271-72.

[4]CV VI:337; VIII:206; IX:203; X:240.

certain terrestrial orders,--a cross section, as it were, at the bottom of those orders, and part of the composite chain by which they are connected with the reptiles."[1]

From the aquatic base of the large cetaceans, Chambers attempted to trace the genealogy of land forms in the fourth through tenth editions. In the fourth and fifth editions Chambers briefly sketched his view of the descent of the pachyderms from the cetaceans. The description of the evolution from the marine forms, through the extinct dinotherium, through the hippopotamus, to marshland proboscideans to the dry-land tapirs was discussed in more detail in the fourth edition than in the fifth. In this edition he explained the large bulk of the tertiary land mammals by alluding to their large cetacean ancestors and suggested that as they evolved their size decreased as evidenced by the tapir. Equids, he theorized, evolved from the tapirs. Another family of large mammals, the suidae, adapted for living in woods and low soft ground, may have evolved from the rhinoceros.[2]

Although Chambers detailed a basically similar evolutionary sequence to that produced in the fourth and fifth editions in the sixth through tenth, he was less certain of the parentage of the equids and suids in these editions. "Their respective parentages in the bulkier families may be left for future decision," he concluded. In the sixth edition alone, Chambers suggested an opinion of Owen's that there was a connection between the hippopotamus and peccary

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[1]CV VI:337-38; VIII:206; IX:203; X:241.

[2]CV IV:267; V:276.

through an extinct South American mammal, the Choeropotamus.[1]

Chambers revised his opinion concerning the origin of the ruminants from the fourth and fifth editions to the sixth through tenth editions. In the fourth and fifth editions he disagreed with naturalists who suspected connections between the pachyderms and ruminants and alternatively suggested that they had their origin in a separate branch of the herbivorous cetacea, in a walrus-like animal.[2]

In the sixth through tenth editions, Chambers mentioned that the herbivorous cetaceans, such as the dugong, manatus, and walrus form the basis of the ruminant order. In a footnote he said that a different position had been ascribed to these animals in the fifth edition but that he now felt the balance of the evidence agreed with the contentions made in these later editions. The ruminants were divided into subdivisions, the bovidae and the cervidae.[3]

According to Chambers in the fourth through tenth editions, the carnivorous land mammals originated with the carnivorous aquatic seals; however, the proposed genealogies differed in the various editions. In the fourth edition, he suggested that this line progressed from the seals to the sea-otters, to the river dwelling common otter, to the mustelidae, and then to the viverridae.[4]

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[1]CV VI:339; VIII:207; IX:204; X:241.

[2]CV IV:269; V:276-77.

[3]CV VI:340; VIII:207; IX:204; X:241.

[4]CV IV:269-70; V:277; VI:338-39; VIII:206-207; IX:204; X:240-41.

These relationships were not specified in the fifth edition, but in the sixth through tenth he suggested that the seal, sea otter, and "shrews and musteline animals in general," represented a single line of descent. The viverrids were not mentioned for, he explained, the succession of these animals is unclear.[1] In the fourth edition, Chambers had suggested that the canids were derived from the viverrids and that the felids were derived from a separate line from the seals, probably the sea lion line.[2] The bears, according to the fourth edition account, are also an independent group, arising from the seals and moving on to the raccoons.[3]

In the fifth edition, Chambers considered the seals to be ancestral to the ursids and mustelids with the canids as the termination of the line. A footnote was included in this edition to indicate a relationship between bears and dogs. As in the fourth edition, Chambers noted that although the cats were probably of phocal origin, the intermediate littoral forms were not found as fossils.[4]

In the sixth through tenth editions Chambers derived a more explicit genealogy for the bears. He suggested that the sea bear phocids gave rise to the true bears; the proximity of certain bears to the oceans where these animals occurred in addition to their

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[1] CV IV:270.

[2] CV IV:270-71.

[3] CV IV:271.

[4] CV V:277.

plantigrade foot arrangement makes this origin likely.[1] As he had tentatively suggested in the fifth edition, he indicated that the canids presumably evolved from the ursids.

The amount of detail which Chambers devoted to the evolution of the primates was greater in the later editions. In the fourth edition he suggested a possible relationship to certain marsupials. Two genera, phalangista and petaurus of the Indian Archipelago, possess characteristics appearing to lead to the quadrumana. Anatomically, the opposable thumb of their hind feet suggested to Chambers a relationship to the primates. The geographic distribution of these animals in an area of the world currently well supplied with primates also suggested a possible relationship. But he declined to speculate on the way in which this progression might have occurred.[2]

In the fourth edition, Chambers explained that the separate development of the quadrumana would make the appearance of bones of members of this group found in association with the bones of pachyderms acceptable to a theory of development. The two sets of animals could have been developing along parallel lines, "although not parallel in organization, and springing from different portions of the animal kingdom."[3]

In the fifth edition, Chambers used the term cheirotheria to embrace the bats, lemurs, monkeys, and man. He considered the origin to be in the manatean cetaceans, e.g. the manatee and dugong.

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[1] CV VI:338; VIII:206-207; IX:203-204; X:240.

[2] CV IV:272.

[3] CV IV:273.

Similarities were noted in both external appearance and in "moral qualities" to humans; for example, "the female sitting up in the water, and holding her young one by the flipper to her pectoral mammae, strikingly recals [sic] the human mother," and if a companion is wounded the manatees "cling around a wounded or captured associate, bewailing his fate, and making common cause with him."[1]

The description of the primates (including bats) was more detailed in the sixth through tenth editions than in the earlier forms.[2] The delphinidae, the dolphin, probably represented the marine base of the primates, speculated Chambers. The superior brain of the dolphins, "the greatest amongst mammalia, next to the oran-outang and man" made it suitable as an ancestor to such an elevated group, he claimed. He also maintained that its predilection for human society further suited it for such a role. Since he was unable to trace the first steps from these aquatic ancestors, he was forced to resume his account with species which were decidedly inland. There was one exception in which intermediate ancestors were evident--the sloths, such as the fossil megatherium and megalonyx. Although it had sometimes been suggested that megatherium was allied to the armadillos, Chambers mentioned in a footnote that he accepted Newman's classification of this animal as a sloth. However, he did not feel that the lack of a shore-dwelling ancestor for most of the primates was a formidable difficulty since "the species hovering between sea and land, or those

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[1] CV V:278.

[2] CV VI:340-41; VIII:314; IX:205; X:241-43.

adapted to live upon shores and low grounds, are most liable to become extinct."[1] After producing mammalian examples, he remarked that his theories were in general conformity with the history of the mammalia.

Chambers summarized the appearance of the different groups in connection with various periods in geological history, explaining that the marsupials and aquatics appeared early, even before the cretaceous. A long blank period then occurred in the cretaceous after which pachyderms and cetaceans appeared. The higher groups came later; man, who was absent until the latest formations, represented the culmination.[2]

In the fourth edition, Chambers, after summarizing the progression from the sea to the land, stated that it ended with "a being erect, majestic, and with many traits of external grace and beauty, to overspread the whole earth with his race, to turn all beneath him in organization to his own pleasure and manifest more than all that glory of the Creator, which he alone could even attempt to understand."[3]

Although he discussed the appearance of man in more detail in the fifth through tenth editions, he was less explicit in this edition than in the later forms. In the sixth through tenth editions, he admitted that although similarities with existing simians were obvious, it was doubtful whether "the particular species whence the human family was derived has ever come under the attention of naturalists."[4]

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[1] CV VI:341; VIII:208-209; 314; IX:205; X:241-44.

[2] CV VI:341-42; VIII:208-209; IX:206; X:241-44.

[3] CV IV:274.

[4] CV V:278-80; VI:342-43; VIII:209; IX:206; X:243.

He was less vague in the fifth edition, stressing that mantean families were in close proximity to areas where simiadae were common.

But in the sixth through the tenth editions, Chambers stated that a larger species would be necessary than any of the present ones in order to be ancestral.[1] In the fifth through the tenth editions, in tracing the ancestry back, Chambers concluded that of the reptilian orders the batrachians were the most probably ancestors. It is significant, he suggested, that the frog is the only animal besides man to have a calf to its leg. Even so, he admitted, it was "but a humble off-shoot of the main line terminating in the Primates."[2] In these editions, Chambers foresaw the possibility of ridicule but stated that the "large-hearted and truly devout man" would discover in the idea of development "interesting traces of the ways of God to man, and a deeper breathing of the lesson, that whatever lives is to him kindred."[3]

While admitting the imperfections in his classificatory system, Chambers claimed, in the sixth through tenth editions, that it represented "the only approach yet made to a truly natural classification."[4] He insisted that he had proceeded from obvious affinities and found that his system agreed with palaeontological findings.[5]

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[1]CV VI:343; VIII:209; IX:206; X:243-44.

[2]CV V:279; VI:343-44; VIII:209; IX:206-207; X:244.

[3]CV V:280; VI:343-44; VIII:209; IX:206; X:248.

[4]CV VI:344; VIII:209-10; IX:207; X:244.

[5]CV VI:344; VIII:210; IX:207; X:244.

In the fifth through tenth editions he stated that the organic kingdoms should be regarded as a series of forms which originate in the lowest sub-kingdom and pass through higher grades, although individual species need not pass through all, until the highest grade is reached.[1] Chambers summarized that beginning from the "grand matrix of organic being in the sea," trunk lines passed through the sea up to and including the mammals. Again he stressed the two main ways by which evolutionary change was accomplished--a development in the normal gestative process and a response to the environment.[2]

Two decidedly different approaches were apparent in Chambers' attempt to theorize about the affinities of animals. The approach in the first through third editions was based upon Chambers' acceptance of the Macleay system and consisted of an attempt to correlate known palaeontological and geographical data with this hypothesis. However, by the third edition, he was not unqualified in his acceptance of the hypothesis and his doubts intruded upon the text of this edition.

As he wrote the fourth edition, Chambers rejected most of Macleay's suppositions but had not yet arrived at a satisfactory replacement. Therefore, although he had begun the pattern of the later editions, his information was not yet complete and his ideas not fully developed on the basis of the two-strand approach. By the writing of the fifth edition he had tentatively proposed this system and his approach to a discussion of the affinities of animals approached that of the sixth through tenth editions.

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[1] CV V:280-81; VI:344-45; VIII:210; IX:207; X:244-45.

[2] CV V:280-81; VI:345; VIII:210; IX:207; X:245.

Since he was unable to use what for him was a very attractive scheme, the Macleay Hypothesis, Chambers' middle editions, the fourth and fifth, reflect his struggle to locate an acceptable numerical substitute. After this was accomplished, he filled out the later editions with phylogenetic speculations based on the application of his theory to palaeontological data.

CHAPTER VI

MAN AND THE DEVELOPMENTAL HYPOTHESIS

Unwilling to exempt any portion of creation from the laws of development, Chambers concluded the Vestiges by applying his hypothesis to the development of various aspects of man's being. Even mental characteristics can be shown to have evolved in the same way as physical traits. After presenting all of his evidence in support of the universality of development, Chambers ended his work by speculating on the purpose of the entire developmental sequence.

Early History of Mankind

Variations in Mankind

In the first of Chambers' chapters describing the status of man, he was chiefly concerned with the global distribution of the human races. Many varieties of human beings exist--varieties which have remained constant in the same geographical area and under the influence of the same set of conditions since the beginning of history--stressed Chambers in all of the editions. He explained that variations tended to be absorbed within the main type in the course of a few generations.[1]

Although five major types, the Caucasian or Indo-European, the Mongolian, the Malayan, the Negro, and the aboriginal American

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[1]CV I:277; III:262; IV:286; V:294; VI:369; VIII:225; IX:222; X:259.

were listed in the first six editions, the varieties of man were not listed in the eighth through tenth editions. Chambers was never quite certain whether color represented a basic qualitative difference between races or if it was merely a superficial, although easily diagnosed characteristic. Chambers vacillated from a position in the first six editions in which he was inclined to think of color as a fundamental characteristic to a position in the eighth through tenth editions in which he assumed it was a superficial manifestation. Even in the first six editions he was unsure of his position and, although he had not yet accepted it, cited a study by Dr. Prichard in which he indicated that racial peculiarities were superficial characteristics and suggested a possible single origin for the races of mankind.[1]

Chambers' disposition to treat color variations as superficial was supported by several examples included in all of the editions. He described variations of skin color among the inhabitants of Hindustan known to be of a single descent, black Africans with European-like features, and Arab and Jewish families of northern Africa who after many generations became as black as the natives.[2] A natural transition from white to black and black to white in the ordinary course of generation is possible, suggested Chambers. He explained that true whites, not just albinoes, have occurred in negro families and described "one authentic instance of a set of perfectly

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[1]CV I:277-79; III:262-64; IV:286-88; V:294-96; VIII:225; IX:222; X:259.

[2]CV I:279; III:264-65; IV:288; V:296-97; VI:371-72; VIII: 225-26; IX:222-23; X:259-60.

black children being born to an Arab couple, in whose ancestry no such blood had intermingled."[1]

Various styles of living can cause superficial modifications of human structures, continued Chambers. Life style is extremely important; formerly handsome people when transplanted into crude surroundings will be unfortunately modified. "All those people who live miserably are ugly and ill made," but conversely, concluded Chambers, those who have been removed from a barbaric environment and placed in comfortable surroundings tend to become handsome and well-made.[2]

The Origin of Mankind

Still Chambers remained uncertain as to whether all men had a common origin with the races being merely environmental modifications or whether there was a more basic difference between the races which could only be accounted for by assuming them to have separate origins. Because of his views in the first through sixth editions, that although man is ignorant of the laws of the production of varieties, the bulk of the evidence indicates that the races of man are from one stock, he was more inclined to consider color a distinctive factor than in the later editions when he was modifying his views as to a single origin of man.[3]

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[1] CV I:279-80; III:264-65; IV:288-89; V:296-97; IX:371-72; VIII:226; IX:223; X:260.

[2] CV I:280-81; III:265-66; IV:289-90; V:297-98; VI:371-73; VIII:226-27; IX:223-24; X:260-61.

[3] CV I:281-83; III:267-68; IV:290-92; V:298-300; VI:373-75.

Race as a Developmental Phenomenon

In all of the editions, Chambers attempted to apply the principles of development to the production of certain of the characteristics of the varieties of man. Applying the developmental philosophy, Chambers explained that the brain of man after having completed the series of animal transformations goes through another series of developmental changes in which it becomes successively the brain of the negro, the American Indian, the Mongolian, and "finally assumes that perfect character which it bears in the superior Nations comprehensively called Caucasians by Cuvier."[1] The structure of the skull was also traced through this developmental sequence.[2]

Although Chambers concluded that "the leading characters of the various races of mankind are simply representations of particular stages in the development of the highest or Caucasian type," he subsequently stated in the eighth through tenth editions that all of the external variations between races could be accounted for by physical conditions, "so that these can only at utmost serve as proofs of the distinctness of races, if supported by more decisive evidence." This apparent contradiction was not resolved in the Vestiges and Chambers' vacillation from one point of view to another was evident throughout the book.[3]

W. H. Allen was highly critical of Chambers' application

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[1]CV I:306; III:290; IV:314; V:321-22; IV:396-97; VIII:227; IX:224-25; X:261.

[2]CV I:306-307; III:290-91; IV:314-15; V:322; VI:396-97; VIII:227-28; IX:225; X:261-62.

[3]CV I:306-307; III:290-91; IV:314-15; V:331-32; VI:396-97; VIII:227-28; IX:225; X:261-62.

of the Developmental Philosophy to the races of man, complaining about Chambers' assertion that "we Caucasians are, at least, the only full grown children: all others are more or less abortions." He found himself intolerant of Chambers' insinuation that even the Caucasian might in the future be subject to further development.[1]

In the first through sixth editions, Chambers discussed color as a developmental phenomenon. He explained in the first edition that although an immature Caucasian foetus does not appear black nor its slightly more mature form yellow, there might "nevertheless, be a character of skin at a certain stage of development which is predisposed to a particular colour when it is presented as the envelope of a mature being."[2] But in the third through sixth editions he stressed that at any of its stages of development the Caucasian foetus is "different from that of a being whose mature form only comes up to the same point."[3]

Perhaps, he continued in the first through sixth editions, the skin color of the negro is an unavoidable result of its imperfect organization. In the first edition he remarked that it was favorable to his view that newly born negroes are not a deep black but only get this color after exposure to the atmosphere. In the third through sixth editions he added that the parts of the body concealed by clothing are not usually as dark as the hands and face. This phenomenon, he explained, is identical in character to the photographic process and

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[1] W. H. Allen, Review of Vestiges, p. 459.

[2] CV I:307-308.

[3] CV III:292; IV:315-16; V:323; VI:398-99.

is a result of light. The new science of actinochemistry might provide an explanation.[1] He noted in the third and fourth editions that this was favorable to the doctrine of a single origin, but in the fifth and sixth editions admitted that while this seemed to indicate a single origin it did not necessarily do so since separate developments could explain these phenomena just as well.[2]

In the first edition alone, Chambers explained that a single origin had another factor in its favor since both form and color were seen to be dependent on development. He concluded that everything could be explained by advances and retrogressions in the developing power of the mothers, the immediate modifying effect of external conditions, and to some degree to the "suitableness and unsuitableness of marriages, for it is found that parents too nearly related tend to produce offspring of the Mongolian type,--that is, persons who in maturity still are a kind of children."[3]

According to this view the majority of the human race would have declined from the original type and only the Indo-European family has had the primitive organization improved upon. But all is not lost--"look at the progress even now over the barbaric parts of the earth by the best examples of the Caucasian type, promising not only to fill up the waste places, but to supersede the imperfect nations already existing."[4] Chambers considered it quite possible

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[1] CV I:308; III:292-93; IV:315-16; V:323-24; VI:399.

[2] CV III:292; IV:317; V:324; VI:399.

[3] CV I:308-309.

[4] CV I:310.

that the superior Caucasians might even in a single century reverse the proportions.[1]

After describing the different families of languages, Chambers arrived at varying conclusions in the various editions regarding a single or multiple origin for the races of man. From the linguistic evidence, Chambers concluded in the first through fourth editions that "the slight outline which I have been able to give . . ." indicates "evidence for the various races of men being descended from one stock."[2] Although this conclusion in still open to question, and many qualified people accept the opposite view, "I must say that, without the least regard to any other kind of evidence, that which physiology and philology present seems to me decidedly favourable to the idea of a single origin."[3] In order to approximate a solution to the problem of origin, the proper procedure would be to trace the lines of migration of principal tribes backwards to see if they converge.[4]

Even in the earlier editions Chambers was not entirely convinced of a single origin. The negro, he noted in the first four editions, is unaccounted for in the lines of migration and of all the races it is the most likely to have had an independent origin "seeing that it is a type so peculiar in an inveterate black colour, and so mean in development."[5]

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[1] CV I:310.

[2] CV I:293-94; III:268-69; IV:292-303.

[3] CV I:294; III:279; IV:303.

[4] CV I:294-95; III:279; IV:303.

[5] CV I:296; III:280-81; IV:304-305.

This passage, according to the reviewer for the British Quarterly Review, is inconsistent with the "conclusions of those best acquainted with the science of ethnology."[1] He explained that he could not "pass over this statement without expressing our regret, that in a book published in England at the present day, we should find insinuations thrown out, on such shallow evidence, so much opposed to the scriptural account respecting the origin of the human race--insinuations not only calculated to throw doubt upon the foundations of the Christian religion, but which support views, that on the other side [sic] the Atlantic give countenance to the most wicked system of society that ever oppressed mankind."[2] He continued with his accusations of racism by asserting that nearly every view advanced by Chambers has a "tendency the reverse of the moral and the religious."[3] Although "to the educated and the well-informed this is of little consequence, . . . his book is written in an attractive style, and in specious manner, and is too well adapted to lead the uninformed astray."[4] In the first edition alone Chambers had an additional suggestion, one which really would have offended this reviewer. There is much to be said for the idea, he hypothesized, that the negroes represent only a deteriorated offshoot of the general stock.[5]

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[1]Review of Vestiges, British Quarterly Review, p. 508.

[2]Ibid.

[3]Ibid.

[4]Ibid.

[5]CV I:296.

In the fifth and sixth editions, Chambers had more clearly modified his single origin idea to two origins, concluding that "there is no reason to regard more than two local origins for the human race as necessary; namely, one for the Asiatic, American, and European varieties, and another for the African."[1] The first group, he explained, developed near the quadrumana of southern Asia and the second near the quadrumana of West Africa.[2]

In the eighth through tenth editions, Chambers after mentioning the six language groups moved further from his earlier views of a single origin stating that "there is reason to suspect their being of different origins, albeit identical in species."[3] In these editions he indicated that although it was still impossible to speak authoritatively on the matter, the idea of a single origin was becoming less tenable.[4]

The Geographic Location of the Origin of Man

His changing views regarding a single or multiple origin of man affected Chambers' ideas concerning a geographical focus for the origin of man. In the first four editions, he explained that the Developmental Hypothesis demanded that man originated in a place where the quadrumana were abundant. Although the Indian Archipelago would satisfy this requirement, he was not convinced of this origin in the third and fourth editions, for he considered the chimpanzee of western Africa more closely related to man than the Indian

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[1] CV V:311; VI:385.

[2] CV V:311; VI:385.

[3] CV VIII:229-235; IX:225-32; X:263-69.

[4] CV VIII:234-35; IX:231-32; X:268-69.

simians.[1] Chambers' vacillation between a single and multiple origin for man was again evident as he remarked that it was still an open question as to whether man had one or many origins.[2]

In the eighth through tenth editions, Chambers attempted to correlate a sextuple focus of human population origin with geological views and ancient traditions. In the high plateau of central Asia many tribes are concentrated, although today they have spread out into lower regions. Still this indicated to Chambers a possible cradle of civilization. The Indo-European family of languages, Chambers explained, is divided into two stems, the Indian and the Persian which may have arisen in the southern plateau. This hypothesis, he noted, agrees with early Hindu speculation as to the origin of the race. He continued by expressing Prichard's view that the Chinese also descended from the plateau as did the Syro-Arabians. Although there is no record of the American and African families' early history, Chambers postulated that the table-lands in the middle of each area may have been the area of origin and that the groups subsequently migrated into the adjacent lowlands.

From Prichard's data, Chambers concluded "that, if, at a time when the sea was relatively to the land two thousand feet higher than at present, six centres of human population had been established, four of them on various parts of the Asiatic table-land, one on that of Central Africa, and another on either the Andean or Mexican table-land, the phenomena of their subsequent diffusion in the course of time

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[1] CV I:296-97; III:281-82; IV:305.

[2] CV I:296-97; III:281; IV:205.

during which the sea was subsiding, and the dry land enlarging, might have been expected to be precisely what we have seen."[1] He asserted that the three great table-lands also correspond to the three seats of the quadrumana on earth. But Chambers still admitted the tentative nature of this hypothesis for he stressed that "philological researches do not as yet enable us to pronounce authoritatively whether mankind had one origin, or three, or six."[2] Nevertheless, his general emphasis showed a most decided change in the early and in the later editions.

Civilization as Subject to Natural Laws

In all of the editions, Chambers explained that the current vogue was to ascribe a supernatural origin to civilizations.[3] He stressed in the sixth through tenth editions the importance of disproving this in order to corroborate his hypothesis of a world under the universal influence of the law of development.

Chambers explored, in all of the editions, the currently popular notion that the human race was primarily in a state of high civilization and that barbarism was a secondary condition. Tracing, in the first edition alone, the origin of this idea to a desire to support certain interpretations of the Mosaic record, he reported that "it has never yet been propounded by any writer who seemed to have a due sense of the value of science in this class of investigations."[4]

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[1] CV VI:385; VIII:235-37; IX:232-35; X:269-71.

[2] CV VI:385; VIII:237; IX:234; X:271.

[3] CV I:297; III:282; IV:306; V:313; VI:387; VIII:238; IX:235; X:272.

[4] CV I:297-98; III:282-83; IV:306-307; V:313-14; VI:387-88; VIII:238; IX:235-36; X:272-73.

The chief argument used by those who consider civilization to have been the original state is based upon remains of highly crafted artifacts. Since the current barbaric inhabitants would be incapable of producing such masterpieces, it is postulated by those holding this view, that the current populations represent a decline from an original superior form. Although such examples of decay are common, Chambers expressed the view in the first five editions that isolated examples do not point to a regular and constant decline, but only local failures.[1]

In the sixth through tenth editions Chambers did not elaborate on the particulars, stating that although appearances seem to favor a decline such appearances are only partial compared to what we know of the general advance.[2]

A corollary to the hypothesis of a decline from a superior state disturbed Chambers. The theory that there is no such thing as a self-originated civilization would imply, according to Chambers in the eighth through tenth editions, that there had been no time without civilization and, as stated in the fifth and sixth editions, that civilization had a supernatural origin--suggestions that are an anathema to the developmental hypothesis.[3]

An example of a civilization arising independently among basically savage peoples is seen in the social order of the Mandan Indians, reported Chambers in all of the editions. From this and

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[1]CV I:297-98; III:382; IV:306; V:313.

[2]CV VI:388; VIII:238; IX:235; X:272.

[3]CV I:298; III:282; IV:306-307; V:313-14; VI:388-89; VIII: 238-39; IX:236-37; X:272.

other examples, he concluded that it is reasonable to generalize that self-originating civilizations do occur.[1]

"Mrs. Somerville," explained Chambers in the eighth through tenth editions, wrote a book on physical geography in which she describes the spontaneous civilizations which have arisen in both Africa and America. But the most important rational argument produced against the original civilization of man, noted Chambers in all of the editions, is that certain conditions are necessary in order for a civilization to arise and that these conditions could not have been present at the beginning of the human species.

These conditions, Chambers explained, involved a people both numerous and in close propinquity, fixed in their habitation and safe from violent disturbances; in addition, some must be free from toiling for immediate subsistence. Only after these conditions have been met can man be free to pursue civilizing activities.[2] The previously enumerated conditions, concluded Chambers, should be regarded as natural laws effecting the development of civilization.[3]

According to his previously stated criteria, Chambers predicted, in the first through fifth editions, which new geographical entities might be expected to progress and which would not.[4]

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[1] CV I:298-302; III:282-84; IV:307-308; V:314-16; VI:390-91; VIII:239-40; IX:236-39; X:273-76.

[2] CV I:300-305; III:285; IV:309; V:316; VI:391-92; VIII:240; IX:238; X:274-75.

[3] CV I:301-302; III:285; IV:309-10; V:316-18; VI:392-93; VIII:241; IX:238; X:275-76.

[4] CV I:303; III:287; IV:311; V:318-19.

Language as a Developmental Phenomenon

Just as he had rejected a supernatural origin for civilization, Chambers also explained that language was a developmental, not a miraculous, phenomenon. He defined language as the communication of ideas by any means. Therefore, he concluded that the lower animals possessed language and that the only real novelty exhibited by humans was speech.[1]

Although Chambers realized the value of speech, he also stated that it was attributable to a proper set of physical apparatus. With the proper physical equipment and with "a mental power prompting to, and giving directions for, the expression of ideas; . . ." such an arrangement of mutually adapted things "was as likely to produce sounds as an Eolian harp placed in a draught is to produce tones."[2]

The reviewer for the British Quarterly Review found Chambers' acceptance of the sounds of animals as language both necessary for the Developmental Hypothesis and objectionable. It is important to the Developmental Hypothesis, for "if man is born of a monkey, then there ought to be no more advance, in respect of language, by man on the monkey or . . ."the monkey on the lemur, "and so on."[3] But the "noises of brutes" do not constitute language; "throughout the whole animal kingdom we have no proof that a single noise expresses a thought, an abstraction, a generalization, which is that which characterizes

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[1]CV I:311; III:293-94; IV:317-18; V:324-26; VI:399-400; VIII:242-43; IX:240; X:278.

[2]CV I:312-13; III:295; IV:319; V:326-27; VI:401; VIII:243-44; IX:239-41; X:279.

[3]Review of Vestiges, British Quarterly Review, p. 509.

the language of man."[1] Even admitting the "identity in nature between the sounds of brutes, and the language of man, does not the very fact of the perfection of language in man, as compared with that of the highest known quadrumana, point out an essential difference in the nature of the being that makes use of it," asked this reviewer?"[2]

Language, as all other phenomena, must be regarded as developmental in nature and, suggested Chambers, probably evolved from monosyllables. The height to which language develops varies in individuals as well as nations. Nevertheless it is impossible to equate language level and civilization, for they are largely independent of each other. The aboriginal Americans, for example, have a complex language and an inferior civilization; in the eighth through tenth editions an additional example was included--a primitive African civilization with a complex language. Although Chambers' interpretations might be considered to be contradictory to the Developmental hypothesis, he did not so consider them. Instead, he found them supportive since it could be concluded that cultivated intellect is not necessary for the origination of language--a primitive people could originate it. Therefore, language would not be supernaturally imposed.[3]

The "equally simple reasons" for the great diversity of languages were discussed by Chambers in all of the editions. In "dense and refined" populations language tends to be less variable than when we

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[1] Ibid.

[2] Ibid.

[3] CV I:314-15; III:296-98; IV:320-22; V:328-30; VI:403-404; VIII:244-45; IX:241-42; X:280-81.

have a "scattered and barbarous" people. In the latter case we find great diversities and rapid alterations of languages. It is not difficult to understand, concluded Chambers in the first six editions, "how mankind have come at length to possess between three and four thousand languages all different at least as much as French, German, and English, though, as had been shown, the traces of a common origin are observable in them all."[1]

Creativity as a Spontaneous Occurrence

Creativity, postulated Chambers in all of the editions, can occur spontaneously; art and science is not all derivative.[2] However, if we confine ourselves to the "humbly endowed nations or the common class of minds in those so called civilized, we should see absolutely no conceivable power for the origination of new ideas and devices. But if instead we look at the inventive class of individual the fact of creativity is solved. Nations, Chambers explained in the first through sixth editions, are improved from the ideas of inventive individuals and these nations "become in turn foci for the diffusion of light over the adjacent regions of barbarism."[3] Chambers quoted the phrenologist Dr. Gall to stress the individual factor in creativity; "it is a great mistake . . ." he concluded, "to suppose one people to have proceeded from another on account of their conformity of manners, customs, and arts," for "with the same causes we have the same effects;

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[1] CV I:315-18; III:298-301; IV:322-25; V:330-32; VI:404-407; VIII:245-47; IX:242-44.

[2] CV I:319-22; III:303-305; IV:325-29; V:332-34; VI:207-10; VIII:247; IX:244-46; X:283-84.

[3] CV I:322; III:304; IV:328-29; V:335-36; VI:411; VIII:248-49; IX:246; X:284-85.

with the same organization we have the manifestation of the same powers."[1]

Chambers' major concern in this chapter was the resolution of the question of a single or multiple origin for the races of mankind. Although he never did resolve the question, in the later editions he was more convinced of the reality of a multiple origin, whereas in the earlier editions he tended to advocate a single origin. He was not internally consistent in any of the editions, for certain of the evidence indicated a single origin and other evidence indicated multiple foci of origin and the uncertainty was projected into the text.

Mental Constitution of Animals

Although the evidence had convincingly proved the operation of law throughout the physical world, Chambers admitted that the evidence was scant regarding law and the world of the mind. In all of the editions he explained that the nature of the mental constitution of animals remained unknown.[2]

Metaphysicians, noted Chambers, were unwilling to equate mind with the physical entity, the brain. The reason for this dualism is "a fear that this must needs interfere with the cherished religious doctrine of the spirit of man, and lower him to the level of the brutes."[3] This, he declared, results in the drawing of a

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[1] CV I:323; III:305-306; IV:329-30; V:336-37; VI:412; VIII:250; IX:246-47.

[2] CV I:325; III:308; IV:332; V:338-39; VI:413-14; VIII:251; IX:248; X:286-87.

[3] CV I:325; III:308; IV:332; V:338-39; VI:413-14; VIII:251; IX:248; X:286-87.

distinction between the mental processes of the lower animals, labelled instinct, and those of man, called, mind or soul. This dichotomy, Chambers reported, is untenable. He preferred to regard the mental processes of all organisms as essentially of the same kind although with some more highly developed than others. Man might be allowed an immortal spirit if it is kept separate from the ordinary mental processes. This dichotomy is not blasphemous, he stressed, since God was the first cause of matter as well as of mind.

It is the sporadic character of mind which prejudices people to think that it does not operate under rules as do the predictable physical bodies. He noted that "it seemed impossible that anything so subtle and aberrant could be part of a system, the main features of which are regularity and precision."[1] But he hastened to add that such irregularity is only apparent. The individual, he proposed, must be sacrificed to the whole; when the totality of mental phenomena are investigated they will be seen to possess a predictable regularity just as physical phenomena do. The weather, he explained, provides an analogy; whereas it is impossible to predict the weather for a given date exactly it can be generalized over a long period of time.[2]

Other types of human behavior become predictable when a large sample is considered. "Statistics, . . ." he concluded, "has made out an equally distinct regularity in a wide range, with regard

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[1]CV I:327-28; III:310; IV:334; V:340-41; VI:414-15; VIII:252; IX:249; X:287-88.

[2]CV I:328; III:310-11; IV:334-35; V:341-43; VI:415; VIII:252; IX:249; X:288.

to many other things concerning the mind."[1] He referred to a proposal to establish in London a society for insuring the integrity of those who must handle a good deal of money in the course of their business. It was based on the idea that there would be a statistically predictable amount of dishonesty each year and the premiums were to be fixed so as to cover this. Although in some years the society could expect to lost money, in others it would expect to win, so that the total remained constant. In the first through fifth editions, Chambers included a footnote explaining that such a guarantee society had been established and was likely to become a useful and prosperous institution; no mention was made of this organization in the later editions.[2]

A statistical regularity in the moral affairs of man establishes them under the presidency of law. "Man is seen to be an enigma only as an individual: in the mass, he is a mathematical problem."[3] This hypothesis places mental action out of the realm of the meta-physical and into the realm of the natural, agreeing with observations "that mental phenomena flow directly from the brain."[4]

Mental processes as well as physical are subject to the laws of development, reported Chambers in all of the editions. A progression

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[1]CV I:328-29; III:311-12; IV:335-36; V:342-43; VI:415-16; VIII:252-53; IX:249-50; X:288.

[2]CV I:330-31; III:312-14; IV:336-38; V:343-44; VI:416-18; VIII:252-53; IX:249-50; X:288.

[3]CV I:331; III:314; IV:338; V:345; VI:418; VIII:254; IX:251; X:289-90.

[4]CV I:332; III:314; IV:339; V:345; VI:418; VIII:254; IX:251; X:290.

in mental ability can be seen in the phylogenetic progression of the nervous system. In the humblest orders, there are mere rudiments of a nervous apparatus, whereas in the mollusca and crustacea a simple ganglionic cord is present throughout the body which sends out lateral filaments. Whereas in the first edition Chambers described the nervous apparatus of mollusks and crustaceans, in the third through tenth editions he discussed the articulata.[1] In these later editions he described the system as a double nervous cord with ganglia and filaments going out each side with the ganglia of the head receiving nerves from the sense organs.[2]

After describing the invertebrate nervous system, Chambers discussed that of the vertebrates. In all of the editions he mentioned that although the vertebrate nervous system is strikingly superior to that of the invertebrates it is not qualitatively different, thus keeping the principle of unity intact. For example, the brain is merely an expansion of the ganglia (of the mollusca and crustacea in the first edition and of the articulata in the third through tenth editions).[3]

The reviewer for the British Quarterly Review disapproved of Chambers' lack of distinction between the mental processes of the lower animals and of man. Chambers had confused instinct with intelligence, this reviewer asserted, when he claimed that "animals

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[1]CV I:333-34; III:315-17; IX:339-41; V:346-47; VI:419-20; VIII:254-55; IX:251-52; X:280-81.

[2]CV III:316; IV:340; V:347; VI:420; VIII:255; IX:252; X:291.

[3]CV I:333; III:316-17; IV:340-41; V:347; VI:420; VIII:255; IX:252; X:290-91.

possess intelligence as well as instinct in common with man."[1] Another question was asked in this review, "if all the mental phenomena in man result from organization, in the same way as they do in animals, of what is the author's immortal spirit to consist?"[2]

Sir David Brewster abhorred the materialism expressed by Chambers in his equation of the mind with the brain. The idea that the grades of mind like the forms of being are subject to the same law of development is dangerous, he asserted.

In all of the editions Chambers discussed the relationship of the nervous action to electricity. He explained that artificially produced electricity when sent along the nerves of a dead organism will cause muscular activity. If the brain of a newly killed animal is removed and replaced by a substance which produces electric action, the process of digestion will resume, reported Chambers in the first nine editions, "shewing the absolute identity of the brain with a galvanic battery."[3] This phenomenon is not startling, reported Chambers, for electricity is as metaphysical as mind is supposed to be. Although in all of the editions he declared that electricity is perfectly intangible and weightless, in the tenth alone he added that modern philosophers described it as a force rather than a substance, but have proved by its effects that it has an actual existence in nature.[4] In the first through ninth editions Chambers provided

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[1]Review of Vestiges, British Quarterly Review, p. 510.

[2]Ibid.

[3]Brewster, Review of Vestiges, p. 502.

[4]CV I:333-34; III:317-18; IV:341-42; V:347-48; VI:420-21; VIII:255-56; IX:252-53; X:291.

an example of its weightlessness, explaining that heated or magnetized metal will not be a "hundredth part of a grain heavier," yet, in these same editions he insisted that it had an "actual" existence.[1] In all of the editions he concluded that mental action may be of the same nature as electricity. Possibly, he suggested, there is a correlation between the speed of thought and the speed of light.[2]

It is absolutely ridiculous, commented the reviewer for the British Quarterly Review, to conceive of the identity between mind and a galvanic current. Perhaps, suggested this reviewer,

> he must mean all that he has said to pass as a satire upon modern theories. We wish we could think so, or that others would; but it is the tone of earnestness, the thorough sincerity with which he has written, that has alarmed us, and made us apprehensive that his book may lead many astray; many, seeing further than the author, will perhaps reject the truth that is incompatible with his theories, and thus lose their time in pursuit of chimeras, if they do not jeopardise their happiness by vicious conduct.[3]

Brewster was also appalled at Chambers' suggestion that mental action might be similar to electricity. This position, he noted, is "strongly redolent of materialism, and leading to a godless fatalism, will, we trust, find no response in the minds of any of our readers."[4]

In order to emphasize his postulate that the mind of man differs from the mind of the lower animals in degree rather than in kind, Chambers presented, in all of the editions, examples which

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[1] CV I:334; III:317-18; IV:341; V:348; VI:421; VIII:255-56; IX:252.

[2] CV I:334-35; III:317-18; IV:342; V:348; VI:421; VIII:256; IX:253; X:291.

[3] Review of Vestiges, British Quarterly Review, pp. 511-12.

[4] Brewster, Review of Vestiges, p. 502.

illustrated characteristics found in both animals and man, such as affection, jealousy, and envy.[1] Illustrations of many of these common characteristics were given in all of the editions. In the eighth through tenth editions he provided an example illustrating the use of reason in a monkey, the only example not given in all of the editions.[2]

Animals, concluded Chambers, exhibit actions "in no respect different from similar acts of men."[3] Certain behavioral modifications, he proposed, can be accomplished by educating both animals and man. The results in animals are "identical with civilization amongst ourselves; and the quiet, servile steer is probably as unlike the original wild cattle of this country, as the English gentleman of the present day is unlike the rude baron of the age of King John," concluded Chambers.[4]

Phrenology as Evidence for Development

The ideas of the phrenologist, Gall, intrigued Chambers. Gall, explained Chambers in all of the editions, had shown that part of the brain is devoted to perception and that this part is subdivided into areas which receive different stimuli such as form, color, and weight. Certain parts of the brain function for imitation, others for wonder, for discriminating differences, and for the moral feelings

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[1] CV I:335-38; III:319-22; IV:343-47; V:349-52; VI:422-36; VIII:256-58; IX:253-55; X:294.

[2] CV VIII:258; IX:255; X:294.

[3] CV VIII:257-59; IX:255; X:283.

[4] CV VIII:257; IX:254; X:283; V:351; VI:424.

of benevolence, conscientiousness, and veneration.[1] Gall's system of the mind is admirable, since it is the only one based on nature, stressed Chambers.

Language is the tool by which the ideas arising in the mind are expressed. Memory, explained Chambers, can be compared to the photographic process; without memory, "there would be no accumulation of mental capital, but a universal and continual infancy." Conception and imagination are varieties of the state of the brain which produce memory.[2]

Brewster stated that although he was "very unwilling to meddle with Phrenology, a subject almost tabooed, and fenced with so many sensibilities, male and female, as to enjoy a sort of charmed existence, which like the polypus, survives in its individual parts after it has been cut to pieces as a whole; . . . its acceptance by the author of the Vestiges, and its alliance with materialism and other heresies, exhibits it in the real character and tendencies and compels us to devote a few sentences to its discussion."[3] According to Brewster, most of the adherents to phrenology are female. "It would augur ill for the rising generation, . . ." he conjectured, "if the mothers of England were inferred with the errors of Phrenology. . . ."[4]

In attempting to designate the ways in which the mental consti-

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[1]CV I:341-43; III:324-26; IV:348-49; V:354-56; VI:427-29; VIII:259-60; IX:256-57; X:294-96.

[2]CV I:342-43; III:325-26; IV:349-50; V:355-56; VI:429; VIII:260; IX:257; X:295.

[3]Brewster, Review of Vestiges, p. 503.

[4]Ibid.

tution of man differed from that of the lower animals, Chambers concluded in all of the editions, that an increasing indefiniteness characterized the mental processes of higher animals while those of the lower forms were more specific. Particular actions such as the building of cells by bees and the construction of nests by birds point to the definite application of the same potential which when generalized in man lead "us to the arts of the weaver, upholsterers, architect, and mechanist, and makes us often work delightedly where our labours are in vain, or nearly so."[1] But one class of acts can melt into another, he noted, as is exemplified when "the bee and bird will make modifications in the ordinary form of their cells and nests when necessity compels them."[2]

Chambers differentiated between instinct and reason in all of the editions by putting the more definite activities into the former category and the more indefinite into the latter. He postulated that all faculties were based on internal and inherent impulses and could thus be categorized as instincts. Therefore both the indefinite and definite functions of the mind were basically instinctive, but in the first case it is "in an immature and slightly developed state; in the other, in its most advanced condition."[3]

In all of the editions Chambers mentioned that as we ascend in the animal scale we see the definite mode of expression gradually

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[1]CV I:343-44; III:326-27; IV:350-51; V:356-57; VI:431; VIII:260-61; IX:257-58; X:296.

[2]CV I:344; III:327; IV:351; V:357; VI:431; VIII:261; IX:258; X:296.

[3]CV I:345; III:327-28; IV:351-52; V:358; VI:431; VIII:260-61; IX:258; X:296-97.

replaced by the indefinite. Man's actions are largely indefinite, he explained, and he has great discretionary powers while the lower animals are limited. But when the human brain is diseased or in normal infancy, the indefinite mode of action is slightly developed and man's mental processes resemble those of the lower animals. In an example from the Phrenological Journal, he described the similarities of the mental processes of patients of the Harwell Lunatic Society to those of normal animals.[1]

The essential unity of the whole system with the grades of mind as well as body subject to the laws of development is marvelous, Chambers stated. Although the mind of man has obviously developed from that of lower animals, "we have faculties in full force and activity which the animals either possess not at all, or in so low and obscure a form as to be equivalent to non-existence."[2]

Stressed as novelties were those parts of the mind which connect us to things which are not of this world, in particular, the veneration resulting in the worship of God, which is wholly unknown in lower animals. Man's especially highly developed qualities include reason, conscientiousness, and benevolence, all faculties which can be used, stressed Chambers, to help us understand and imitate the ways of the Creator. "The existence of faculties having a regard to such things is a good evidence that such things exist," he concluded.[3]

In all of the editions, Chambers discussed how a definite form

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[1]CV I:346-47; III:329-30; IV:353-54; V:359-60; VI:433; VIII:262-63; IX:259; X:298.

[2]CV I:347; III:331; IV:354-55; V:361; VI:434; VIII:263; IX:260; X:298.

[3]CV I:347-48; III:331; IV:355; V:361; VI:434-35; VIII:263; IX:260; X:298-99.

of mental action can be redirected towards an indefinite sort in man. "Alimentiveness, . . ." he explained, "may be in powerful operation with regard to its appropriate object, producing a keen appetite, and yet it may not act, in consequence of the more powerful operation of cautiousness, warning against evil consequences likely to ensue from the desired indulgence."[1] According to Chambers, free will is the ability "to move from under the control of one feeling to the control of another, being nothing more than a vicissitude in the supremacy of the faculties over each other."[2]

Individual human beings are not equally inherently endowed with mental facilities, and their environment is never capable of entirely altering these inherited characteristics.[3] The volume of the brain and its general quality are basically responsible for an individual's mental characteristics, he asserted; this would have been recognized long ago if people had not been loathe to accept the connection between mind and brain. The different mental characteristics of individuals are also subject to the law of development with some developing through more stages than others, "thus a Cuvier and a Newton are but expansions of a clown. . . ."[4] He assumed that these differences in individual development applied to the lower animals

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[1]CV I:349; III:332; IV:356; V:362; VI:435; VIII:263-64; IX:260-61; X:299.

[2]CV I:349; III:332; IV:356; V:362; VI:435; VIII:264; IX:261; X:299.

[3]CV I:349-50; III:332-33; IV:356-57; V:362-64; VI:435-37; XIII:264-65; IX:261-62; X:299-300.

[4]CV I:350; III:333; IV:357-58; V:364; VI:436-37; VIII:264; IX:261-62; X:300.

as well as man.[1]

In the first edition only Chambers referred to the quinary system and applied mental characteristics to it. He explained that whereas the pre-eminent type has a harmonious assemblage of all the mental qualities, the sub-typical tends to be ferocious, the rasorial, gentle, etc. This idea is applicable to individual men, for some appear to be chiefly sub-typical, others basically rasorial, and a few have the "fine balance" of characteristics needed to make them typical. He gave examples of great men who represented the typical type.[2]

Moral Implications of Man's Indefinite Qualifications

The indefiniteness of the mental qualities of man make him subject to moral enigmas to which animals without choice are not. Since each individual has at least thirty discretionary faculties and every person has a different proportion of each, "we cannot be surprised at the irregularities attending human conduct" and must consider it a necessary price to pay for superior endowment.[3] Although man is able to imagine moral perfection he is unable to attain it, reported Chambers, largely because of the aforementioned complexities leading to different variations. Even in "the best disposed and most disciplined minds" occasional moral lapses will occur.

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[1] CV I:350-51; III:334; IV:358; V:364; VI:437; VIII:265; IX:262; X:300.

[2] CV I:351-52; III:335-36; IV:360; V:366-67; IV:439-40; VIII:266; IX:263; X:301-302.

[3] CV I:354-55; III:337; IV:361; V:367; IV:440; VIII:266-67; IX:263; X:302.

But even in the matter of morals, Chambers expected to see a developmental improvement in the future, for as an infant changes from a self-seeking creature to adulthood where he learns to control this selfishness, society too can be expected to mature and to control its less desirable characteristics.[1]

Chambers considered the problem of evil in all of the editions. How, he asked, can a benevolent God have created beings destined to be evil? In all of the editions, although in differing forms in the first through sixth editions and in the eighth through tenth, Chambers explained that no problem exists if one considers a system in which the Deity acts under general arrangements. Evil, he concluded, is an unfortunate result of God's laws which usually produce good.[2]

Characteristics which make an individual evil are often inherited, Chambers postulated. He explained in the first through sixth editions that if the parent's emotions had oscillated to an extreme the effect on the foetus could be startling. For example, if the condition of the parents "have been favourable for the development, not of the higher, but of the lower sentiments, and of the propensities of the new being, the result will necessarily be a mean type of brain."[3] But this does not mean that God expressly decreed such an individual, he explained, but that, because of the indefinite range of actions, such an individual is "only a part of

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[1]CV I:355; III:337-38; IV:361-62; V:267-68; VI:441; VIII:267; IX:263-67; X:302.

[2]CV I:355-59; III:338-42; IV:362-65; V:368-70; VI:441-45; VIII:267-69; IX:264-66; X:302-304.

[3]CV I:356; III:338-39; IV:362-63; V:369; VI:442.

a series of phenomena, traceable to a principle good in the main, but which admits of evil as an exception."[1]

Chambers did not change his views as to the importance of heredity in determining moral characteristics in the later editions. In the eighth through tenth editions he wrote that "one human being has his organization determined to vice merely because of the ill-controlled feelings of a parent or other predecessor."[2]

In all of the editions, Chambers described particular moral characteristics. He noted that sometimes not only one but several generations may be involved to "bringing up the result to a pitch which produces crime."[3] But he stressed that the general tendency is towards a limitation of this kind of behavior since society is all against it and in time the "medium and superior natures" will be in control.[4]

It is important to advocate humane treatment of prisoners, stressed Chambers in all of the editions. Since they had inherited their evil qualities it seemed only reasonable to Chambers that an acceptable penal system be established. A moral community, he noted, tends to have a just penal system while an immoral one will tend to have harsh and unjust laws. Criminal jurisprudence should "address itself less to direct punishment than to the reformation and care-taking

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[1]CV I:357; III:339; IV:363; V:369; VI:442.

[2]CV VIII:267; IX:264; X:303.

[3]CV I:358-59; III:339-42; IV:364; V:370; VI:443-44; VIII:268; IX:265; X:303.

[4]CV I:358-59; III:340; IV:364; X:370-71; VI:444; VIII:268-69; IX:265; X:304.

of those liable to its attention."[1] Such an arrangement would not be conducive to more crime, but is "evidently no more than justice seeing how accidentally all forms of the moral constitution are distributed, and how thoroughly mutual obligation shines, throughout the whole frame of society--the strong to help the weak, the good to redeem and restrain the bad."[2] Bosanquet was horrified to conclude that Chambers thought criminals should be left to self punishment.[3]

Chambers' conclusion to this chapter summarized his goals for the entire Vestiges. He noted again the unity in nature, ranging from the cosmos to the mind of man. The inorganic world is subject to one ultimate law, gravitation, and the organic is also dependent on one law, development, he reiterated. These two laws may actually be one, "the expression of that unity which man's wit can scarcely separate from Deity itself," according to the first edition or "the expression of a unity, flowing immediately from the One who is First and Last," according to the third through tenth editions.[4]

Purpose and General Condition of the Animated Creation

In all of the editions Chambers proposed to consider how the developmental view "bears upon the condition of man upon the earth,

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[1] CV I:359; III:341; IV:365; V:371-72; VI:444-45; VIII:269; IX:266; X:304.

[2] CV I:359; III:341; IV:365; V:371-72; VI:444-45; VIII:269; IX:266; X:304.

[3] Bosanquet, Review of Vestiges, p. 44.

[4] CV I:360; III:342; IV:366; V:372; VI:445-46; VIII:269; IX:266; X:304-305.

and his relation to supra-mundane things."[1] The main purpose of animal existence, he asserted, is enjoyment. This enjoyment spans the entire scale of animal being, from the lower animals in which enjoyment consists of the gratification of a series of needs, to man with his more indefinite and wider range of enjoyment.[2] It was inconceivable to Chambers that such a vast system could be constituted for any other purpose than this.[3]

But how can this pleasure principle be correlated with the existence of suffering and misery in the world at all levels? A view of the Deity in which the individual is disregarded but in the operation of whose laws the general result is good would justify evil, Chambers conjectured. In the physical department the laws are definite in their purpose so no variability is evidenced, but in the organic department where development acts in the individual or individual group independent of the whole, one law may interfere with another, or it may operate in excess or upon an improper object.[4] Two laws both basically good may interfere with each other with unfortunate results. A boy was crippled for life after a fall from a tree. Two conflicting things, the boy's love for violent exercise and the law of gravitation, both good in themselves, combined with

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[1]CV I:361; III:343; IV:367; V:373; VI:447-48; VIII:270; IX:267-68; X:306.

[2]CV I:361-62; III:343; IV:367; V:373-74; VI:447-48; VIII:270; IX:267-68; X:306.

[3]CV I:362; III:344; IV:367-68; V:374; VI:447-48; VIII:270; IX:267; X:306.

[4]CV I:363; III:345-46; IV:368-69; V:374-75; VI:449-51; VIII: 271; IX:268; X:307.

unfortunate results. Although it certainly is not a primary object of gravitation to hurt boys, he explained, its nature being universal, it caused evil to result as a "casual exception from something in the main good."[1]

The same explanation will also apply to the evils which afflict society, Chambers claimed. A societal condition such as war may represent a tremendous evil. It may be produced by certain human characteristics such as "keen assertion of a supposed right, resentment of supposed injury, acquisitiveness, desire of admiration, combativeness, or mere love of excitement," all of which have a survival value for man and without which he would be a "tame, indolent, unservicable being, . . . and his fate would be starvation."[2] Fortunately, other characteristics in human nature such as benevolence tend to mitigate the frequency and destructiveness of war. Reason interferes so that war can be seen as "purely an evil, even to the conqueror."[3] With his usual optimism, Chambers supposed that the higher impulses may be expected to prevail as civilization advances. When, according to Chambers in the fifth through tenth editions, we think of the long periods of time necessary to evolve a cosmos and the short span of time since the creation of man, we may expect progress to eventually result in "an evolution of a superior being

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[1]CV I:363-65; III:346-47; IV:370-71; V:376-77; VI:451; VIII:272; IX:268-69; X:307-308.

[2]CV I:365-67; III:347-50; IV:371-74; V:377-80; VI:451-54; VIII:272-74; IX:269-71; X:308-10.

[3]CV I:366; III:348; IV:372; V:378; VI:452; VIII:273; IX:270; X:309.

which has been pre-arranged and set forwards to independent action, free within a certain limit, but in the main constrained through primordial law, to go on ever brightening and perfecting, yet never, while the present dispensation of nature shall last, to be quite perfect!"[1]

The "sex passion" is another characteristic of man which works mainly for good with the exceptive examples of evil, explained Chambers in all of the editions. Here again, he reminds us that we are viewing the world in a particular stage of development, and "as reason and the higher sentiments of man's nature increased in force, this passion is put under better regulation, so as to lessen many of the evils connected with it."[2]

Although Chambers considered disease to be a great evil, he still assumed it to be an exception "from a general rule of which the direct action is to confer happiness." He rationalized that if humans were infinitely hardy they might be deprived "of a large portion of that delicacy in which lie some of our most agreeable sensations."[3] Or another possibility would be that man would be restricted to definiteness of action like the lower animals. Although they are seldom victims of disease, they are not capable of higher enjoyments.[4] By reducing the power of disease producing agencies, the "derangement

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[1]CV V:379; VI:453-54; VIII:274; IX:270-72; X:309.

[2]CV I:367-68; III:350-51; IV:374-75; VI:454-55; VIII:274-75; IX:271-72; X:310-11.

[3]CV I:369; III:352; IV:376; V:382; VI:456; VIII:275; IX:272; X:311.

[4]CV I:369; III:352-53; IV:376-77; V:382-83; VI:456-57; VIII:275; IX:272; X:311.

of the whole economy of nature as would have been attended with more serious evils," might occur.[1]

Man, being an intelligent creature, with his indefiniteness of approach to the solution of mental problems will, according to Chambers, be likely to eliminate certain diseases in the future by applying his intelligence to conquering them. The quality of human life, he noted, has improved greatly since its early stages; this improvement can be attributed to the greater ascendancy of reason.[2]

Although the innocent often suffer with the guilty in the case of disease transmission, this unfortunate condition must be expected since universal law acts for the general rather than for the specific good. Even in these tragic cases, he stressed, the basis is good, but "with regard to the innocence of the suffering parties, there is one important consideration which is pressed upon us from many quarters, namely, that moral conditions have not the least concern in the working of the physical laws."[3] But, if this was not the case, he concluded, no dependence could be placed upon these laws. Therefore, "virtue forms no protection against the evils connected with the physical laws, while, on the other hand, a man skilled in and attentive to these, but unrighteous and disregardful of his neighbour, is in like manner not protected by his attention to physical circumstances from the proper consequences of neglect or

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[1] CV I:270; III:353; IV:377; V:383; VI:457; VIII:276; IX:273; X:312.

[2] CV I:371-74; III:356-57; IV:380-81; V:384-87; VI:457-61; VIII:277-78; IX:273-74; X:312-14.

[3] CV I:375; III:357-58; IV:381-82; V:387-90; VI:461-62; VIII: 279-80; IX:275-77; X:314-15.

breach of the moral laws."[1]

In the first edition, Chambers especially stressed the insignificance of the individual in the operation of natural laws. If an individual is not properly endowed or if evil things happen to him, he can at least assume that "there was at least no partiality against him." In this edition Chambers likened the system to the "fairness of a lottery, in which every one has the like chance of drawing the prize." But Chambers noted that "few evils are altogether unmixed."[2]

God's unbending laws are modified somewhat, suggested Chambers, by others which appear to have been designed to have a "compensating, a repairing, and a consoling effect."[3] As illustrations, he explained that the blind have a more acute sense of touch and those born without hands learn to use their feet as hands; people also tend to protect those born with handicaps, thus making the handicap more bearable. "In short, . . ." he noted, "we never see evil of any kind take place, where there is not some remedy or compensating principle ready to interfere for its alleviation."[4]

The Importance of Free Will

Free will must be used intelligently, stressed Chambers in

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[1]CV I:376; III:358; IV:382-84; V:389-90; VI:463-64; VIII:279-80; IX:276-77; X:315.

[2]CV I:377.

[3]CV I:377-78; III:359-61; IV:388-89; V:394-95; VI:468-69; VIII:282; IX:279; X:317-18.

[4]CV I:378; III:360-61; IV:369; V:395; VI:469; VIII:282; IX:279; X:318.

all of the editions, so "that the arrangements which Providence has made impartially for all may be in our favour, and not against us; such are the only means by which we can obtain good and avoid evil here below."[1] In doing this, he explained, the rights of others must not be infringed upon so that they may have the opportunity of doing the same thing. He noted that the same rule of morality applied to groups of men and nations as to individuals. By acting on the principle "that our greatest happiness is not to be realized by each having a regard for himself, but by each seeking primarily to benefit his fellow-creatures" would result in the advance of the human race beyond its present position in intellect and morals.[2]

"A progression resembling development may be traced in human nature, both in the individual and in large groups of men," concluded Chambers.[3] In the fifth edition Chambers discussed future progress in man by assessing the possibility of his evolving into a higher species. Zoology would favor this, he noted, for whereas all of the families nearest to man, the lemuridae, vespertilionidae, and simiadae are divided into numerous species, the family of man contains only one, and by following a system of analogies it might be expected that there is a future progress in development designed.[4] Man's use

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[1]CV I:380-81; III:363-64; IV:390-91; V:397; VI:471; VIII:283-84; IX:280-81; X:319.

[2]CV V:397-98; VI:471-72; VIII:285; IX:281; X:320.

[3]CV I:381-83; III:364-65; IV:394; V:398; VI:472-73; VIII: 284-85; IX:281-82; X:320.

[4]CV I:381-82; III:268-69; IV:395-98; V:400-403; VI:474-77; VIII:285-87; IX:282-84.

of his brains made possible a progression which Chambers in the fifth through tenth editions conceived as "preparations for, and causes of, the possible development of higher types of humanity."[1]

All of the editions converged with an optimistic note. After explaining that man must take his chances in a "natural system of undeviating operations" he asserted that there is a "system of Mercy and Grace behind the screen of nature, which is to make up for all casualities endured here, and the very largeness of which is what makes these casualties a matter of indifference to God."[2] Nature itself indicates the existence of a future redress in the whole "Great Progress."[3]

It would be unworthy of God to create a static situation in which "an endless monotony of human generations with their humble thinkings and doings, . . ." came and went without providing for future progress.[4] Chambers concluded that even if one does not accept his arguments for the future "there may yet be a faith derived from this view of nature sufficient to sustain us under all sense of the imperfect happiness, the calamities, the woes, and pains of this sphere of being." When we think of the contingencies of this world as having melted into a larger system of progress, "let us wait the end with patience, and be of good cheer."[5]

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[1]CV V:405; VI:474-77; VIII:286-87; IX:282-84; X:321-22.

[2]CV I:384; III:377; IV:400-401; V:406-407; VI:478-79; VIII:288; IX:285; X:323-24.

[3]CV I:385; III:377; IX:401; V:407; VI:479; VIII:288; IX:285; X:324.

[4]CV I:385; III:377-78; IV:401-402; V:407-408; VI:479-80; VIII: 288; IX:285; X:324.

[5]CV I:386; III:379; IV:402-403; V:408-409; VI:480; VIII:289; IX:285; X:325.

The interaction between the individual and the total creation occupied Chambers' attention throughout the last section of the Vestiges. Two apparently contradictory ideas emerged from his presentation. Having stated that the prime purpose for the existence of all organisms is enjoyment, he noted that the individual is unimportant in the total scheme of things--a mere statistic. These two suppositions are difficult to reconcile. If the entire creation is observed, then all of the individual evils can be shown to add up to a total good. Then enjoyment as a purpose would have to be on the level of the entire production rather than on an individual level--an unsatisfying hypothesis. Chambers attempted to make his hypothesis of the insignificance of the individual more palatable, by indicating that there would be an ultimate redress of individual grievances.

CONCLUSION

Most of the comments about the Vestiges contained in the reviews were devastating. Moreover, most of them were valid. Nonetheless although ravaged by these ferocious critical attacks, and to a degree because of them, the book assumed a prominent position in the Victorian landscape. Fear of change and the realization that the popularity of the Vestiges might portend a mighty upheaval in the current intellectual configuration were major factors in inducing critics, from the polemecist Bosanquet to the scientist Thomas Henry Huxley, to lash out furiously at the Vestiges. Many people who read the Vestiges were converted by its nonsense, insisted the critics. Educated men, they hoped, would recognize the book's obvious faults; however, the majority of the reading public would lack the discriminating taste of the intellectual. Therefore, while protesting the insignificance of Vestiges, Victorian intellectuals were unable to leave it alone. Some such as Sedgwick and Huxley presented detailed critiques, whereas others such as John Herschel and Agassiz were content with a few jabs.

The "facts," according to Victorian scientific dogma, should lead to the "truth." Chambers appeared to approach the problem from the wrong direction. His hypothesis of the universality of the law of development did not stem from the collection of data. Instead, he appeared to select facts to conform with his preconceived hypothesis. Although there have been times in the history of science when such an admittedly Platonic approach would have been the most acceptable way

of explaining the phenomena, the nineteenth century was not one of these times. Brewster, for one, despised Chambers as one of those low revellers in speculation

> who practise their orgies in the temple of science, ransacking its storehouse for the materials of hypothesis, and not infrequently adulterating them for popular taste, or fashioning them for vulgar apprehension, or perchance suppressing or denouncing the testimony which they bear. Writers of this class have neither learned, nor wish to learn, the real meaning and sterling value of A FACT IN SCIENCE--that eternal and immutable truth, which every man must believe, and which all men may possess, that indestructible element of knowledge, which time cannot alter, nor power crush, nor fire subdue--that self-luminous atom, which shines brightest in the dark, and whose vestal fire an intellectual priesthood will ever struggle to maintain. . . .[1]

Another reviewer, Edward Newman, writing in The Zoologist: A Popular Miscellany of Natural History, concluded that

> as a work of science the 'Vestiges of Creation' is on a par with the 'Metamorphosis of Ovid.' It is equally absurd, unnatural, and illogical. In reading Ovid's beautiful work, we make the necessary allowance: we feel that the poet is neither deceiving himself, nor attempting to deceive us; whereas in the present work there is abundant evidence that the author is in earnest; that his hasty and superficial reading has supplied wild schemes and illusory visions, which nothing but time and knowledge are likely to dispel.[2]

The wrath of the reviewers was out of proportion to the significance of the Vestiges as a scientific work. This over-reaction is directly related to Chambers' violation of the nineteenth-century concept of the scientific ideal--the deification of the "fact." Here was a work which, then, rejected all that was revered--the very essence of science. The token tributes which Chambers offered to the fact-oriented Victorian scientific world, such as the Ghentian experiments as "proof"

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[1] Brewster, Review of Vestiges, pp. 473-74.

[2] Newman, Review of Vestiges, p. 963.

of the Nebular Hypothesis and observational evidence for the spontaneous generation of white clover, were insufficient to compensate for his Platonic-Pythagorean preoccupation with numeralogy, noted in his use of the Macleay system of classification and in the interpretation of the results obtained from Babbage's calculator. His ill-chosen "facts" gave his critics something tangible to criticize. It seems most likely that Chambers was only peripherally aware of his deficiency in selective fact collecting. But his inclusion of factual supports in his theoretical discussions indicates at least a surface awareness of contemporary scientific standards--a desire to conform to science's Baconian demands. In addition to attempting to satisfy the Victorian scientific world's thirst for the empirical through the inclusion of "facts," Chambers himself found trivia intriguing although unimportant.

Nevertheless, the critical reactions to errors that he was apt to consider minor amazed him. As a messenger of truth, Chambers found it inconceivable that others would fail to recognize his message's cogency when it was placed before them in an attractive form, even though marred by a few insignificant mistakes or inconsistencies with received knowledge. Not for a single moment did he believe that his creation would elicit the kind of adverse response that it did in fact engender. Although Chambers' decision to publish anonymously indicated that he did not expect uniform approval of his ideas, particularly from ecclesiastical sources, he was totally unprepared for the barrage of criticism which resulted. Such innocence suggests that he was not thoroughly in tune with the scientific intellectual climate of his time. Victorian science sought after and rewarded the meticulous, original investigator and the judicious expositor of empirical science, not the second-hand advocate of shamelessly intemperate

and ill-founded hypothetical fancies.

After the first rude shock passed, Chambers mobilized his defenses and began the laborious and continuous process of revision. As is characteristic of "good scientists"--and Chambers had this trait in common with good scientists--he added additional postulates to force his theory to conform with the phenomena. Never did he consider discarding the theory. In his mind, its truth was clearly evident. Objections could be made to details, of course, but these were insignificant in comparison to the total conception. The incredible ignorance of the reviewers in failing to recognize the strength of the total theory because of a few factual discrepancies startled and horrified Chambers--another indication that he was not fully attuned to the temper of his own times. Perhaps the reviewers would come to their senses if he could correct the factual errors and add new confirmatory evidence.

Chambers' misuse of "facts" was stressed by his reviewers because it represented a concrete basis for criticism and was obviously vulnerable to attack, even though there was a deeper ideological conflict between the Vestiges and its critics. For no matter what their stated methodology, contemporary scientists did not indiscriminately gather data without a preconceived goal in mind. If they had proceeded in this random fashion the results would have been sterile scientifically. On a more fundamental level it was not the deductive order of procedure which so disturbed the critics; rather, it was Chambers' operation outside of the traditional theoretical framework of special creation and his acceptance of the not-yet-acceptable developmental frame of reference.

By changing the insignificant, Chambers hoped to attain acceptance for that which was really important--his theory of progressive

development. A progressive disillusionment can be noted in his increasingly defensive attitude in each subsequent edition. Nevertheless he continued to try. The first four editions were published in such rapid succession that few changes were made. But even these editions were far from identical. When his facts were assailed or his pet theories assaulted, he attempted to modify them in order to save his grand conception--the idea of universal development. Time to digest the reports of the reviewers and to read, study, and think about current scientific developments allowed Chambers to revise his ideas more radically in the fifth edition. Not only did he continue to correct factual errors and modify dubious supportive theories such as the Limestone Hypothesis and the Macleay system of classification, he began to change the structural basis of his "progression" of animate beings. He abandoned a linear progression, but had not yet created an adequate substitute. However, by the sixth edition he had conceived the two-strand approach to development and revised the book accordingly. The changes were minimal after this revision until the tenth edition. Although the theory itself was basically unchanged, this edition included selections from highly-regarded scientists who had written works which could be use to support certain aspects of the developmental philosophy, as well as answers to some of his most vituperative critics. The tenth edition was an especially attractive book, containing, for the first time, numerous illustrations. But even its aesthetic qualities were insufficient to appease the reviewers, so Chambers finally ceased the constant revisions that had occupied so much of his time for years. After many arduous years spent in continually remolding the Vestiges, Chambers at last did what he had proposed to do so many years before--allow the book to go

"forth to take its chance of instant oblivion, or of a long and active course of usefulness in the world."

It was the scientific rather than the ecclesiastical critics who elicited most of the changes in Vestiges. Sedgwick's barbs were especially effective because they were found in one of the better known review magazines, The Edinburgh Review. They could not be ignored because of their wide circulation, nor could those hurled by the respectable although polemical Hugh Miller in his book, The Footprints of the Creator. Their opinions were evidently important to Chambers since he chose to answer their objections in the tenth edition of Vestiges. Of less importance to Chambers, but of more significance to subsequent generations because of the destiny of evolutionary thinking, were the comments of Huxley, Darwin, and Wallace.

Since Chambers regarded himself as a scientist, he was less concerned with the comments of his religiously-oriented critics. The concerns of both W. H. Allen and J. H. Allen, the first an immoderate partisan and the second a reasonable critic, were of little interest to Chambers because he did not respect their scientific ideas. It was the awful antagonism of those whom he would like to consider colleagues, the scientists, that was most devastating and which, therefore, wrought most of the changes.

Chambers was more competent in geology than in any other scientific field. He published the results of some original geological investigations. But his geological work did not leave him any less vulnerable to criticism in this area than in others in which he had less knowledge. Although critics such as Huxley and Darwin acknowledged that he made fewer errors of fact in the later than in the earlier

editions, they found his increasingly accurate use of data uniformly intolerable, for he persisted in misusing the facts to support an insupportable theory.

Leaving aside the irrelevant standard of our modern scientific convictions, historical instinct informs us that the Vestiges is not intrinsically of high value as a scientific work. But assessing the reasons for this feeling involves a discussion of certain of the characteristics of science. Many of Chambers' allegedly non-scientific qualities have been shared by individuals whom we must consider scientists if the term is to have useful meaning. Qualities such as the a priori creation of a theory, disrespect of facts, retention of an unsatisfactory theory, excessive dependence on the work of others, and failure to give credit to others whose work is borrowed are not usually considered ideal scientific qualities. Yet if those who have exemplified these characteristics were not scientists, a roster of "true scientists" would be exceedingly brief.

Any retrospective examination of science reveals that many great scientific accomplishments have rested on a priori creation of theories--Ptolemy, Kepler, Descartes, and Dalton spring to mind as examples. Chambers' accomplishment cannot be dismissed as unscientific merely on the grounds that it was basically "a prioristic," or even inconsistent with the approved scientific methodologies of his own day or ours. When such a problem arose he followed an excellent past precedent and reinterpreted the phenomena rather than revising his theory. Vestiges is clearly a derivative work. Yet so is Euclid's Elements, much of Newton's Principia, and Lyell's Principles of Geology. But there is a difference. Whereas these synthetic

works are obviously of scientific importance, our twentieth-century data-oriented instinct concurs with Chambers' contemporary critics in branding Vestiges as insignificant scientifically.

Often Chambers did not give credit to the originators of ideas that he claimed as his own. But this does not, of necessity, detract from the scientific nature of his work. If this procedure is unscientific then it too is a crime perpetrated by many individuals whom we want to recognize as scientists. It is most probable that Chambers was unaware of the derivative nature of his ideas. He was a widely read individual but his reading usually consisted of secondary materials which, in turn, did not credit the originators of the included ideas. He also was a popular member of a salon society in which currently relevant ideas were constantly discussed. It is not in the least surprising that he absorbed these ubiquitous ideas and reconstituted them to form what he thought was an original theoretical conception.

Even though the Vestiges shared several characteristics common to scientific works of the first order its importance clearly lies not so much in its scientific merit but in the effect it produced on nineteenth-century society. Science involves a delicate interaction between theory and phenomena. And Chambers was unable to fathom this interrelationship. He tried, but his attempt failed. He simply did not possess the necessary scientific tools to delve extensively into the phenomena himself, nor the critical judgment born of experience and perception that would enable him to properly evaluate the research of others. Therefore, although Vestiges exhibits many of the characteristics of a significant scientific work, Chambers' inability to assimilate the theories and data available to him in the mid-nineteenth century kept him from being a scientist of

primary importance.

But Vestiges was far from being an insignificant work! Even the unflattering attention of the reviewers established this. Its subject was obviously fascinating. The curiosity of the reading public was piqued. When "true" scientists such as Darwin and Wallace appeared they found a ready made audience--once which possessed some sophistication on the subject of evolution--able to understand what they were proposing.

More in retrospect from a twentieth-century vantage point than from a contemporary nineteenth-century view, can Chambers' magnificent concept of development be appreciated. The theme which pervaded much of the history of science in the nineteenth and twentieth centuries was presaged by Chambers. The cosmos seen at all levels as a creature of law following an inevitable, relentless progression from the simple to the complex signifies a vital new theoretical approach. No matter how misguided his use of factual evidence or how poorly integrated into the theoretical fabric of his narrative is his supportive data, there can be no doubt that Chambers articulated a new way of looking at the universe.

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