

EVOLUTION VERSUS CREATION SCIENCE: WHAT IS
SCIENCE? THE CONTROVERSY CONTINUES

By

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SCIENCE? THE CONTROVERSY CONTINUES

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TABLE OF CONTENTS

Chapter	Page
I. INTRODUCTION	1
Creation Science	2
Evolution Science.	4
Religion and Theory.	4
II. LEGAL CONFLICTS	7
Introduction	7
History of Legislative Strategies.	7
Strategy One.	8
Strategy Two.	9
Strategy Three.	9
III. MODEL	12
Evolution.	12
Definition.	12
Problems With the Model	14
Creation Science	17
Definition.	17
Problems With the Model	18
IV. POINTS OF CONFLICT.	20
Introduction	20
Age of the Earth	30
Evolution	20
Creation Science.	23
Anatomy and Morphology	24
Evolution	24
Creation Science.	27
Molecular Similarities	29
Evolution	29
Creation Science.	31
Mutation	31
Definition.	31
Evolution	31
Creation Science.	34
Noachian Deluge.	33
Definition.	33

Chapter	Page
Evolution	34
Creation Science.	36
Fossil Evidence.	38
Definition.	38
Evolution	39
Creation Science.	41
Origin of Man.	41
Evolution	41
Creation Science.	49
V. WHAT IS SCIENCE?.	51
Definition	51
Equal Time	54
Evolutionists	54
Creationists.	54
Noncreationist Christians	55
Biology Teachers.	56
Conclusion	57
BIBLIOGRAPHY	59

LIST OF TABLES

Table	Page
I. Radiometric Dating Processes	21

CHAPTER I

INTRODUCTION

Evolution versus creation science is a controversial subject facing the scientific community today, especially for teachers of the biological sciences. The increased attempts by creationists to legislate balanced treatment for the teaching of creation science in public schools as a counterpoint to evolution has forced evolutionists to define and defend science.

This study involved a literature investigation of the evolutionist and creationist views on the origin of life. Since the literature covering issues surrounding both evolution and creation science are so vast, an attempt was made to summarize some key points of conflict between the two models. Evolution and creation science are defined, and some of their major areas of conflict are given. The last section of the report deals with the definition of science and whether or not equal time should be given in the classroom to evolution and creation science, based upon a rigorous definition of science.

The main thrust of this report is to present an unbiased summation of the two opposing views. The reader can then draw his or her own conclusions as to whether or not evolution and creation science meet the predetermined standards of science, and whether or not equal time should be given to both in public education classrooms.

A brief description of both creation science and the creationist, as well as evolution and the evolutionist, are presented in this chapter. A broader explanation of both positions will be presented in subsequent chapters.

Creation Science

Creation science deals with the origins and destinies of life and its meaning. Creation science also seeks to explain how all living things, present and extinct, were created. Creationists believe this was carried out by processes which do not exist as natural processes in the present day (Morris and Parker, 1982).

Creationists, many of whom are scientists and also fundamental Protestants, regard the Bible (particularly the book of Genesis) as infallible. Their aim is to have creation science presented as an alternative to evolution in all public school science classes (Newell, 1982).

There are now many "creation" institutes, colleges, societies, and organizations across the nation. A few of these are as follows:

1. The American Scientific Affiliation (ASA) was formed in 1941 to investigate problems concerning relations between the Christian faith and science.

2. The Creation Research Society (CRS) was founded in 1963 in Ann Arbor, Michigan. Some members of CRS had previously been members of the ASA, but left when the ASA did not take a firm position on the teaching of evolution. The CRS subsequently split into several factions.

3. The Creation Science Research Center (CSRC) was founded in 1970 in San Diego, California, by several members of the CRS.

4. The Institute for Creation Research (ICR) was formed in 1972 as an offshoot from the CSRC. It later became the research division of the Christian Heritage College, a dominant creationist organization. To become a member, an applicant must sign a form affirming subscription to the following statements:

1. The Bible is the written Word of God, and because we believe it to be inspired throughout, all of its assertions are historically and scientifically true in all the original autographs. To the students of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including man, were made by direct creative acts of God during Creation Week as described in Genesis. Whatever biological changes have occurred since Creation have accomplished only changes within the original created kinds.
3. The great Flood described in Genesis, commonly referred to as the Noachian Deluge, was an historical event, worldwide in its extent and effect.
4. Finally, we are an organization of Christian men of science, who accept Jesus Christ as our Lord and Savior. The account of the special creation of Adam and Eve as one man and one woman, and their subsequent Fall into sin, is the basis for our belief in the necessity of a Savior for all mankind. Therefore, salvation can come only through accepting Jesus Christ as Savior (Lewin, 1982a, pp. 142-143).

California is the center of most creationist activities, although similar organizations can be found in other states. The Genesis School of Graduate Studies, Gainesville, Florida, offers a Ph.D. in science-creation research and emphasizes special creation and the young earth model. Bob Jones University in South Carolina teaches courses which present both evolutionary theory and special creation.

Other support organizations include the following: Educational Research Analysts in Texas; Creation Research Science Education Foundation in Ohio; Triangle Association for Scientific Creationism in the Research Triangle near Raleigh, North Carolina; and Missouri Association for Creation, to name several. There are two British equivalent associations. One is the Evolution Protest Movement (EPM), founded in 1932. The second group is the Newton Scientific Organization. It was founded in 1973 to distribute creationist literature and to advance the scientific study of creation (Nelkin, 1982).

There are publishing organizations who distribute creationist work. One of these organizations is Bible Science Association of Caldwell, Idaho, and in 1973, a new chapter of Bible Science Association was formed, calling itself the "Scientific Creationism Association of Southern New Jersey."

Evolution Science

Evolution science, generally speaking, states that all organisms, past and present, are interrelated by a process of ancestry and descent (Eldredge, 1982). Evolutionists are scientists from all areas of research who accept organic evolution as fact, based upon evidence collected and experiments conducted (Newell, 1982).

Religion and Theory

Finally, there are two other terms, religion and theory, that need to be briefly defined. First, religion is defined in Webster's Ninth New Collegiate Dictionary (1985, p. 995) as "the service and

worship of God or the supernatural; a cause, principle, or system of beliefs held to with ardor and faith."

Gilkey (1983) stated that there are many different kinds of religions. Not all religions have gods; likewise, not all religions worship God. Christian and other monotheistic religions refer essentially and exclusively to God, which, in these religions, is the ultimate principle of reality, the source of every religious way of life, the founding agent of religious communities, and the creator of all things, living and extinct.

Webster's Ninth New College Dictionary (1985, p. 1223) defined theory as "the analysis of a set of facts in their relation to one another." According to Gould (1981), an evolutionist's view of evolution is both a theory and a fact. In science, "fact" can only mean ". . . confirmed to such a degree that it would be perverse to withhold provisional assent. Theories are ideas that explain and interpret facts" (Gould, 1981, p. 35). Eldredge (1982) stated that to define something as a theory in science is really to call it a complex idea.

Moore and Slusher (1981) defined "theory" as an imagined unit or aspect, such as a gene, atom, or electron. Therefore, no theory can be tested directly. Theories cannot be labeled true or false. A theory can be confirmed or supported indirectly as deductions or predictions based on statements of the theory that are put to direct tests.

Keeton and McFadden (1983) stated that when scientists use the word "theory," they are referring to theory as a hypothesis that has been tested repeatedly and extensively and always found to be true.

Keeton and McFadden further stated that no theory is absolutely and finally proved. Scientists should be ready to alter or abandon generalizations whenever new facts become available.

CHAPTER II

LEGAL CONFLICTS

Introduction

Conflicts between evolutionists and creationists have been taking place since the Civil War, mainly in the south, where Bible teachings were thought to be threatened by scientific doctrine in schools and colleges (Ruse, 1982). A brief history of legislative strategies by creationists to counteract the influence of the theory of evolution in American public schools is given in the following paragraphs. These strategies include banning the teaching of evolution, requiring equal time for evolution and biblical creationism, and balanced treatment of evolution and creation science.

History of Legislative Strategies

Several states such as Oklahoma, West Virginia, Delaware, Georgia, North and South Carolina, Indiana, Minnesota, California, Iowa, Texas, and Louisiana (to name a few) had antievolution bills introduced into their states' legislatures. These have since been ruled unconstitutional. However, the following are examples of state court cases which explain each of the creationist strategies (Lightner, 1977).

Strategy One

The first strategy was to ban the teaching of evolution (1920-1968). In the 1870's, one of the earliest casualties in the cause of science was geologist Alexander Winchell at Vanderbilt University, who lost his job for informing his class that humans were descended from organisms that lived before Adam (deCamp, 1969).

After World War I, as a result of fundamentalist lobbying efforts, Oklahoma passed a law banning evolutionary textbooks. In 1925, the Tennessee state legislature passed a bill making it a crime to teach evolutionary ideas. This set the stage for one of the most famous trials of the century, the Scopes trial.

In 1925, John Thomas Scopes was tried in Tennessee for violating the state's law against teaching evolution in public schools. Clarence Darrow was Scope's defense attorney, and William Jennings Bryant, thrice defeated presidential candidate, was the spokesman for the fundamentalist Protestants. Scopes was found guilty and fined \$100, but later his conviction was reversed on a technicality (Grabiner and Miller, 1974; Ruse, 1982). As a result of the Scopes trial, anti-evolutionist bills became law in Mississippi and Arkansas; thus, evolution was not taught. The Anti-evolution Rotenberry Act, which forbade the teaching of evolution in Arkansas, went unchallenged from 1927 to 1965.

The legal conflict between creationists and evolutionists surfaced again in 1965. Susan Epperson, a high school biology teacher at Central High School in Little Rock, Arkansas, challenged the state's antievolution law in the case of Epperson versus Arkansas, 1968. She

used a newly adopted text that emphasized evolution rather than a previously used text that de-emphasized evolution. The United States Supreme Court ruled that the anti-evolution law was unconstitutional because it limited a teacher's freedom of speech (deCamp, 1969; Fowler, 1982).

Strategy Two

The second strategy declared equal time for religion (1970-1980). By the 1970's, creationists sought ways and means to get schools to require equal time for the teaching of creation science (the Genesis account) and evolution science. In other words, if evolution science was to be taught to students, equal time for creation science according to the Genesis account in the Bible must also be given. Some states adopted this strategy. The first constitutional test of the strategy occurred in Tennessee in 1973. The Tennessee Creationism Act stated that a textbook used to teach evolutionary theory should also include an equal amount of space to other theories, including but not limited to, the Genesis account in the Bible. (This Act was challenged in *Daniel versus Walters*, as cited in Fowler, 1982.) A court of appeals in Tennessee ruled this bill unconstitutional on April 10, 1975, because it violated the "Establishment of Religion" clause of the First Amendment (Fowler, 1982; Zetterberg, 1983).

Strategy Three

The third strategy balanced treatment for creation science (1978 to present). A new model bill created by Paul Ellwanger in 1980 (cited in Fowler, 1982) was introduced to legislatures in Arkansas,

Louisiana, South Carolina, Illinois, and New York. By 1981, this new model bill had been introduced in a total of 15 states. Ellwanger's model bill sought balanced treatment for the teaching of evolution and creation science theories under the constitution's free exercise clause (Fowler, 1982).

On March 19, 1981, Arkansas signed a bill (Act 590) which enacted the balanced treatment of teaching evolution and creation science. This involved giving balanced treatment to lectures, course book materials, library, and other educational materials. On May 27, 1981, a lawsuit (McLean versus the Arkansas Board of Education) was filed, challenging the constitutionality of Act 590 on the following grounds: it was founded on the establishment of religion (prohibited by the First Amendment of the Constitution), that it violated the right of academic freedom (guaranteed by the Free Speech Clause of the First Amendment), and it was vague (violating the Due Process Clause of the Fourteenth Amendment) (Zetterberg, 1983).

On January 5, 1985, District Court Judge William Overton ruled that the Arkansas Balanced Treatment Act (Act 590) violated the constitutional separation of church and state. The evidence presented during the trial showed that Act 590 was religious (Fowler, 1982; Lewin, 1982b).

In March of 1981, Kelly Segraves and his son Kasey went to court to oppose the teaching that men evolved from apes. The case took place in the Sacramento, California, Superior Court. Kasey stated: "I believe that God created man as man and put him on the earth" (Gorman, 1981, p. 33). After five days of arguments, Judge Irving Perlus ruled that statements pertaining to evolution did not infringe

upon an individual's free exercise of religion, thus the bill stood unamended.

Since the Segraves case, some state legislatures have been pressed to introduce bills requiring that creationist views be presented in science classes. One Florida district required that creation science be taught in biology classrooms. In 1982, Louisiana passed a balanced treatment bill. The bill was subsequently proven to be unconstitutional in 1985.

The states of Kansas, Illinois, and Iowa have voluntarily included creationists' ideas in their public school science courses. Texas school boards insisted that those biology textbooks used in public schools refer to evolution as a theory, not a fact. Several textbook publishers have reduced the amount of space in biology texts devoted to Darwin's theory or have added sections on creation science (Gorman, 1981; Zetterberg, 1982).

CHAPTER III

MODEL

Evolution

Definition

Good (1981), a philosopher, stated that the word evolution meant "unfolding" and has become particularly associated with life on earth. The evolutionary concept of biology is based upon the belief that all living things, past or present, are the descendants of prior different kinds and owe their characteristics to a process of change over long periods of time.

Several textbook authors define evolution. For example, Keeton and McFadden (1983, p. 509) defined evolution as "change in the genetic makeup of a population with time." Mader (1985, p. 502) defined evolution as "genetic changes that occurs in populations of organisms with the passage of time resulting in an adaptation to the environment." Stansfield (1977, p. 295) defined evolution as the "process whereby changes in the gene pool are affected . . . genetic change can occur in a population without it splitting into two or more new species."

Eldredge (1982), an evolutionist, defined evolution as the idea that all species of organisms on earth today have descended from a single common ancestor. When evolutionists refer to the "evolutionary

theory," they are referring to ideas about how the evolutionary process took place.

Evolution, to most scientists, is a fact, and the theory of evolution means that life has changed. This basic idea that life has changed explains how the organic world as we know it today came into existence without recourse to supernatural beings or special rules. The process of ancestry and descent is responsible for the hierarchical order of all interlinking forms of life.

If evolution is a scientific theory, it must be predictive. One way to predict is by observing the fossil record. If all organisms descended from a single ancestor, there must be fundamental similarities shared by all living things, and there must be similarities among all living organisms and their ancestors (for example, genetic, anatomical, or behavioral similarities). Similarly, as new species arose, some of these similarities were modified from the older ancestors. As the evolutionary process continues, forming new species from the old, this process generates diversification of organisms. Therefore, there must be one inherent pattern of similarity interlinking all forms of life. This results in each species having features unique to itself, but sharing with other related species similarities in structure and behavior.

The basic prediction of evolution is that all life, being diverse, is linked in a hierarchical arrangement of similarities. Scientists conclude that evolution is predictive and is therefore thoroughly scientific.

Due to the legal conflicts associated with evolution and creation science, summaries of the points to support the two theories are

given. Creationists sometimes refer to creation science and evolution as "models" rather than theories (Morris, 1974). Bird, Bliss, and Gish (1983), who are creationists, summarized the evolution model as follows:

The evolution model includes the scientific evidence and the related inferences, suggesting that:

- I. The universe and the solar system emerged by natural processes.
- II. Life emerged from nonlife by naturalistic processes.
- III. All present kinds emerged from simpler earlier kinds, so that single celled organisms evolved into invertebrates, then vertebrates, then amphibians, then reptiles, then mammals, then primates, including man.
- IV. Mutation and natural selection have brought about the emergence of present complex kinds from simple primordial organisms.
- V. Man and apes emerged from a common ancestor.
- VI. The earth's geologic features were fashioned largely by slow, gradual processes, with infrequent catastrophic events restricted to a local scale (Uniformitarianism).
- VII. The inception of the earth and then of life must have occurred several billion years ago (pp. 200-201).

Although this summary is provided by creationists, the literature review did not reveal any evolutionists who refuted these points, or who gave a comparable summary.

Problems With the Model

The problem that evolutionists today face is proving how the evolution occurred by using this model. For example, evolutionists are confronted with how living organisms exist on earth today, how they developed through the eons of history, and how these organisms

achieved the forms and distributions characteristic of each species, alive or extinct. Many different hypotheses have been presented down through the ages to explain these problems.

Not until Darwin (1859) discussed natural selection of the fittest organism was a hypothesis presented that explained all of the accumulated data provided by other hypotheses. Darwin's basic hypothesis was that only the best adapted organisms could survive the competition for food and other resources and could endure the harshness of their environments. For example, the organisms would have to endure the exposure to disease and the attack of natural predators, while retaining the ability to reproduce. As a result, their genotypes would be maintained in populations from one generation to the next, because these adaptive traits of survival would have been naturally selected (McEachron and Root-Bernstein, 1982).

When Darwin (1859) first put forth his idea of natural selection, it was before Mendel's work with genetics. Therefore, Darwin lacked knowledge of genetics. He also lacked the knowledge of modern geology and radiometric dating.

The Neo-Darwinian model coupled genetics with natural selection in the 1930's and 1940's. Neo-Darwinism is a theory of modification, recognizing that mutation, recombination, and natural selection can lead to evolutionary changes in populations and species. This new theory once again recognized the essential part that natural selection plays in the evolutionary process (Eldredge, 1985; McAlester, 1968).

Later, paleontologists began to question why the fossil record did not correspond with Darwin's (1859) predictions of gradual evolution. According to the fossil record, there is a lack of transitional

forms between groups of closely related species, coupled with the sudden appearance of new kinds of organisms from their ancestors. This led paleontologists to dispute that part of Darwin's theory of natural selection which emphasized gradual change.

Paleontologists of the 1980's are now trying to further explain these gaps in the fossil records. They are puzzled by certain groups of organisms which show gradual transitional forms, yet in other groups the abrupt appearance of new forms is seen. Eldridge and Gould (1982) put forth new ideas to explain these abrupt and rapid changes followed by periods of stasis (which is a period of lack of change), followed by more rapid changes, which they called "punctuated equilibria." To Gould and Eldredge, the idea of punctuated equilibrium was a better explanation of how these abrupt changes occurred (Eldredge, 1985).

Ayala (1983) noted that rapid changes, followed by periods of stasis, did occur with fossil records, but he and other scientists still believed in phenotypic evolution which seemed to occur gradually within a lineage. The point of disagreement is one of relative frequency of the two modes, rather than the sole existence of one mode or the other.

According to Gould (1981), despite the debate among evolutionists on how evolution happened, no one doubted the fact that evolution has occurred. "We are all trying to explain the same thing: the tree of evolutionary descent linking all organisms by ties of genealogy" (Gould, 1981, p. 35). Gould believed that three basic arguments support the fact that evolution has occurred. First, there is abundant evidence of evolution from direct observation from both the field

and the laboratory. The second and third arguments for evolution do not involve direct observation but rather rest upon inferences. These arguments are no less secure for that reason, however. These inferences are based upon living and fossil organisms, and some of them may be somewhat imperfect, but the current theories put forth are mechanisms that try to explain how evolution occurred. As with all historical sciences such as geology, cosmology, or human history, inferences regarding evolution have to be made. Therefore, the second argument is that evolution is revealed through the imperfections of nature, and thirdly, that transitions are often found in the fossil record.

Creation Science

Definition

Anderson (1983), a creationist, stated that creation science shows that the ". . . basic systems of nature were developed by supernatural creative processes which were different from, and existed prior to, the present natural laws and processes" (p. 237). Morris (1974), another creationist, stated that:

Creation cannot be proved. Creation is not taking place now, so far as can be observed. Therefore, it was accomplished sometime in the past, if at all, and thus is inaccessible to the scientific method. It is impossible to devise a scientific experiment to describe the creation process, or even to ascertain whether such a process can take place. The Creator does not create at the whim of a scientist (p. 5).

Gish, another creationist (cited in Lewin, 1982a), stated:

We do not know how the Creator created, what processes He used, for He used processes which are not operating anywhere in the natural universe. This is why we refer to creation as special creation. We cannot discover by

scientific investigation anything about the creative processes used by the Creator (p. 142).

As with the evolution model, Bird, Bliss, and Gish (1983) summarized the views of the creation model as follows:

The creation model includes the scientific evidence and the related references, suggesting that:

- I. The universe and the solar system were suddenly created.
- II. Life was suddenly created.
- III. All present living kinds of animals and plants have remained fixed since creation, other than extinctions, and genetic variation in originally created kinds has only occurred within narrow limits.
- IV. Mutation and natural selection are insufficient to have brought about emergence of present living kinds from a simple primordial organism.
- V. Man and apes have a separate ancestry.
- VI. The earth's geological features appear to have been fashioned largely by rapid, catastrophic processes that affected the earth on a global and regional scale (catastrophism).
- VII. The inception of the earth and of living kinds may have been relatively recent (pp. 200-201).

Problems With the Model

Taylor (1983) pointed out that not all creationists are alike in the way they think and believe. Not all of them insist upon the literal interpretation of the biblical account of creation in six days. Instead, they believe in radiometric dating and that biblical creation did not happen in six 24-hour days, but "days" covering many millions of years, each in accordance with the geological time charts. This same group of creationists, however, claim that a Creator formed various forms of life that appeared on earth (Gallant, 1975). "Many

creationists accept microevolution, but others reject any change in species" (Anderson, 1983, p. 236).

Some creationists are arguing about the interpretation of geological data relating to "flood geology." The Noachian Flood was supposedly the result of catastrophism. The geologic data does not support catastrophism. Creationist geologists are working to reinterpret the geologic flood data, and to re-evaluate all radioactive dating methods. Henry Morris (cited in Gallant, 1975) is in charge of the CRS Ararat Project, which is committed to discover Noah's ark. He thinks this will help in the creationists' concepts of origins.

In 1981, Ellwanger (cited in Lewin, 1981) began a new, improved draft of a creationist bill to circulate in legislatures throughout the country. This bill is called the "Unbiased Presentation of Creation-Science and Evolution-Science Bill." It is designed to modify phrases referring to a supernatural being in hopes of being unbiased.

For instance, its definition of creation-science begins with '. . . evidences that indicate creation of the universe, matter and energy, suddenly.' The phrase '. . . from nothing' has been dropped. Also dropped from this section is reference to a world-wide flood. Similarly, the words '. . . evidences for a relatively recent inception of the earth and living kinds' has been replaced by '. . . evidences for consideration of several chronometric processes that could reliably indicate the ages of the earth and life, including both those processes that indicate a multibillion year age and those processes that indicate a relatively more recent inception' (Lewin, 1981, p. 1224).

Creationists hope that these new changes in the bill will give them more support in presenting creation science along with evolution in public schools (Lewin, 1981).

CHAPTER IV

POINTS OF CONFLICT

Introduction

Many conflicts exist between evolutionists and creationists on the origin of life. In this chapter, several of these points of conflict will be discussed. Evolutionists' views and creationists' views will both be presented. The points of conflict to be discussed are the age of the earth, anatomy and morphology, molecular similarities, mutations, the Noachian Deluge, fossil evidence, and the origin of man.

Age of the Earth

Evolution

For centuries, scientists and philosophers have been trying to estimate the earth's age. At times, dating of the earth has evoked much controversy, even among those scientists who agreed that the earth is approximately 4.5 billion years old. The methods used to determine the age of the earth elicit much of this controversy.

One of the earliest scientists to estimate the earth's age was a physicist, Lord Kelvin, who performed calculations to estimate how long it would take for a body the size of the earth to cool to its present temperature from an initially molten state (Cloud, 1978). His

calculations, performed considerably before the advent of radioactive dating, showed the age of the earth to be 20 to 40 million years old. Radioactive dating commonly involves several systems of decay, along with the types of materials dated using these systems, and the range and half-life in years (Table I).

TABLE I
RADIOMETRIC DATING PROCESSES

Process	Dating Material	Years	
		Range	Half-Life
Carbon-14	wood, shell, charcoal	70,000	5,730
Protactinium-231	sea sediment	12,000	32,000
Thorium-230	sea sediment, coral, shell	400,000	75,000
Uranium-234	coral	1,000,000	250,000
Chlorine-36	igneous, volcanic rock	500,000	300,000
Beryllium-10	deep sea sediment	8,000,000	---
Helium-4	coral, shell	---	4.5 billion
Potassium-40 Argon-40	volcanic ash, lava	---	1.3 billion

Callaghan (1980, p. 422) stated: "The most accurate dates are derived from the mineral Zircon ($ZrSiO_4$), which is common in igneous and metamorphic rocks and contains small impurities of both uranium and thorium." The radioactive isotopes decay into other isotopes, according to Futuyma (1982), meaning that "certain atoms, or 'parent nuclides,' become spontaneously transformed into stable 'daughter nuclides' by the loss or addition of protons, neutrons, or electrons" (p. 70). This decay rate for each radioisotope is constant and is expressed as a half-life. Half-life is "the length of time necessary for one-half of any given amount of isotope to decay" (Ayala et al., 1977, p. 315). By knowing the half-life of a radioisotope, the quantity present in a rock and its state of decay can be calculated, thus permitting the age of the rock to be determined.

Problems associated with radioisotopes can generate inaccuracies in dating. One of the problems that could be involved is that for long spans of time (such as billions of years), even small percentages of decay represent a considerable amount of time. For example, one percent of a billion years is 10 million years, which is a great deal of time in terms of evolutionary events. Another problem is preservation of parent and daughter isotopes (Ayala et al., 1977).

All radiometric dating techniques depend upon a constant rate of decay. If it were proven that not all rocks or fossils decayed at a constant rate, the derived dates would have to be adjusted accordingly. Even if radiometric dating were to be invalidated, other nonradiometric methods could be used to calculate the age of the earth, such as calculating the ratio of the amount of sodium chloride (salt) in the ocean to the average annual addition of salt. By using this method

and other alternative methods, minimum possible dates rather than absolute dates would be generated for the age of the earth (Callaghan, 1980).

However, by using radioactive isotopes, scientists have dated ancient earth rocks, moon rocks, and meteorites, finding consistent ages for the solar system (Futuyma, 1982). The oldest earth rocks have been dated at approximately 3.8 billion years, moon rocks at 4.1 billion years, and the oldest meteorites at 4.6 billion years. All these factors indicate that the earth is approximately 4.6 billion years old (Callaghan, 1980).

Creation Science

In the fourth century, Christian scholars estimated that the age of the universe was approximately 6,000 years old. They obtained this figure by adding up the biblical genealogies (Newell, 1982). In 1664, Anglican Archbishop Ussher dated creation at 4004 B.C., and in 1658, one of the great Hebrew scholars of his day, Vice-Chancellor John Lightfoot of Cambridge, confirmed Ussher's date and went further. He calculated that "God had created Adam out of the dust of the earth on Friday morning, September 17, 4004 B.C. at nine o'clock" (Newell, 1982, p. 105). Modern creationists, however, have estimated the age of the earth to be 10,000 years old by using the decay of the earth's magnetic field (Morris, 1974). The evidence used to support this method of estimating the earth's age was begun by the ancient Greeks, who experimented with the magnetism of rocks that could attract or repel iron. In 1600, William Gilbert, an English physician, realized

that the whole earth behaved like a gigantic magnetic bar, but he was unable to determine why.

In the early 1800's, Sir Horace Lamb, an English scientist, became interested in the earth's magnetic field and conducted experiments to determine its decay. His findings were not well publicized because they contradicted the possibility of the earth's being approximately three to five billion years old (Allford, 1978).

A study done by Thomas G. Barnes (professor of physics at University of Texas in El Paso) evaluated the decay of the earth's magnetic field and estimated the age of the earth to be 10,000 years (Morris, 1974). Barnes stated that the decay of the earth's magnetic field was occurring rapidly, and that "The strength of the magnetic field is reduced by one-half every 14,000 years" (Allford, 1978, p. 167). The earth's magnetic field is continually changing in positions and decaying in strength, a result of the molten core of the earth. Therefore, Barnes concluded, if man goes far enough back into time, the entire earth would have a composition like the sun. This information would suggest that the earth could not have sustained life as we know it for more than 10,000 years, much less billions (Allford, 1978).

Anatomy and Morphology

Evolution

Comparative anatomy is a field in science where inferences about relationships among animals can be made (Dodson, 1960). Similarities in structures of animals that have descended from a common ancestor are homologous, that is, structurally identical. One example of

homologous structures is limb bones of tetrapods. Other structures are analogous, which means that they function similarly but are built from different structural plans, such as an insect wing and a bird wing. Both bird wings and insect wings have similar functions but differ in their anatomy. Thus, evidence shows that they evolved independently from one another (Volpe, 1977).

Homology of structures is indicated in the following instances: (1) if data suggests intermediate forms between two existing species; (2) if two living forms have descended from a common ancestral structure, and (3) if two species have a common embryonic origin (King, Sanders, and Wallace, 1981). An example would be the appendages of animals--some are used for flight, some for swimming, and others for land movement. There is a vague, external resemblance between the arm of man, the flipper of a whale, and the wing of a bat. Yet, an anatomical comparison shows that the structural design of these animals' appendages, bone for bone, is basically the same. The main difference is merely the lengths of the component bones. The conclusion is that the forelimbs of man, bat, and whale are modifications of a common ancestral pattern (Volpe, 1977). Other examples of homologies are the tiny bones of the middle ear of man, which are similar to reptilian jaw bones and which are believed to have evolved from the bony supports of the gills of ancient fishes. Also, close examination shows that the vertebral column and the eyes of all vertebrates are similar (King, Sanders, and Wallace, 1981).

There are several embryological homologies among vertebrates. For example, the early embryos of fishes, amphibians, reptiles, birds, and mammals look similar because they possess gill slits, aortic

arches, notochords, neural tubes, and postanal tails (Hickman, Hickman, and Roberts, 1982).

In human embryos a tail appears and then is usually lost. In a small percentage of cases the rudimentary tail is still present at birth and must be surgically removed. The early developmental stages of the human embryo resemble a one-celled organism. In later stages, the embryo looks Amphioxus-like, fish-like, and amphibian-like. Some features of the heart and kidney of the human embryo appear to be reptilian. Finally, the embryo develops characteristics that are mammalian, and eventually, unmistakably human (King, Sanders, and Wallace, 1981).

Vestigial organs are a third way of looking at homologies. The term "vestigial" is ". . . ordinarily limited to organs that apparently have lost their original function as compared with other species, and are of little use" (Newell, 1982, p. 178).

Many terrestrial invertebrates (flightless birds, for example) have rudimentary wings that are homologous with the wings of other birds. The skeletal structure of all birds are basically the same, but the ability to fly has been replaced by other means of locomotion (Newell, 1972).

In man, the best known vestigial structure is the vermiform appendix, which is a blind sac located between the large and small intestines. In certain other mammals such as guinea pigs and horses, the homology of this organ is the cecum, in which bacterial digestion of food occurs. It is presumed that the human appendix had a similar function in their distant ancestors (Stansfield, 1977).

A python has a greatly reduced, seemingly functionless pelvis and rudimentary hind limbs that are completely concealed within the body. Pythons, however, do not walk at any stage of their lives. Bones of the girdles are lacking in other snakes.

Embryos of some whales have teeth, but they are absent before birth. Other whales use whale baleen to filter their food, and teeth are unnecessary. The teeth of whale embryos thus indicate a different mode of past life.

Biologists have long suggested that birds and reptiles had a common ancestor in the early Mesozoic era. To confirm this, scientists have been successful in growing reptilian-like teeth from chick embryos. This indicates that chickens still possess genes for tooth formation that is similar to some Jurassic and Cretaceous birds. Scientists believe that evolutionary changes in embryonic development have rendered these genes functionless, thus leaving all living birds toothless.

Other scientists have altered the developmental rates in chick embryos to produce leg bone patterns like those of reptiles. All these experiments show how the function of ancestral genes may change or be discontinued in embryonic development (Newell, 1982).

The problem of studying comparative anatomy and morphology is that some species lack examples of ancestors in the fossil record. Generally, invertebrates and protists without hard parts do not fossilize (King, Sanders, and Wallace, 1981).

Creation Science

Creationists believe that the Creator, when shaping the

forelimbs, used a single blueprint. When He made the hand of man, the wings of bats, and the legs of horses, He varied His blueprint each time to give a different body plan for each animal. Even though the forelimbs are used for moving about, each is specialized for certain environmental conditions.

According to this model there is no genetic relationship between man, bat, and horse; all they have in common is that they were made from the same blueprint, by the same Creator (Gallant, 1975).

Allford (1978) stated that human "tails," as referred to by some physicians, are not true tails. Allford indicated that this tail is a congenital anomaly. In human embryonic development, the neural groove fuses and becomes the neural canal during the early part of the fourth week after conception. The cephalic portion of the neural folds become the forebrain, the caudal portion is referred to as the "tail bud." In some humans, this tail bud is retained at birth. These anomalies occur as a result of changes in the nervous system.

In reference to gill slits, Allford (1978) maintained that the slits seen in the pharyngeal arches (or folds) may remain open. This does not indicate that man once had gills. If the gills remain open, it is a congenital defect and can be surgically corrected.

Allford (1978) also explained the vermiform appendix in man as an organ for which the function is unknown. This does not mean that it has no use. Since the human appendix contains lymphoid tissue, it may be a part of the immune defense system. Allford concluded that "there is similarity in animals and man in growth and development from the fertilized egg into adult, but it does not mean that all came from a common ancestor" (p. 36).

Molecular Similarities

Evolution

Molecular similarities between species are even more convincing than those at the morphological level, because the molecular similarities are either closer to immediate gene products or are themselves gene products. There are basically five biochemical methods used to compare homologous proteins, nucleic acids, or DNA: amino acid nucleotide sequencing, nucleic acid hybridization, electrophoresis, immunology, and chromosomes.

Hemoglobin is the oxygen-carrying pigment of red blood cells. A comparison of the amino acid sequence in the beta chain of hemoglobin of humans and gorillas shows them to be identical, except at one position. Humans differ from pigs and horses at 10 and 26 sites, respectively.

Cytochrome-c is a respiratory pigment essential for oxidative metabolism. This molecule is identical in chimpanzees and humans, consisting of 104 amino acids in exactly the same order (Stansfield, 1977).

DNA hybridization involves heating DNA to break its double-stranded helix into its complementary single strands. When allowed to cool, the complementary strands then recombine. Ahlquist and Sibly (cited in McKean, 1983) of Yale University performed tests to see how complementary were human and chimpanzee DNA. They treated DNA from humans and chimpanzees to break the double helix of each, then allowed a strand from each animal to cool together. Their molecular studies

showed that DNA from human beings and chimpanzees was about 98% identical (McKean, 1983).

Electrophoresis is an application of an electric current through a fluid or gel to separate enzymes (gene products). Tissue samples from different organs of a species are compared to those from another species by comparing the migration rates of the enzymes through the starch gel when electricity is applied. An enzyme's three-dimensional configuration affects the molecule's net charge and hence a particularly charged molecule will migrate either faster or slower than a charged enzyme molecule from another species. By comparing migration rates between similar enzymes taken from different species, estimates of similarities for these species can be calculated.

The immunological method involves the reaction between antigen and antibody. This test is used to detect the union of antigen and antibody in vitro and to measure the amount of precipitate formed. The more a protein is antigenically related to that molecule from which the antiserum was derived, the more precipitate is formed. In both of these methods, electrophoresis and immunology, it has been shown that the average human polypeptide is more than 99% identical to a chimpanzee.

Chromosome evidence has shown that 18 of the 23 pairs of chromosomes are identical in modern man and the common ancestor of chimpanzees, gorillas, and man. Humans have 23 pairs of chromosomes; apes have 24 pairs. One pair of human chromosomes is larger than one pair of ape chromosomes, which may be a result of two chromosome pairs fusing in the ape lineage that led to man (King and Wilson, 1975; Stansfield, 1977).

Creation Science

Similarities in DNA between chimpanzees and humans only indicate a common Designer (Morris, 1982). The Creator made each organism with its own distinct DNA (Morris, 1974). Morris (1982) also argued that since chimpanzee and human structures are similar, it is no surprise that the DNA of chimpanzees and humans are similar.

Mutation

Definition

Chromosomal mutations are structural and numerical deviations from the norm. Gene mutation is a permanent, random chemical change in the DNA molecule (King, Sanders, and Wallace, 1981).

Evolution

Gene mutations and chromosome mutations can safeguard a lineage against the extinction which can result from environmental change. Mutations produce the genetic variation which characterize most populations and which enable them to survive when environments change. Some gene and chromosomal mutations apparently occur continually, possibly triggered by environmental factors.

One common form of chromosome mutation is polyploidy, where chromosome numbers are increased in offspring. Oats, wheat, cotton, tobacco, potatoes, bananas, coffee, and sugar cane are a few domesticated plants that are actually polyploids of wild ancestors.

The British peppered moth (Biston betularia) occurs in two forms--light and dark. The light-colored forms were at one time the

most dominant form in England because they blended in with the tree trunks or rocks which were covered with light-colored lichens. Under natural conditions, the dark moths were easy prey for birds. The advent of industrialization in 1895 caused tree trunks and rocks to blacken from the large amounts of soot discharged from factories. This environmental change then favored the mutation which produced dark-colored moth, because the dark phenotype matched the darkened background. The dark moth consequently increased in frequency, and the light-colored forms became prey for birds because they were more conspicuous against the black background (Keeton and McFadden, 1983).

Experiments have shown that some mutations are actually preadaptive, which means that they occur randomly before exposure to the environment and are adaptive only fortuitously. The environment, in other words, does not induce these mutations, but only selects the preadaptive mutations after they have already occurred. Some examples of organisms that show preadaptive mutations are some strains of bacteria that are now immune to penicillin, some species of insects that have developed resistance to DDT, and some cockroaches that thrive on insect spray (Edwards, 1983a; Keeton and McFadden, 1983).

Most gene mutations observed today in organisms are changes for the worse. "The chance that a new mutant gene will be more advantageous than an already favorable gene is slim" (Volpe, 1977, p. 50). Mutations may occur regardless of their usefulness or nonusefulness; their value is that they provide variation within populations that way, and survive adaptively when the environment changes (Volpe, 1977).

Creation Science

Creationists think that most mutations are harmful and unlikely to contribute to the continuation of life (Morris, 1982). For example, mutations can be identified by the disease or abnormality they cause.

It is not impossible to get beneficial mutations. For example, bacteria that lose the ability to digest certain carbohydrates can regain this ability through mutation. This does not, however, support the evolutionary position, since the bacterium only returns where it started, but at least the mutant is helpful (Morris and Parker, 1982).

Mutations are only changes in already existing genes. New varieties between basic kinds of plants and animals can be developed by mutation, but a new kind cannot be created. For example, there are different breeds of dogs which represent variation between kinds, but dogs do not mutate into cats. Also, a moth species can change from primarily light-colored to dark-colored as a result of gene variation in a changed environment, but a moth does not become a dragonfly or even a different species of moth.

Thus, creationists believe in mutations, in so far that they create variations within species. However, creationists do not believe that mutations actually cause the evolution of a new species (Morris, 1982).

Noachian Deluge

Definition

The Noachian Deluge refers to the biblical account in Genesis of

a great flood, as described by Noah. Essentially, this story states that all animal and plant life was destroyed by a great worldwide flood, except for those plants and animals that Noah placed in his ark. The only people who survived were Noah and his family. The animals, plants, and humans on the ark then repopulated the world.

Evolution

Evolutionists do not believe in a worldwide flood. They do not think that the fossil record is the result of such a great flood. The evolutionists use the fossil record to support evolution (Eldredge, 1982). Evolutionists do have records of great floods of the past, but not so extensive that they would produce the fossil record as described by the creationists.

Grand Canyon rocks show sediments everywhere. It takes long periods of time for the weathering of rocks to produce thick layers of sediment or millions of generations of marine plants and animals to produce the large accumulations of limestone which is tens or even hundreds of meters thick. This could only have been done by slow deposition in a marine environment, not as a result of a catastrophe (Newell, 1982).

Evolutionists argue that the fossil record does not fit the creationist description. They state that some species of plants and animals are found at all levels in the geologic columns; for example, single-celled, light, soft-bodied animals. This is what scientists expect to find if evolution is true (Edwards, 1983a).

Some biological questions that cannot be answered by the creationists concerning the flood have been presented by Moore (1983), an

evolutionist. Some of his questions are as follows:

1. Since this was a worldwide flood, how did nonlocal animals and plants migrate to the site of Noah's ark to be loaded aboard? For example, how did those plants and animals in Australia migrate to the ark site?

2. What was responsible for the modified behavior of the animals so that they all were able to exist together during the voyage?

3. If the ark was about 150 meters long, 2 meters wide, and 15 meters high, how could roughly 2,000,000 species of organisms inhabiting the earth today (including marine, fresh-water, and terrestrial forms), plus food and water, last for a year in the ark?

4. If, according to the biblical account in the book of Genesis, all things were destroyed, how could the dove that was sent out to search for dry land find a freshly plucked live olive leaf?

5. When the plants and animals were finally released from the ark, how did they migrate to their present localities? What was their source of food?

Schadewald (1983) also posed the question of disease. He cited examples of several communicable diseases (for example, germs or viruses such as measles, pneumococcal pneumonia, leprosy, typhus, typhoid fever, smallpox, syphilis, and gonorrhoea) in which man is the only known reservoir. How did these diseases get carried onto the ark? How did they survive without becoming extinct? If they were a result of mutations, then would that not be a source for evolution?

Evolutionists conclude that there are too many unanswered questions to confirm the existence of a worldwide flood like that documented in Genesis.

Creation Science

The creationists use the Noachian Deluge to describe the history of life on earth and the distribution of the fossil record. The major points to describe the Noachian Deluge are as follows:

The land masses were divided by the seas, and surrounded by a great water vapor. When the flood came, water was brought forth through the earth's crust and the torrential rains from heaven broke up the vapor canopy.

All animals and plants that were not in the ark were destroyed and later deposited in the sediments. These plants and animals became fossilized. After the flood, the remaining plants and animals in the ark were dispersed. They bred, multiplied, and spread themselves over the new earth.

Creationists use the geologic fossil formations in the rock strata to help explain the Noachian flood. The creationists predicted that more marine invertebrate animals would be seen than any other type of animal, since there were more of them and most were immobile and unable to escape.

Most animals caught in the flood would be buried with others in the same region. This would represent ecological communities. In general, animals living at low elevations would be buried at that elevation. Similarly, animals living at high elevations would be buried at high elevations. Most marine invertebrates would normally be found in the bottom rocks, since they lived on the sea bottom. Marine fish would be found at higher elevations, as they would escape burial longer. Amphibians and reptiles would be found at even higher

elevations. Terrestrial land plants and animals would be found at a stratigraphic sequence about the same as that for amphibians and reptiles. Mammals and birds would be found at greater elevations than reptiles and amphibians, because of their habitat and mobility. Few birds would be found at all. Since higher animals congregate in herds when there is danger or fear, fossils of these animals (if found) would be in large numbers. Therefore, higher animals (land vertebrates) would be found vertically in a column. The most complex or the most mobile animals would escape burial for longer periods of time.

Men would escape burial. After the flood waters receded, their bodies would lie on the ground until they decomposed. The same would hold true for lighter plants and animals.

The arrangement of the above-mentioned fossil record has been arrived at statistically by creationists. Creationists do state that there are exceptions in every case. This is only the general order for the deposits (Morris, 1974).

The formation of many of the mountain ranges and canyons on land and in the ocean are attributed to the Noachian Flood. Also, the extinction of dinosaurs and the existence of fossil graveyards have been attributed to this flood (Allford, 1978; Morris, 1974).

Creationists conclude that the earth's geological features were partially fashioned by the catastrophic process of the great Noachian Deluge. Furthermore, the flood can be associated with claims for a young earth, since the catastrophic process was not a gradual one that took millions of years (Anderson, 1983).

Fossil Evidence

Definition

Stansfield (1977) defined fossils as "The remains or traces of former life" (p. 67). Soft parts of plants and animals generally do not fossilize or have little chance of being preserved as fossils. Hard, inorganic parts of bones, teeth, and shells are expected to survive in the fossil records. In order for cadavers to become fossilized without retarding decomposition, they must be covered with dirt or sediment and excluded from air.

Generally, marine organisms are preserved more easily than terrestrial organisms, due to their environment. Marine deposits have contributed much to the knowledge of past life. Organisms can be preserved, becoming fossils by different methods. Petrification can turn organic remains into stone. Permineralization allows dissolved minerals to enter the air spaces of bones and shells and deposit there without distorting the original shape. An example of this process is petrified bones. Mineral Replacement is a process in which water dissolves the organic matter, which is then replaced by minerals such as silica, calcium carbonate, and iron pyrites. Petrified wood is an example of this process. Distillation is a process in which volatile organic matter may be removed, leaving a residue which reveals the soft parts. Leaves are commonly preserved by this process (Stansfield, 1977).

Other organisms with parts that resist decay are buried in sediments that become solidified into rock. These rocks must be able to escape erosion and geologic metamorphosis for years, and they must be

exposed in places where it will be found by geologists in order for the fossil to become part of the record (Stanley, 1981).

Evolution

Interpretations of the fossil record to support evolution has been the subject of numerous arguments among scientists. The fossil record does contain some gaps within the evolutionary history, but this does not lessen the validity of the fossil record. Paleontologists recognize the value of the fossil record, in spite of gaps which exist. Alexander (1978) listed some reasons why these gaps exist in the fossil record:

1. Not all species are preserved
2. The more time that has elapsed, the more chance there is for loss
3. Earlier animals tended to be softer and smaller; hence, less likely to be fossilized
4. Evolution is sometimes more rapid, giving less opportunity for fossilizing some of its stages

Gaps between major groups occur because:

1. We define groups as those between which gaps still exist
2. Intermediates between major groups, as one would expect, tend to be more ancient than those between groups lower in the taxonomic hierarchy and accordingly more recent; hence, they are less likely to be available as fossils (pp. 101-102).

Even though the fossil record is incomplete, the past can be reconstructed to test a particular model or to make predictions (Alexander, 1978).

As geological time moves toward the present, the fossils become more and more modern. As one would expect, fossils of some groups

(such as blue-green algae and horseshoe crabs) have persisted since early geological time, but many groups of animals and plants have arisen, flourished, and died out. The older fossils are the most strange to the paleontologist, but as changes occur through time, fossils become more familiar. For example, between the Eocene and Pliocene ages, modern looking mammal species appear from ancestors which looked and were different. This sort of regularity is in accord with evolution.

None of the different periods of the geological time scale have a complete series of geological strata. There are gaps of millions of years.

Poor as the fossil record is, it still reveals an orderly story of the history of life. The rocks tell that extinction is the fate of nearly all species, and that the rate of extinction does slow down as time goes on. Fossils show that mammals, just like all other species, are adapted to their immediate environment. Fossils can show these patterns. For example, some groups evolve very rapidly at first, then level off after their new adaptations have been more or less stabilized in a final form. This pattern suggests that fossils for such groups need to be found before they begin to stabilize, otherwise the fossil records appears incomplete. The majority of the main group of organisms suddenly appears in the rocks without any evidence of transition from their ancestors.

Mayer (cited in Futuyma, 1982) proposed in 1954, as a result of conclusions from the fossil record, that widespread species may evolve only very slowly and persist virtually unchanged, while small, isolated populations of that species may experience rapid evolutionary

changes and form new species. As a result of this process, rapid evolution occurs, along with multiplication of species. When the newly formed species reproduces and extends its range, it will overlap with its ancestor. When such rapid changes occur in evolution, it is very likely that the fossil record is not established until the newly evolved species reproduces and extends its range. This is where the fossil record becomes inadequate but is needed most--at the origin of major groups of organisms (Futuyma, 1982).

Creation Science

Creationists disagree that there are well-documented fossil records in rock strata that contain characteristic assemblages of fossils. They do not believe in the sudden appearance of new species within the rock strata, since the Creator created all "basic kinds" of plants and animals. Although new varieties have occurred, a new species has not been created, according to creationists. For example, there are different breeds of dogs which are varieties, yet they belong to separate distinct breeds or basic kinds.

Creationists interpret the sudden appearances of different kinds of plants and animals that do not show a common ancestor to sudden creation by the Creator. Likewise, one should not claim a common ancestor for apes and for man, for they both are separate and distinct species of kinds (Gallant, 1975).

Origin of Man

Evolution

Darwin and Lamark (cited in Jacobs, 1985) proposed less than a

century ago that Homo sapiens had to be a product of evolution. At that time, they did not have any hard evidence to back up their assumptions. Since then, fossils of human remains have become vastly abundant. Traces of early man can be found in Africa (birth place of the earliest biped), China, Europe, Russia, and Australia.

Not until the end of the Miocene and the beginning of the Pliocene epoch did man's evolution begin. When looking at human evolution, one must ask why certain ape populations gave up their arboreal life and becoming upright, terrestrial hominids.

Brian, director of the Transval Museum in Pretoria, South Africa (cited in Weaver, 1985), suggested that drastic changes in the environment caused forest primates to adapt. From documented fossil records, a drastic cooling occurred between five and six million years ago, following millions of years of mostly warmer climates. The changes producing the new environment provoked extinction of some groups and the sudden appearance of new species, including the early Australopithecines. Scientists are now able to trace human evolution to at least 3.7 million years ago.

There are four species of Australopithecus and three species of Homo in the bipedal family, Hominides. Australopithecus is the earliest example of bipedal hominids (Weaver, 1985).

Australopithecus afarensis. In November, 1974, anthropologist Donald C. Johanson (cited in Weaver, 1985) and his team of archeologists were in the Afar Badlands in Hadar, located in north central Ethiopia, where they found the partial skeleton of a hominid they named "Lucy." However, Johanson and his colleagues coined another, more scientific name: Australopithecus afarensis (Weaver, 1985).

Johanson found other fossil specimens of A. afarensis which they named the "First Family," because these individuals apparently formed a cohesive family unit (Jacobs, 1985).

Lucy was the most complete and oldest hominid known up to that time. The dating of Lucy was done by the radiometric potassium argon method, which placed her age at three million years. Approximately 40% of Lucy's skeleton was recovered, which was very remarkable because up until that time only fragments of bone (such as teeth, knee, and jaw bones) had been found of this species. Lucy's pelvic bones established that she had walked with an erect, bipedal stride. Some scientists in Europe and the United States argued that because of Lucy's curved phalanges, bipedal locomotion was not as efficient as in modern humans. Other scientists did not agree. Other hominid characteristics of Lucy and the First Family were their small heads and large teeth. Ape-like features were the low forehead, a bony ridge over the eyes, a flat nose, and no chin. The cranial capacity was about half that of modern man. The brain indicated the lack of ability for articulation of speech. If there were tools used by this species, they were probably made of material that did not fossilize.

In 1981, in Maka and Belohdelie in the Middle Aswash Valley in Ethiopia (south of Hadar), an expedition headed by Desmond Clark and Tim White of the University of California at Berkeley (cited in Weaver, 1985) Berkeley) found several fragments of bones. These bones have been dated at close to four million years. Methods used in dating these specimens were X-ray and radiometric argon-40/argon-39 analysis. That these bones belonged to a biped was established by the neck bone, which is thicker in the lower than in the upper portions,

a characteristic found in bipeds but not apes. There was also a groove on the pelvis left by the depression of a muscle, the obturator externus.

In 1976, Mary and Louis Leakey discovered fossils at Laetoli in Northern Tanzania that resembled A. afarensis hominids from Hadar, in Ethiopia. As a result, two controversies arose.

First, Johanson and his colleagues (cited in Weaver, 1985) considered both the Hadar and Laetoli specimens to be A. afarensis. They argued that A. afarensis was the ancestral stock leading to Homo and the later Australopithecines:

Phillip V. Tobias, successor to Raymond Dart as head of the Anatomy Department at Withwatersrand University, believes that what has been called afarensis at Hadar is the same species as a variety of africanus found at Makapansgat in South Africa. In his view, the fossils at Laetoli link back to earlier specimens at Maka and Belohdelie, and they form the ancestral stock leading to africanus and then Homo (Weaver, 1985, p. 592).

Since there is not enough evidence to irrefutably support either of the two arguments, human evolution at these early stages is left with some uncertainties.

Australopithecus africanus. South African caves produced most of the fossils of A. africanus, including the Taung child. There is some dispute among anthropologists concerning A. africanus as an ancestor to all later hominids. Some (including Johanson and colleagues and those who adhere to their model) think africanus is ancestral to A. robustus and A. boisei only; others think that africanus and afarensis are the same and are ancestral to all hominids.

In 1924, in Taung Cave in South Africa, the Taung child was discovered. Professor Raymond Dart (cited in Weaver, 1985), head of

the Anatomy Department at Withwatersrand University, named the Taung child "Australopithecus africanus" (the Taung child was discovered 50 years before the discovery of Lucy). Some scientists at the time of its discovery argued that the Taung child was not a hominid because of its small brain, low forehead, and small, humanlike lower jaw. The scientists at that time were comparing the Taung child to the Piltdown skull, which was later found to be a fraud. The Piltdown specimen had a high forehead, big brain, and large, canine teeth. Twelve years later, Scottish physician and paleontologist Robert Broom (cited in Weaver, 1985) discovered an adult skull of the same kind as the Taung child, and parts of the skeleton below the skull. Based upon these additional skeleton parts, Dart and Broom were able to label Australopithecus africanus as bipedal and not ape.

Australopithecus robustus. In 1936, in South Africa in Kromdraai, near Sterkfontein, Robert Broom (cited in Weaver, 1985) discovered A. robustus. As the name robustus implies, this is a heavier built animal. A. robustus possesses a flat face with no forehead, and small but massive grinding front teeth. This indicates that A. robustus ate mostly tough, coarse, plant food that required a lot of chewing. A. robustus appeared about two million years ago and survived for a million and a half years before it disappeared.

Australopithecus boisei. In 1931, Louis B. Leakey (cited in Weaver, 1985) discovered Australopithecus boisei in Olduvai Gorge in Northern Tanzania. A. boisei had the same brain size as robustus, but larger facial and cheek teeth. Anthropologists think boisei is a close relative of robustus and also was a vegetarian. Radiometric

dating placed the age of A. boisei at 1.8 million years. A. boisei is also believed to be an extinct branch of the hominid line.

Homo habilis. Remains of early Homo dating to 1.8 million years ago were found at Olduvai Gorge in 1959 by Louis Leakey (cited in Weaver, 1985). However, the best specimens were found in Northern Kenya in 1968 from the Koobi Fora area by Richard Leakey, son of Louis and Mary Leakey. These hominid remains were that of an earlier species, Homo habilis. Homo habilis showed much advancement over the Australopithicines. His face was still primitive, but his back teeth were narrower. Brain size was larger than africanus, thus increasing his brain power. Homo habilis also showed the beginning of using stone tools and the beginnings of culture. Artifacts associated with H. habilis showed that these early hominids lived at a home base, shared food, built shelters, and used simple stone tools.

Homo erectus. In 1891, a Dutch doctor, Eugene Dubois (cited in Weaver, 1985) discovered hominid fossils he called Pithecanthropus erectus, meaning "upright ape-man." To the public, this ape-man would be known as Java man. In 1929, other similar specimens were found and the name Sinanthropus pekinesis (meaning "Chinese man of Peking") was coined for these specimens, which were also known by the public as Peking man. Later, the names of Java man and Peking man were changed to the biological name of Homo erectus, meaning "upright man." H. erectus existed through a time span from 1.6 million to 200,000 years ago.

The brain size of Homo erectus is about 1,000 cubic centimeters, compared to the average of 1,350 cubic centimeters for modern humans. This led to more advancement of speech over Homo habilis. Evidence

showed the use of fire and better stone tools. Homo erectus was the species which dispersed from Africa, extending the range of Homo to Asia, China, and India.

Homo sapiens. The fossil materials showed the transition from erectus to sapiens to be scarce and fragmentary. Dating these fossils is often very difficult. The oldest known sapiens remains date from 200,000 to 300,000 years ago. Early Homo sapiens were crude in appearance, but their teeth were smaller and brain volume had also expanded.

There were three varieties of Homo sapiens. The first was discovered in Europe and was called "archaic" Homo sapiens. This variety was transitional between Homo erectus and Homo sapiens. The second variety was the discovery in Germany in 1856 of Homo sapiens called Neanderthal man. The Neanderthal man was not much different than modern man. He did have heavier bones with markings of powerful muscles. He also had facial characteristics of the classic Neanderthals of Europe--heavy brow ridges, receding cheekbones, weak chins, large noses, and protruding jaws. The average brain size was larger than modern man's, but was well developed. His tools were improved and greater in number than those of erectus. Further evidence showed that these individuals buried their dead.

Dating of the Neanderthal man has been difficult. He was too young for potassium-argon dating and too old for the carbon-14 dating method. The period of the Neanderthal was 40,000 to 200,000 years ago, at which time they died out or were replaced by the third variety of Homo sapiens, modern man (Weaver, 1985). This third variety of

Homo sapiens is sometimes referred to as Cro-Magnon, because the first fossils were found in France (Allford, 1978).

About 10,000 years ago, the beginning of agriculture, followed by the emergence of civilized society, occurred. Cro-Magnon man is believed to have introduced new tools and industries and is known for his artistic ability. Cro-Magnon man has also been cited for the extinction of many types of animals, which may have led to the rise of an agricultural economy.

Considering the evolution of man, two questions must be addressed: why did humans evolve and what makes us human? Some possible answers are that environmental changes led to bipedalism. Bipedalism, as a mode of locomotion, was advantageous in watching for predators and freeing the hands, which promoted carrying of material and sharing of food at a home base. With the freeing of the hands, tool use was encouraged, especially with sticks and stones. The larger brains led to a greater intellectual ability.

The combination of tool use and home base and food sharing led to possibly longer survival and increased reproductive rates. Offspring were born needing more attention after birth as brains got larger. Females thus provided more time for care of the young until they became mature. This possibly led to division of labor between the sexes. Men became hunters and females were responsible for child rearing and for foraging for vegetable food. Selective pressures led to males being involved in child care also, as well as in human sexual behavior changes. There was a loss of estrus, thus allowing males and females to copulate the whole year. This would seem like a waste of energy, but being able to continuously copulate formed strong pair-

bonds between males and females. Thus, both sexes cooperated in meeting the needs of survival and reproduction; together they shared their food supply and helped with child care. Pair-bonding may also have helped reduce intra-group strife (Ruse, 1982).

Creation Science

Creationists accept literally the biblical doctrine of creation, which states that all basic types of living things, including man, were made by direct creative acts of God during the creation week described in Genesis (Nelkin, 1982). Buffaloe and Murray (1983) stated that creationists believe "man was instantaneously created by God's direct act, physically and spiritually" (p. 474).

Creationists do, however, respond to evidence from the fossil record. According to Allford (1978), fossil findings of prehistoric modern man could be a result of microcephaly. This term is used when referring to small skulls. Allford further stated that similarities in facial features of early man and apes could be the result of congenital malformations.

Morris (1974) stated that the Neanderthal man was just "plain people" who suffered from a bone disease called rickets. Charles Oxnard, professor of anatomy at the University of Southern California (cited in Morris and Parker, 1982) pointed out that anatomical relationships cannot be simply established by subjective opinion. For example, a pelvic bone of Australopithecines can be interpreted as an intermediate between man and apes or, when viewed another way, as an intermediate between apes and man.

Morris and Parker (1982) stated that there was a mixing of bones when the Java man was discovered. The skull cap and femur were found a great distance apart. They thus concluded that discovery of the Java man was the result of the lack of evidence on hominid evaluation.

Creationists also referred to the Piltdown hoax and to the Nebraska man. The Piltdown man was discovered in 1912, but it was not until 1950 that it was found to be a hoax. The Piltdown man was the result of the artificial aging of a human skull and the coupling of it with a bit of ape jaw. The tooth of the Nebraska man discovered in 1925 eventually proved to be that of an extinct pig. Therefore, creationists caution people about accepting the evolutionary theory of the origin of man (Morris, 1982). In each case, paleontologists at one time regarded both of these discoveries as being a link to human ancestors.

CHAPTER V

WHAT IS SCIENCE?

Definition

In Webster's Ninth New Collegiate Dictionary (1985), science is defined as the following:

Knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method. The scientific method can be defined as principles and procedures for the systematic pursuit of knowledge involving the recognition and formulation of a problem, the collection of data through observation and experiment, and the formation and testing of hypothesis (p. 1051).

Futuyma (1982) noted that the Oxford English Dictionary defined science as the following:

. . . branch of study which is connected with a body of demonstrated truths, or with observed facts, systematically classified and more or less colligated by being brought under general laws, and which includes trustworthy methods for the discovery of new truths within its own domain (p. 166).

Futuyma described the word "trustworthy" as meaning repeatable:

But what are the 'truths' that science is supposed to discover? 'Truth,' according to the same dictionary, is 'conformity with fact,' agreement with reality.' 'Fact,' in turn, is 'something that has really occurred or is actually the case; something certainly known to be of this character; hence a particular truth known by actual observation or authentic testimony.' . . . In the scientific sense, then, 'facts' must be propositions agreed upon by individuals who have repeatedly applied rigorous, controlled methods of direct or indirect observation (p. 166).

Facts are hypotheses supported by the available evidence. By investigators following a planned course of experiments and observation, science seeks to explain the knowledge gained from these experiments and observations.

Theory in science, as described by Futuyma (1982), using the Oxford English Dictionary, is as follows:

. . . a scheme or system of ideas and statements held as an explanation or confirmed or established by observation or experiment, and is propounded or accepted as accounting for the known facts; a statement of what are known to be the general laws, principles, or causes of something known or observed (p. 168).

A good scientific theory creates the possibility of making predictions which can be tested. Even if a prediction supports a theory, it does not prove it to be true. Another theory could possibly be conceived that makes the same logical prediction. Science can consist of formulating a hypothesis by observations, by intuition, analogy, or other sources or insight that are not fully understood; then, deducing conclusions from these hypotheses that can be directly or indirectly tested by observation or experiment.

A scientific theory can be falsified by observations and experiments which are incompatible with the theory. It relies on objective observations made by trained, unbiased observers who have repeatedly performed the observations and experiments (Futuyma, 1982). Futuyma stated that:

Science cannot deny the existence of supernatural beings. It cannot prove that God didn't create the universe. . . . Science can neither affirm nor deny supernatural powers. Science is the exercise of reason, and so limited to natural powers. Science is the exercise of reason, and so is limited to questions that can be approached by the use of reason, questions that can be answered by the discovery of objective knowledge and

the elucidation of natural laws of causation. In dealing with questions about the natural world, scientists must act as if these can be answered without recourse to supernatural powers. There can be no scientific study of God (pp. 169-170).

Ayala et al. (1977) stated that science "strives to explain why observed events do in fact occur" (p. 475). Overton (cited in "The Arkansas Decision, 1983), who served as the presiding judge in the court case of McLean versus The Arkansas Board of Education, listed several essential characteristics of science:

(1) It is guided by natural law; (2) It has to be explanatory by reference to natural law; (3) It is testable against the empirical world; (4) It's conclusions are tentative; i.e., are not necessarily the final word; and (5) It is falsifiable (p. 415).

Morris and Parker (1982) defined science as truth. "The very word 'science' comes from a Latin word meaning 'knowledge,' and so properly refers only to that which is known--that is, to demonstrated facts" (p. 157).

Bentley (1981), former elementary and secondary classroom teacher, listed three criteria that usually makes an explanation scientific:

(1) Scientific theories almost always begin with observations of phenomena; (2) Scientific theories must be based on new evidence; and (3) Scientific theories should be consistent with the principle (known as 'Occam's Razor') that an explanation should be no more complicated than is necessary to explain the facts (p. 68).

Definitions of what science is have been given from the dictionary, from evolutionists, Futuyma (1982) and Ayala et al. (1977); from creationists, Morris and Parker (1982), from a judge, Overton (1982), and from a former classroom teacher, Bentley (1981). With these definitions in mind, the reader may decide whether evolution or creation science (or perhaps both or neither) best fits the scientific method.

Equal Time

The last question to consider is whether or not equal time should be given to evolution and creation science in the public school classroom. In lieu of defining science, should biology teachers teach both evolution and creation science as science in the public school classroom? An attempt will be made to answer these questions based on views from evolutionists, creationists, noncreationist Christians, and from science educators that teach science.

Evolutionists

Gould's (1981) main contribution to science was in both evolutionary biology and paleontology. Gould took the position that attempting to force biblical teachings into the science classes of public schools was stepping over the line separating church and state, as well as undermining the education of future scientists.

Edwards (1983a) stated that scientists were fighting for the integrity of science itself, and they did not wish to ban creation science from public schools. Their objection was the categorization of creation science as science. This will only serve to confuse students about the real nature of science and the methods of scientific inquiry.

Ruse (1982) did not believe in giving equal time to the teaching of evolution and creation science because the latter interferes with the fight for knowledge.

Creationists

Gish (1983) emphasized that if creation science was excluded from

textbooks or from the realm of science because it cannot be tested by the experimental method, then so should evolution be excluded because it also cannot be tested. Bliss (1983) argued that students should be taught both evolution and creation science so that a child would not be denied the opportunity to think and make his or her own decision.

Morris and Parker (1982) contended that public schools are tax-supported institutions. They are supported by both creationists and evolutionists and therefore both models of origins should be taught.

If Christians want to have only creationism taught, then they should establish private schools for that purpose. By the same token, if secularists or others want to have only evolution taught, they should establish private humanistic schools for that purpose. . . . Teaching both evolution and creation on a strictly scientific and objective basis is the only approach in the public schools which is consistent with the constitution, with civil rights, religious neutralism, scientific objectivity, educational effectiveness, academic freedom, and general fairness (p. 237).

Noncreationist Christians

Olson (1983) stated that he understood creationism, but could not support it. In his judgment, creationism did more harm than good. Creation science is not science, stated Berry (1983). The heart of science is the scientific method, to test hypotheses and theories with the objective of verifying or falsifying them. The Genesis story is not testable. Berry was quick to emphasize that he was not trying to diminish the importance of creation science by stating that it was not a science. Vawter (1983) stated:

'Creation Science' is the ruse of well-intentioned but very naive religious believers to gain acceptance of their convictions under the coloration of a purely secular discipline which would be given equal time with the

scientific consensus concerning the origin and development of biological life (p. 80).

Frye (1983) believed that:

In addition, Christians have also recognized that we have available to us not just one book of God, but two: the book of God's work in Scripture, which concerns the ultimate nature and destiny of humanity, and the book of God's Works in Nature, which contains the created order

Pope Pius XII had the same idea: 'man learns from two Books--the universe for human study of things created by God's superior will, and truth. One belongs to reason, the other to faith. Between them there is no clash' (p. 199).

In the midst of pressures put upon school teachers and school boards to teach or not teach evolution or creation science, one should note that:

Christianity does not assume that nature and science can tell us all we need to know about God and man; so too it does not assume that the Bible can tell us all we need to know about science and nature (Frye, 1983, p. 203).

Science and faith will continue to conflict

. . . only if we insist upon confusing and conflating the two books of God. . . . There is only one God, to be sure, but we will both understand him better and honor him more fully if we approach him in terms of both of the two books which he has made available to us (Frye, 1983, p. 204).

Biology Teachers

Moore (1983, p. 445) commented: "To give 'equal time and emphasis' to creation myths and to biological theory of evolution must lead to the destruction of the former." Anderson and Kilbourn (1983) stated:

. . . do not believe that one explanation of man's origins is as good as another. Nor do we believe that a creationist's account of origins is on the same footing as that of evolution. A creationist's explanation is not very satisfying to us, but that is because of the

scientific world view from which we tend to look at things (p. 54).

Creation science does not meet the test for true science; it has been rejected by the scientific community. Since it is not testable or modifiable, creation science is not science (Kenkel, 1985). In wanting to present creation science and evolution as equals, it becomes important to understand what is and what is not science.

Our problems with creationists are just one example of the inadequate job we do in educating the young. . . . Nevertheless, we must accept the fact that today most Americans do not seem to know what is science and what is not (Moore, 1982, p. 609).

Conclusion

Despite the legal conflicts between evolution and creation science, the controversy still exists over which theory or model, evolution or creation science, can best be described as science. Both evolution and creation science defend their position to be recognized as science, and both have answers to the origin and diversification of life.

According to the definition of science and the scientific method, evolution can be observed. It can be tested by such methods as radiometric dating, carbon-14 dating, and DNA hybridization, to mention a few. Therefore, inferences and conclusions can be made; however, the evolutionists themselves will say that there are gaps in their findings, and that some of their methods of testing are controversial. But evolutionists agree that evolution has definitely occurred. In spite of gaps and inaccuracies, does this still allow evolution to be considered as science in terms of the way we define science today?

On the other hand, creationists (such as Gish, 1983) admit that creation science cannot be tested by known means. But is creation science observable and can inferences be drawn from those observations? Is it possible, even though not testable, to say that all living and extinct life was created instantaneously by a creator?

There are some who say that creation science is religion, because it depends upon the action of a supernatural being. But if creationists restated their model and did away with any language referring to the Bible, then is it science? Finally, evolutionists such as Futuyma (1982) acknowledge that science cannot dispose of God and that science has no intention of doing so. Neither can science disprove that God created the universe. Science cannot study God.

The last question to answer is that of equal time being given in the public classroom for the teaching of evolution and creation science. To answer that question, we must ask again, "What is science?"

BIBLIOGRAPHY

- Alexander, R. D. 1978. Evolution, creation, and biology teaching. American Biology Teacher, 40(2):91-94.
- Allford, D. 1978. Instant Creation Not Evolution. New York: Stein and Day.
- Anderson, T. and Kilbourn, B. 1983. Creation, evolution, and curriculum. Science Education, 67(1):45-55.
- Anderson, V. E. 1983. Scientific creationism and its critique of evolution. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- The Arkansas creationism act (1981). 1983. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- The Arkansas decision: Memorandum opinion in Rev. Bill McLean et al. versus the Arkansas Board of Education et al. 1983. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- Ayala, F. J.; Dobzhansky, T.; Stebbins, L.; and Valentine, J. W. 1977. Evolution. San Francisco: W. H. Freeman.
- _____. 1983. Microevolution and macroevolution. In: Evolution From Molecules to Men, D. S. Bendall, ed. Cambridge: Cambridge University Press.
- Bentley, M. L. 1981. On the teaching of origins. Today's Education, 70:66-68.
- Berry, R. W. 1983. The beginning. In: Is God a creationist?, R. M. Frye, ed. New York: Scribners.
- Bird, W. R.; Bliss, R. B.; and Gish, D. T. 1983. Summary of scientific evidence for creation. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- Bliss, R. B. 1983. A two-model approach to origins: A curriculum imperative. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.

- Buffaloe, N.D. and Murray, N. P. 1983. Creationism and Evolution: The real issues. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix, Oryx Press.
- Callaghan, C. A. 1980. Evolution and creationist arguments. American Biology Teacher, 42(7):422-427.
- Cloud, P. 1978. Cosmos, Earth, and Man. New Haven: Yale University Press.
- Darwin, C. 1859. (revised, 1979.) Origin of Species. Baltimore: Penguin Books.
- deCamp, L. S. 1969. The end of the monkey war. Scientific American, 220(2):15-21.
- Dodson, E. O. 1960. Evolution: Process and Product. London: Chapman and Hall.
- Edwards, F. 1983a. Is it really fair to give creationism equal time? In: Scientists Confront Creationism, L. R. Godfrey, ed. New York: W. W. Norton.
- _____. 1983b. Decide: Evolution or creation? In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- Eldredge, N. 1985. Evolutionary tempos and modes: A paleontological perspective. In: What Darwin Began, L. R. Godfrey, ed. Boston: Allyn and Bacon.
- _____. 1982. The Monkey Business: A Scientist's Look at Creationism. New York: Washington Square Press.
- Eldredge, N. and Gould, S. J. 1982. Punctuated equilibria: An alternative to phyletic gradualism. In: Models in Paleobiology, T. J. M. Schopf, ed. San Francisco: Freeman.
- Fowler, D. R. 1982. The creationist movement. American Biology Teacher, 44(9):528-542.
- Frye, R. M. 1983. The two books of God. In: Is God a Creationist?, R. M. Frye, ed. New York: Scribners.
- Futuyma, D. J. 1982. Science on Trial. New York: Pantheon.
- Gallant, R. A. 1975. How Life Began. New York: Four Winds Press.
- Gilkey, L. 1983. Creationism: The roots of the conflict. In: Is God a Creationist?, R. M. Frye, ed. New York: Scribners.

- Gish, D. T. 1983. Creation, evolution, and public education. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- Good, R. 1981. The Philosophy of Evolution. Great Britain: Dovecote Press.
- Gorman, J. 1981. Creationists vs. evolution. Discover, 2:32-33.
- Gould, S. J. 1981. Evolution as fact and theory. Discover, 2:34-37.
- Grabiner, J. V. and Miller, P. D. 1974. Effects of the Scopes trial. Science, 185:832-836.
- Hickman, C. P.; Hickman, F. M.; and Roberts, L. S. 1982. Biology of Animals, 3rd ed. St. Louis: C. V. Mosby.
- Jacobs, K. H. 1985. Human origins. In: What Darwin Began, L. R. Godfrey, ed. Boston: Allyn and Bacon.
- Keeton, W. T. and McFadden, C. H. 1983. Elements of Biological Science, 3rd ed. New York: W. W. Norton.
- Kenkel, L. A. 1985. A case against scientific creationism: A look at content issues. Science Education, 69(1):59-68.
- King, J. L.; Sanders, G. P.; and Wallace, R. A. 1981. Biology: The Science of Life. Glenview, Illinois: Scott, Foresman.
- King, M. C. and Wilson, A. C. 1975. Evolution at two levels in humans and chimpanzees. Science, 188:107-115.
- Lewin, R. 1981. New creationism bill already drafted. Science, 214:1224.
- _____. 1982a. Where is the science in creation science? Science, 215:142-146.
- _____. 1982b. Judge's ruling hits hard at creationism. Science, 215:381-384.
- Lightner, J. P. 1977. A compendium of information on the theory of evolution and the evolution-creationism controversy. Reston, Virginia: National Association of Biology Teachers.
- Mader, S. S. 1985. Inquiry Into Life, 4th ed. Dubuque, Iowa: William C. Brown.
- McAlester, A. L. 1968. The History of Life. Englewood Cliffs, New Jersey: Prentice-Hall.
- McEachron, D. L. and Root-Bernstein, R. 1982. Teaching theories: The evolution-creation controversy. American Biology Teacher, 44(7):413-420.

- McKean, D. 1983. Reading the molecular clock. Discover, 4:28-31.
- Moore, J. A. 1983. On giving equal time to the teaching of evolution and creation. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- _____. 1982. Evolution and public education. BioScience, 32(7):606-611.
- Moore, J. N. and Slusher, H. S. 1981. A Search for Order in Complexity. Grand Rapids, Michigan: Zondervan.
- Morris, H. M. 1974. Scientific Creationism. San Diego: Creation-Life.
- _____. 1982. Evolution in Turmoil. San Diego: Creation-Life.
- _____ and Parker, G. E. 1982. What is Creation Science? San Diego: Creation-Life.
- Nelkin, D. 1982. The Creation Controversy. New York: W. W. Norton.
- Newell, N. D. 1982. Creation and Evolution: Myth or Reality? (R. N. Anshen Series in Convergence, No. 3.) New York: Columbia University Press.
- Olson, E. A. 1983. Hidden agenda behind the evolutionist/creationist debate. In: Is God a Creationist?, R. M. Frye, ed. New York: Scribners.
- Ruse, M. 1982., Darwinism Defended. Reading, Massachusetts: Addison-Wesley.
- Schadewald, R. J. 1983. Six "flood" arguments creationists can't answer. In: Evolution Versus Creationism: The Public Education Controversy, J. R. Zetterberg, ed. Phoenix: Oryx Press.
- Stanley, S. M. 1981. The New Evolutionary Timetable. New York: Basic Books.
- Stansfield, W. D. 1977. The Science of Evolution. New York: Macmillan.
- Taylor, G. R. 1983. The Great Evolution Mystery. New York: Harper and Row.
- The Tennessee anti-evolution act (1925). 1983. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.
- The Tennessee creationism act (1973). 1983. In: Evolution Versus Creationism: The Public Education Controversy, J. P. Zetterberg, ed. Phoenix: Oryx Press.

- Vawter, B. 1983. Creationism: Creative misuse of the Bible. In: Is God a Creationist?, R. M. Frye, ed. New York: Scribners.
- Volpe, E. P. 1977. Understanding Evolution, 3rd ed. Dubuque, Iowa: William C. Brown.
- Weaver, K. F. 1985. The search for our ancestors. National Geographic, 168(5):560-623.
- Webster's Ninth New Collegiate Dictionary. 1985. Springfield, Massachusetts: Merriam-Webster.
- Zetterberg, J. P., ed. 1983. Evolution Versus Creationism: The Public Education Controversy. Phoenix: Oryx Press.

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