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Scope of Study: An integration of the sciences with all phases of life should begin with a student's introduction to science. This paper outlines historical backgrounds of several sciences which can be used as introduction to units of study. These units can help knit the whole sphere of scientific endeavor into a cooperative whole rather than each an entity of its own. There are several outlines of histories of science presented, and several units are given as a suggestion to teachers using this method for General Science classes.

Findings and Conclusions: The use of historical introductions to various units, if presented in an interesting and valuable way, rather than that of a traditional way, will broaden the scope of the student's thinking along the lines of scientific research. The student will realize that not everything had been done or discovered. His enthusiasm for exploration and discovery of the unknown will encourage him to start projects of his own, even while in junior or senior high school.

ADVISOR'S APPROVAL ______________________________

HISTORY AS AN INTRODUCTION TO
UNITS IN GENERAL SCIENCE

By

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CHAPTER I

INTRODUCTION

An integration of the sciences with all phases of life should begin with a student's introduction to science. For this reason, a junior or senior high school introductory course quite logically should begin with an outline of certain key scientific discoveries which established scientific principles and methods. These key events are found in such field as Astronomy, Biology, Physics, Mathematics, Geology, Chemistry, and also Technology.

One unit in the History of Science can develop an interest and appreciation of modern science and technology, if presented in a logical, interesting, and valuable way. Here, also, the science teacher can clarify fact from fiction and superstition by showing the incorrect thinking that developed such ideas. Science has too long been stifled by superstition and statements taken for granted as true.

An interest in research and reading can develop from an introduction of the History of Science. Likewise, these several units can knit the whole sphere of scientific endeavors into a recognizable, efficient, and cooperative study. All too often students can think of the study of science, other than one which may interest them, as isolated from the world about them. Laboratory work can do part of this enlightening, but often, historical data can give a little stronger impression.

A teen-ager student beginning in science has scanty concepts as to the time and effort demanded to establish scientific fact. He is all too willing to think that the only worthwhile science is that which he experiences in his daily life through radio, television, and newspapers. The fact that the principles and methods of todays' science were developed many centuries ago could easily be pointed out by its historical development. There are interesting stories involved in the history of science which can certainly hold the attention of students while they learn to appreciate the early scientists' efforts and better understand the principles being discovered. These are the basic principles of our modern science, and they have only now been more fully explored, combined, and refined into complex ideas and technologies.

It is the purpose of this report to (1) acquaint the general science teacher of the importance of an historical approach to science, and (2) illustrate several possible units that could be utilized before certain topics of discussion. The only necessary equipment is that of a few good historical outlines of the fields of science for the students' use, and a teacher who does not mind library research to help students' inquiries about historical pacemakers.

CHAPTER II

BRIEF OUTLINE OF HISTORIES

Historical epochs move as the tide. Each is dependent on another. At first all sciences were one idea. In the Medieval and Renaissance Ages the parts were separated and studied from the whole of the original scientific world. So each has a common ancestry with branches from there.

The earlies or pre-Socratic period may be divided into the Ionic and Italic Schools. Both attempted to determine the nature, origin, laws, and testing of the world of sensible experience. The earliest definite mane is that of the founder of the Ionic school, Thales of Miletus. Thales began the transition from mythological to observable description and interpretation of nature plus the search for the "original substance" giving life. This "original substance" he found in water. He was followed by Anaximander, who found such an original substance not in water, but in indeterminate matter, while later he preferred the definite substance of air. The greatest of the pre-Socratic philosophers, Heraclitus, held that one substance, changing itself into all the elements known to us was fire, which exhibits most clearly the constant movement and activity of the world.

Next is Pythagoras of Samos, about 530 B.C., founded the Italic school. In contrast to the Ionic school, which taught the ever-changing, self-developed universe, the Italic philosophical teachers found the key to the universe in numbers and proportions.

A second Italic school founded by Xenophanes, called Eleatic, assumed that all the exists has existed and will exist the same forever, and that change and multiplicity are illusions. (An early idea of the industructibility of matter.)

Empedocles and Anaxogoras, the teacher of Pericles and Euripides, agreed in accepting the principle of the immutability of substance, but did not accept its absolute oneness.

Democritus of Abdera was the chief exponent of the atomic theory which based the universe on combinations of indivisible, unchangeable atoms. The pre-Socratists, then devoted themselves to the investigation of nature as a whole.

Between them and Socrates is a skeptical era. Many other investigators and philosophers of this time effected the disintegration of these established beliefs.

Socrates came in with some of the general skepticism but maintained the certainty of moral distinctions and searched for the discovery of error and the finding of truth. Most famous of Socrates' disciples were Plato and Aristotle. The following is a short outline of Greek Philosophers:

I. PRE-SOCRATIC PHILOSOPHERS

Their philosophical speculation was mainly objective; were concerned with the study of nature and the origin of the world. Asked themselves: "What is reality."

a. Early Ionian Philosophers

Studied <u>Nature</u>: sought out material principles of natural phenomena.

Dynamists:

Thales born c640 B.C.
Anaximander born c610 B.C.
Anaximenes death 528 B.C.

b. Pythagoreans
Made numbers the basis of their philosophy.
Founded by Pythagoras.

c. Eleatics
Noted oneness and immutibility of nature and being and used this as the center of their philosophy.

Later Ionian Philosophers departed from the monastic dynamism of the early Ionians and adopted a dualistic mechanical concept.

Heraclitus	born c530 B.C.	Was connecting link between earlier and later Ionian philosophy. Actually a dynamist, not a mechanist.
Empedocles	born c490 B.C.	Poet and philosopher.
Anaxagoras	born c500 B.C.	

Atomists were the last phase of Ionian philosophy.

Leucippus and Democritus

d. Sophists
The first skeptics of Greek philosophy. Showed negatively the unsatisfactory nature of knowledge and positively sought to inquire into the limitations of knowledge.

II. SOCRATES AND THE SOCRATIC SCHOOLS
This was the highest development of Greek philosophy.
a. Socrates and the Socratic School
b. Plato and the Academicians
c. Aristotle and the Peripatetics

III. POST-ARISTOTELIAN PHILOSOPHY
Purely speculative.
a. Stoics
b. Epicureans
c. Skeptics
d. Ecleatics
e. Mathematicians and astronomers[1]

The history of Chemistry can be discussed in many ways. One approach is that of a discussion of the ages.

The Dark Ages to many left no real scientific discoveries. The most that can be said of it is that it lead to the Middle Ages which offers very much in the line of Chemistry and its progress. Medieval Science was steeped in superstition and error, but gives most to interest students. Many of the people of this time are referred to

[1]Sister Mary Xavier, "History of Science," (unpb. Ph.D dissertation, Mount Mary College, 1960)

commonly because of their basic work. Those involved in Chemistry are particulary interesting because this was the time of its true development, along with pharmacology and medicine. These pre-Chemists are called Alchemists.

The fundamental ideas of the alchemists were that there was a certain "materia prima" which was present in all things though always contaminated by impurities. These they tried to remove by processes of purification, especially by calcination, sublimation, or by distillation, and in this way they expected to obtain the essence or tincture, or the "Philosopher's stone" only in material other than metals. Once purified, this was expected to work wonders of many kinds as the change of baser metals to gold by contact, heal all diseases and regenerate the character of the discoverer of the essence. This materia prima may have been originally derived from the idea of "quintescence" described by Aristotle. The alchemists accepted his four elements, namely earth, air, fire, and water which made up all things on earth, but often added others of their own such as mercury, sulfur, or salt. These are not the same substances that we are familiar with, rather they refer to compounds that were defined as such by the preeminent alchemists of the day. Mercury stood for the metallic and also the volatile character of substances in general. Sulfur represented the properties of combustibility, and salt stood for the salty or earthy properties, and also the resistance to fire. All these terms were in use in an unorganized and inconsistent way, as the following selection from a book possibly written by Basilius Valentinus certainly shows:

> That there can be no perfect generation or resuscitation without the cooperation of four elements, you may see from the fact that

> when Adam had been formed by the Creator out of earth, there was no life in him until God breathed into him a living spirit then the earth was quickened into motion. In the earth was the salt, that is the body; the air that was breathed into it was mercury or the spirit, and this air imparted to him a gentle and temperate heat which was sulfur or fire. The Adam moved, and by his power of motion showed that there had been infused into him a life giving spirit. For as there is no fire without air so neither is there any air without fire. Water was incorporated with the earth. Thus living man is a harmonious mixture of the four elements; and Adam was generated out of earth, water, air, and fire; out of soul, spirit and body; out of mercury, sulfur, and salt.[2]

The recipes and direction in alchemistic books laid great weight upon the phases of the moon, the position of the planets and the utterance of appropriate incantations. Also, they had little accurate measurement of weights, or regulation of heat or pressure. The materials used could hardly have been pure or uniform. Actually, since they were not accurate, and often the results were interpreted as being unnatural happenings.

These people depended often on the planets. Their "seven planets" had been associated with the then known "seven metals." In their writings the astronomical signs were used to signify the metals. The sun stood for gold, the moon for silver, Jupiter for tin, Saturn for lead, Mars for iron, Venus for copper, and Mercury for the metal of the same name. It followed naturally that when a metal was to be acted upon chemically in a certain was, its proper planet must be rightly situated. In spite of this the alchemists did achieve some practical results.

The world gradually did accumulate scientific information. The tendency to heat, distill, and combine all obtainable substances in order to obtain the philosopher's stone had the practical result that many important reactions were observed and many important compounds prepared. Unfortunately the alchemists were so unwilling to use in-

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[2] F. J. Moore, A History of Chemistry, (New York, 1931), p.1.

telligible language in the description of their discoveries that most of these remained unfruitful.

The alchemists were searching for immortality and the elixir of life. But this originated as far back as the second or third century with a Chinese alchemist, Wei Po-yang. He wrote a treatise on the proparation of "the pill of immortality," and there is an interesting story connected with it. He, three of his disciples and a dog, tried out a carefully prepared "medicine" on the dog. The dog died, and Wei Po-yang was so discouraged that he felt he was ashamed to go back and tell of the failure. So he and one of the disciples took some of the medicine and fell dead. The other two disciples went off to fetch an undertaker, but in their absence Wei Po-yang recovered and with the aid of more medicine joined the immortals together with his friend and the dog.

Attempts to trace alchemy as far back as possible lead some authors to believe that Adam had a knowledge of such an elixir which enabled him to reach a very old age. Also, the French name for a hot-water bath is Bain-Marie, and tradition says that Marie, the sister of Moses knew about alchemy and invented the bath.

Such Chemistry is to be found in Arabia, but through the Egyptians. In A.D. 640 Egypt was overrun by Arabs. They found books there which described how to make gold and cure ills, and these were translated into Arabic. For a century a stream of books were sent to the Mohammedans. Subsequently the Egyptian knowledge reached Europe in the form of Latin translation from Arabic works, and many historians have thought that the Arabs were the originators of Chemistry. Of the early writers, the most important were Jabir ibn-Haijan, Razi (Rhases or Rhazes, and Avicenna, also called ibn-Sina.

The full name of Jabir, rarely used, is Jabir ibn-Haijan, and in the later Latin writings he is usually called Geber or Giaber. Geber, according to tradition, is the founder and greatest representative of alchemy and probably lived at about A.D. 720-800. The place of his residence is uncertain, but his numerous works brought him great fame in the middle ages. Some of these are still extant in Arabic, while certain Latin treatises purposing to be translations of Geber are preserved in European libraries. The latter books date from about the 13th century and Bertholet, after comparing them with the Arabic writings of Geber, came to the conclusion that they were to work of another hand and had been attributed to Geber in order to enhance their prestige. It is interesting to note that Bertholet found the Latin works superior from the chemical point of view. The writer is called the pseudo-Geber. He was probably a cleric well versed in science.

Al Razi -- or Rhases (A.D 886-925) was a skillful and practical Persian physician and has been called the Persian Boyle. He is frequently referred to in alchemical literature. He described "The Stone" as triangular in essence, square in quality. He as well as Geber and Avicenna, described the practical achievements of alchemy.

Avicenna (A.D. 980-1036) was a famous physician and has been called the Aristotle of Arabians. He was willing to tell the world the secret of the Magisterium. He probably made no experiments himself, and in his interesting books he at times seemed to doubt the possibility of transmutation. Later, Paracelsus burned the works of Galen and of Avicenna in a brass pan, with the aid of sulfur and potassium nitrate, in his first lecture and then expressed the hope that these authors were in like circumstances.

These men taught that theory, the germ of which was also taught by Aristotle, that metals are composed of mercury and sulfur. Their information may have come from Mesopotamia, Syria, or even China. The association of metals with the planets was introduced into Arabian alchemy probably from Babylonia.

Some names of interest:

Vincent de Beauvais (1190-1264) was a Dominican monk who wrote an encyclopedia, the Speculum Naturale, with a section on alchemy which was mostly derived from Lation translations of Arabic works.

Albert Magnus (1193-1280), sometimes called Doctor Universalis, was one of the most important and best representatives of alchemy. He was the wisest man and greatest German scholar of that time and was distinguished as a priest, monk, scientist, philosopher, mystic, and astrologer, as well as alchemist. He has been called the Aristotle of the Middle Ages because of his wisdom and his work in arranging and systematizing the writings of the famous Greek. He was Bishop of Regensburg in 1260, was a friend of Thomas Aquinas, and is mentioned by Dante. He wrote a great deal, but many of his reputed writings are undoubtedly forgeries. As a monk he wandered about from place to place and practiced alchemy. He thought that all metals were more or less mercury and sulfur. To him the liquid yet metallic mercury represented water and earth, whereas sulfur represented the volaticle and combustible (fatty) material. He had the idea that all matter was composed of a prime material. In describing the relation between sulfur and the metals, he spoke of the attraction of sulfur to metals, indicating ideas concerning chemical affinity. He defined flame as ignited smoke. In his writings Plato's logic that like seeks like appears. He had some knowledge of metallurgy. To him nature was the only real alchemist and he admitted that he had never known an alchemist who could accomplish a perfect transmutation.

Roger Bacon (1214-1294), called Doctor Mirabilis by his contemporaries, was a Franciscan monk and the leading English alchemist. He was an inventive genius much in advance of his time who added materially to knowledge by his mathematical studies and experiments. A great number of practical inventions are commonly ascribed to him, though in many cases the proofs are lacking. Among his writings are found a recipe for making gunpowder, directions for the construction of a telescope, and a study of the rainbow which is said to be extremely good.

He recognized the value of experimentation and mathematical deduction. He was a profound believer in alchemy but wrote soberly and clearly.

Ramon Lull (1235-ca.1315), sometimes called Doctor Illuminatus, was a romantic Spanish nobleman. This man was a poet, philosopher, mystic, alchemist, artist, troubadour, and missionary who loved the mythical picture more than reality. He lost his life on a missionary expedition, being stoned to death by the natives.

Bernard Palissy (c1510-1589), was a leader of chemical and scientific thought in France, just as Bacon was in England. He emphasized the value of experimental results rather than belief in the speculation of philosophers. He invented enameled pottery in France established a factory, and made beautiful pieces in which the forms of animals are produced in their natural colors. He had the first mineralogical and geological collection in Paris - lectured - died in Bastille.

Denis Zachaire (Dionysuis Zacharias), was another French alchemist of repute. He wrote a book on alchemy which was published in Antwerp in 1567.

Bernard Trevisan (1406-1490), was an Italian gentleman who spent his life and his fortune in the vain search for the secret of transmutation.

Basilius Valentias - The Truimphal Chariot of Antimony.

Leonardo da Vinci (1452-1519), he was brilliant in mathematics, astronomy, mechanics, hydraulics, geology, geography, and casmogency, and art. He discovered capillarity, and one hundred years before Francis Bacon he showed a greater grasp of the principles upon which experimental science is based. His ideas were far in advance of his time and were hidden in manuscript from which no one was able to extract their wisdom.

Decay of alchemy - The development of experimental science, and a division between philosophy and science.

Chemistry in the Renaissance

Revival of learning: voyages of Columbus, Vasco da Gama; Luther at Wittenberg in 1517; Copernicus conclusion that the sun, not the earth is the center of the solar system.

Paracelsus was born in Einseldeln, Switzerland about 1493. At 16 he was a student at Basel, and after this time he is said to have traveled extensively. Paracelsus was already famous for his marvelous cures and now devoted this academic position to the establishment of his revolutionary theories and the denunciation of more conservative practitioners.

The fundamental idea of Paracelsus seems to have been that life is essentially a chemical process. If, then, man is a chemical compound of Hg, S, and salt, then good health must be the sign that the elements are mingled in correct proportions, but illness shows that one or more of these elements is deficient. The logical treatment is to dose the patient with that which he lacks in some form suitable for assimilation, such consideration induced Paracelsus to abandon the herbs and extracts chiefly used by the physicians of his time and to prescribe inorganic salts. Mercury and its compounds owe their present prominence in the pharmacopoeia originally to him.

In the mystical writings of Paracelsus the heart is the moon and the lives is Jupiter. His elements, Hg, S, and salt, stood for (1) inflammability, (2) fusibility and volatility, and (3) fixity and incombustibility. In the body he compared these with spirit, soul, and body.

His service to chemistry consisted in this, that he induced the alchemists to give up the search for gold and to devote their chemical skill to the preparation of remedies while at the same time he compelled the physicians to learn a little chemistry.

His motto, "Let him not belong to another who may be his own."[3]

[3]Ibid., Sr. M. Xavier.

History can be approached in several other ways. One is by chapter subjects as:

1. THE BEGINNINGS

Evolution of Science

Early motive was the struggle to maintain life and increase bodily comforts.
The beginnings were found wherever civilization centered-in Mesopotamia, China, India, Egypt, and European Greece.
There were invented tools making use of physical laws, even though these laws were not recognized or understood.
Amont these were the wedge, the lever, the screw, the wheel, the blast furnace, and the potter's wheel.

Industrial Arts: Metallurgy

Six metals known-gold, silver, tin, iron, copper, and lead, mentioned by Homer and the Bible.
Mercury and electrum later.
Later the Romans used zinc and bronze.
The egyptians knew of a way of hardening and tempering copper without alloying it and that is now considered one of the so-called lost arts.

Minerals and salts

Antimony sulfide (kohl) used to paint the eyebrows.
Oxides of copper used in glass making.
White lead a cosmetic and medicine.
Red lead a paint.
Black oxide of manganese used in glass making for clearing up colored or darkened glass and so received the name pyrolusite.
Carbonate of zinc used in making brass.
Sulfides of arsenic used as pigments.

Soda and potash were used in washing and whitening clothes and in saponifying fats for soaps and unguents.
Lime was burned and mortar made from it, though the earliest cementing materials seem to jave been pitch and bitumin.
Salt and saltpeter were used as food preservatives.
Alum was used in dyeing.
Vinegar was the only acid known.

Glass making and pottery

Originated in Egypt., the to Byzantium (eastern empire), the Europe through the Crusaders.
Specimens of pottery and the potter's wheel have been unearthed from the earliest ruins.
Etruscans and Egyptians excelled in enamels, glazes, and decorations.
Chinese alone knew how to make porcelain.

Dyeing and tanning

Mineral colors known at the time of Pliny:

White lead, red lead, zinc white, cinnabar, smalt, verdigris, ochre, lampblack, realgar, orpiment, stibnite, and the oxides of copper.

Soaps and medicaments

Soap was made by mixing wood ashes with animal fats, thus saponifying them. Burnt lime often added. Hard and soft soaps were known. Sulphur was used as a disinfectant, and bleaching.

Soda and potash were used in washing and whitening clothes and in saponifying fats for soaps and unguents.

2. EARLY DEVELOPMENT

Naming the science

Egypt had chemi, Plutarch refers it to black soil, also meaning the black of the eye, symbolizing that which was obscure or hidden.

The Coptic word chems also signifies obscure, occult.

The Arabic chema means to hide.

It was then, the occult or hidden science, the black art.

Arrangement of facts.

Second stage, gathering of facts and observations and their systematic arranging and recording.

Mysticism

Magic and superstition were accompanied with chemistry and its development.

Manuscripts and original sources

Earliest - Thebes - wrapping of a mummy - Greek and Demotic characters, known as Greek papyri.

Laws

Newton's law of gravity.

Lavoisier story of burning.

Greek philosophers guessed at the indestructibility of matter.

Mutability in Nature

The Greek philosophers stand preeminent as the greatest, clearest thinkers of all time.

- Socrates - speculation
- Plato - separates matter from immaterial
- Aristotle - observation and experimentation

Theories

Thales of Miletus, first of the natural philosophers, water was first element out of which things are made.

Anaximenes regarded air as the primal element.

Heraklitos, fire.

Pherekides, earth.

Empedokles introduced the idea of four distinct primal elements - earth, air, fire, and water - which were not interchangeable but formed all things on being mixed.

Atomic theory

Internal structure of elements.

Anaxogoras of Klazomene (500 B.C.) was first to theorize on it.

Leukippos and Demokritos extended it.

Atoms

Word means that which cannot be divided.

Ether

The fifth element or quinta essentia.

Indivisibility of the atom

Insignificant

World building
Mixing various elements.
Apparatus
Dry methods---crucibles, furnaces, etc.
Blow pipe and bellows
Jars and bowls of clay
Glass later.

3. THE DARK AGES
The old order overturned
Universities in northern Africa and Spain.
Ancient books collected.
University of Bagdad in Arabia first.
Progress made by the Arabians
Chief interest - the art of healing, included the philosopher's stone, which at first was a remedial agent or universal medicine. Later it became a supposed means of turning base metals an lead into gold.
Transmutation of metals
Base metals into gold.
Geber
Considered all metals to be compounds of mercury and sulfur in varying proportions.
Understood the purification of substance by crystallization, solution, and filtration.
The majority of the processes in use up to the 18th century were known to him.
New Substances
Wet processes of chemistry:
saltpeter and sal ammoniac
mineral acids, nitric, sulphuric, and aqua regia.
Sulfates or vitriols
Schools and universities in Paris, Naples, Padus, and Montpeliet and others.

4. THE MIDDLE AGES
The only noted scientific workers of the early part of this period came from the monkish orders.
Albert Magnus 1193-1280
Introduced the affinity to designate the cause of the combination of the metals with sulphur.
Roger Bacon 1214-1294
Made gunpowder.
Invented telescope, camera obscura, and burning lenses.
Subjected organic substances to dry distillation and noted the inflammable gases given off.
Changes in the 16th century
Copernius and his stellar system.
Reformation by Luther.
Gutenberg and printing.
Paracelsus 1493-1511
Taught medicine, chemistry, and pharmacy
Agricola 1494-1555
Improved metallurgy and industrial arts

Van Helmont 1577-1644

Willow experiment.

Separated flammable and inflammable gases.

Glauber 1604-1668

Sodium sulfate or Glauber's salt.

The rise of theory

17th century advanced chemistry more than the previous centuries.

Robert Boyle 1626-1691

Inductive method to experimentation.

Experiments upon air

Boyle's gas laws.

Constitution of matter

Listing of metals and various acids showing relativity between them.

5. THE CHEMISTRY OF COMBUSTION

Phlogiston theory:

The purpose was to explain the changes which occur when a metal is heated in air and changed into a powder. The metal was said to be calcined and the resulting powder was called a calx. The metals supposedly lost something which was the hypothetical hplogiston and the calx remained. The metal then, was a compound made up of calx and phlogiston. The trouble was that the discussion became one of logic with neglect or disregard of facts. One of the last of the phlogistics was Priestley, who argued in behalf of his views until his death in 1804.

Composition of Air:

A problem to phlogistons.

Hooke's theory of combustion:

Published in 1665 of his Micographis: Air supports combustion but this combustion will take place only after the substance has been sufficiently heated. There is no such thing as elemental fire. This combustion is caused by a substance inherent in and mixed with the air which is very much like, if not the very same as that which is fixed in saltpeter.

The discovery of oxygen blew the Phlogiston theory.

Priestly called it dephlogisticated air.

The discovery of hydrogen by Cavendish and the fact that on burning it formed water completed the proof of the new theory that combustion is simply combining with oxygen or oxidation. Lavoisier named it hydrogen or the water-former.

6. THE NEW CHEMISTRY

The finding of new elements and compounds now depended upon analytical results.

Analysis:

First outlined by Boyle, then Bergman of Sweden, using wet methods.

Scheele 1742-1786

Among organic acids he discovered tartaric, oxalic, malic, citric, and gallic; among inorganic, molybdic, tungstic, and arsenic.

Three elements were discovered by him, oxygen, manganese, and chlorine; and one new alkaline earth, baryta.
His chief deficiency lay in the matter of understanding phenomena and formulating theories.

Analysis of Air
Scheele isolated oxygen or fire-air, as he called it because it supported combustion more readily than air.

Boerhaave 1668-1738
Holland - skilled in interpreting facts.

Fixity of proportions
Grew naturally out of the experience of the analytical chemist who tested the quantitative relations with his balance.

Bertholler 1748-1822
He contended that these proportions were not constant but that the relative masses of the combining substances determined the proportions in which they would unite to form compounds. Proust found that metals might have several oxides and laso that hydroxides existed. The victory finally remained with Proust.

Views as to affinity
The name affinity had been given early to this combining force between different substances. Bergman's tables shows a knowledge that affinity phenomena depend upon the temperature and physical state.

Lavoisier
Father of Modern Chemistry - gases and atmosphere discoveries.

Character of his work
Introduced a deeper study of chemical reactions and the relations of quantity.

Experiments of combustion
He showed that when metals were calcined their weights increased and that a portion of air, equal to their increase in weight, had been absorbed from the surrounding atmosphere.

Composition of the atmosphere
The year 1786 may be fixed as the date of the overturning of the phlogiston theory, because Lavoisier proclaimed the nonexistence of phlogiston and replaced this old theory by a new one, explaining the phenomena of combustion and reduction as due to the combination with oxygen or its separation.

7. THE FOUNDATIONS

Composition of water
Lavoisier and Cavendish; oxygen and hydrogen, but could not explain it fully.

Transmutation of water
Lavoisier began analytical work on the nature, but was only the beginning of the series of experiments on this subject which after many years established the law.

The Atmosphere
Priestly began, Lavoisier completed the discovery of oxygen and nitrogen.

The nature of heat and of matter
Lavoisier and Laplace in experiments upon specific heat showed that solids differ in their capacity for taking up this heat. His views are in partial accord with the modern theory of heat when he comes to define that form of energy..."Heat

is the result of invisible motion of the particles, the sum of the product of the masses multiplied by the square of the velocities."

Investigation of organic substances

Lavoisier determined that all organic substances were composed of carbon and hydrogen, sometimes oxygen, and less often nitrogen and other elements.

Theory as to acids

Lavoisier -- 1. An acid results from the union of a simple body, ordinarily non-metallic, with oxygen.
2. An oxide is a compound of a metal and oxygen.
3. A salt is a compound of a metal and oxygen.

Elements

Priestly

Study of atmosphere

Views as to combustion

A combination of errors concerning phlogiston, hydrogen, and oxygen.

8. THE ATOMIC THEORY

The proposition of Lavoisier

1. In all chemical reactions, only the form of the materials changes, the quantity remaining the same.
2. In all combustions the burning body unites with oxygen, and in general an acid is formed by combustion of a non-metal, and a metallic calx is formed by combustion of a metal. This calx is an oxide.
3. All acids contain oxygen united with a base or a radical which, in the case of inorganic substances, is generally an element; in organic substances it is made up of carbon and hydrogen, and often contains nitrogen and phosphorus as well as other elements.

Richter (1762-1807)

Constructed a table giving the proportions by weight in which substances combine.

Dalton's atomic theory

Constitution of mixed gases

Provided repulsive force.

Law of constant proportions

Brought about a clear distinctinction between compounds and mixtures.

Law of Multiple proportions

1. Every element is made up of similar atoms of constant weight.
2. Chemical compounds are formed by the union of the atoms of the different elements in simple numerical relations.

Determingin the weights of the atoms

Used proportions of chemical combinations.

Dalton's Rules

1. When only one combination of two bodies can be obtained it must be presumed to be a binary one unless some cause appear to the contrary.
2. When two combinations are observed they must be presumed to be a binary and a tertiary.

3. When three combinations are obtained we may expect one to be a binary and the other two tertiary.
4. When four combinations are observed we should expect one binary, two ternary, and one quaternary, etc.

Gay-Lussac (1778-1850)

Worked on iodine, cyanogen, the alkaline oxides, the isolation of boron, improved methods for organic analysis, and many similar studies.

Law of volumes

The volumes in which two gases combine bear a simple ratio to one another and to the volume of the resulting gaseous product.

Objection to the law - Gay-Lussac vs. Dalton

Avogadro's theory

Molecules were compound particles and were made up of the indivisible atoms.

9. THE ATOMIC WEIGHTS

Dalton used hydrogen as the unit.

The Standard for the Atomic Weights.

Hydrogen as opposed to oxygen.

Wollaston's Equivalents

Wollaston meant by it the relative quantities or proportions in which bodies unite, thus doing away with the idea of atoms.

Law of specific heats

Dulong and Petit- The atoms of the different elements have the same capacity for heat. It is possible by means of the specific heat to approximate the true atomic weight.

Isomorphism

Mitscherlich-compounds of analogous compositions and containing the same number of atoms crystallize in the same form or, in other words, or isomorphous.

Elector-chemical equivalents

Work of Dumas on the Atomic Weights

Vapor Densities

Gmelin's Views

Confusion in the Sixth Decade

Standard not uniform

Revision of the Atomic Weights

Dumas, Erdmann, Marchand, Marignac, DeVille, and Scheerer.
Number 16 used for oxygen.

Clearing up the confusion

Through organic chemistry.
In 1860 a meering was called at Karlsruhe by distinguished chemists of various nationalities to see of some general agreement could not be reached as to standards, atomic weights, and chemical notation.

Constancy of the Atomic Weights

10. NATURE OF THE ATOM

Prout's Hypothesis

Elements were only different grades of condensation of hydrogen.

Periodic System

Mendeleef-

> 1. The elements, if arranged according to their atomic weights, exhibit an evident periodicity of properties.
> 2. Elements which are similar as regard their chemical properties have atomic weights which are either nearly of the same value or which increase regularly.
> 3. The arrangement of the elements in the order of their atomic weights corresponds to their so-called balances as well as to some extent to their distinctive chemical properties.
> 4. The elements which are most widely diffused have small atomic weights.
> 5. The magnitude of the atomic weight determines the character of the element just as the magnitude of the molecule determines the character of a compound body.

And others as:

1. Affinity, The atomic Attractive Force
2. Growth of Inorganic Chemistry
3. The Development of Organic Chemistry
4. Further Theories as to Structure
5. Physical Chemistry
6. Biochemistry
7. Radioactivity[4]

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[4]Francis P. Venable, History of Chemistry (Chicago,c1922) .

Or as History through People:

St Hildegard of Bingen:

Personality and reputation--- From repeate statements in the prefaces to Hildegard's works, in which she tells exactly when she wrote them and how old she was at the time,-for not only was she not reticent on this point but her different statements of her age at different times are all consistent with one another--it is evident that she was born in 1098. Her birthplace was near Sponheim. From the age of five, she tells us in the Scivias, she had been subject of visions which did not come to her in her sleep but in her wakeful hours, yet were not seen or heard with the eyes and ears of sense. During her lifetime she was also subject to frequent illness, and very likely there was some connection between her state of health and her susceptibility to visions. She spent her life from her eighth year in religious houses along the Nahe river, and in 1147 became head of a nunnery at its mouth opposite Bingen, the place with which her name was henceforth connected. She became famed for her cures of diseases as well as her visions and ascetic life, and it is Kaiser's opinion that her medical skill contributed more to her popular reputation for saintliness than all her writings. At any rate she became very well known, and her prayers and predictions were much sought after. Thomas Becket, who seems to have been rather too inclined to pry into the future, as we shall see later, wrote asking for "the visions and oracles of that sainted and most celebrated Hildegard," and inquiring whether any revelation had been vouchafed her as to the duration of the existing papal schism. "For in the days of Pope Eugenius she predicted that not until his last days would he have peace and grace in the city." It is very doubtful whether St. Bernard visited her monastery and called the attention of Pope Eugenius III to her visions but her letters show her in correspondence with St. Bernard and several Popes and Emperors, with numerous Archbishops, and Bishops, Abbots, and other Potentates, to whom she did not hesitate to administer reproofs and warnings. For this purpose and to aid in the repression of heresay she also made tours from Bingen to various parts of Germany. There is some disagreement whether she died in 1179 or 1180. Proceedings were instituted by the Pope in 1233 to investigate her claims to sainthood, but she seems never to have been formally canonized. Gebenon, a cistercian prior in Eberbach, made a compendium from her Letters, "because few can read her works," Also of Scivias, Liber divinorum operum.

> ...We cannot take the time to note all of Hild.'s minor variations from the natural science of her time, but may note one or two characteristics in which her views concerning the universe and nature seem rather daring and unusual, not to say crude and erroneous. In the Scivias she represents a blast and lesser winds as emanating from each of four concentric heavens which she depicts as surrounding the earth they are - a sphere of fire, a shadowy sphere like a skin, a heaven of pure ether, and a region of watery air under it. In the Liber divinorum operum she speaks of winds which drive the firmament from east to west and the planers from west to east. In the Subtilitates she entertains the notion that rivers are sent forth from the sea like the blood in the veins of the human body. One gets the impression that the rivers flow up hill toward their sources, since one reads that "the Rhine is sent forth by the force of the sea." and that some "rivers go forth from the sea impetuously, other slowly according to the winds"
>
> On the subjects of whether waters are wholesome to drink or not she comes a trifle nearer the truth and somewhat reminds us of the discussions of the same subject in Pliny and Vitruvius. She says that swamp water should always be boiled and well water is better to drink than spring-water and spring-water than river water, which should be boiled and allowed to cool before drinking; that rain-water is inferior to spring-water and that drinking snow-water is dangerous to health.

The devil as the negative principle:

> Her theory: Lucifer in his perverse will strove to raise himself to nothing and that, since he wished to do was nothing, he fell into nothingness and could not stand because he could find no foundation under him. But after the devil was unable to create anything out of nothing and fell from heaven, God created the firmament and sun, moon, and stars to show how great he was and to make the devil realize what glory he had lost.

Natural substances and evil spirits:

Common feature of her natural history and pharmacy - namely, the association of natural substances with evil spirits either in friendly or hostile relationships.

e.g. Not only does the touch of red-hot steel weaken the force of poison in food or drink, but that metal signifies the divinity of God, and the devil flees from and avoids it.

Stars and fallen angels: sin and nature:

In Scivias, Lucifer is cast out of glory because of pride, the fallen angels are seen as a great multitude of stars.

Spiritual lessons from natural phenomena:

Neither she nor Medieval Christians in general thought that the only purpose of natural phenomena and science was to illustrate spiritual truth and point a moral. She in the course of her writings, especially the Subtleties and Causae et Curae, lists many natural phenomena and medical recipes without making any mention of what spiritual truth they may or may not illustrate.

Hildegard's attitude toward magic:

It is an evil and diabolical art, claims it is taught by the devil.

Magic Arts' defense vs True Worships reply to magic 138 and 139.

Magic properties of natural substances:

She states that while herbs in the east are full of virtue and have a good odor and medicinal properties, those in the west are potent in the magic art and for other phantasma but do not contribute much to the health of the human body.

Instances of counter-magic:

In the Causae et Cruae she describes methods and substances to counter-act magic.

Ceremony with a Jacinth and wheaten-loaf:

This is described in the Subtilitates and recommended if anyone is bewitched by phantasms or magic words so that he goes mad.

Hildegards' superstitions nature:

She accepts not only marvelous and accult virtues of natural substances such as herbs and gems, but also the power of words and incantations, and rites and ceremonies of a most decidedly magical character. It is also employed for ordinary medicinal purposes, and it is a characteristic feature of her conception of nature and whole mental attitude; illustrated in the Subbtilitates.

Magic and astrology - closely connected

Astrology and divination - condemned

If she resorts to a magic of her own in order to counteract the diabolical arts, and if she accepts a certain amount of astrological doctrine for all her censure of it, it is not surprising to find her in the Carsae et Curae. Saying a word in favor of natural devination in dreams despite her rejection of augury and such arts. She believes that, when God sent sleep to Adam before he had yet sinned, his soul saw many things in true prophecy, and that the human soul may still sometimes do the same, although too often it is clouded by diabolical illusions. But when the body is in a temperate condition and the marrow warmed in due measure, and there is no disturbance of vices or contrariety of morals, then very often a sleeper sees true dreams. Her own true visions came to her in her waking hours. [5]

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[5]Lynn Thorndike, A History of Magic and Experimental Science (New York,1923), pp. 124-155.

Four other interesting stories

John Mayow

John Mayow was a contemporary of Robert Boyle. He was born in London in 1645, and educated at Wadham College, Oxford; although he graduated in law, he chose medicine as his profession. Mayow was attracted by the problem of combustion, and his experiments and observations led him to conclusions which anticipated Lavoisier by 100 years. The experiments were performed at Oxford, but not in Bolye's laboratory; they are described in one of Mayow's wight "tracts" entitled "De Sale Nitro it Spirito Nitro-aero," which appeared in 1669, when he was 24 and still at Oxford. Botle had left Oxford for London the year before, yet it would seem unavoidable that he should learn of the young man's conclusions, for in 1678 Mayow was elected a Fellow of the newly formed Royal Society in which Boyle was a prominent figure, in fact its president from 1680 to 1691. Within a year of this election Mayow died, at the age of 34; he remained practically unknown to his contemporaries and without influence on scientific thought. His work did not receive the publicity which its importance worranted.

...If his contributions had become generally known in the scientific world, we would have been saved a hundred years of the pernicious, wholly false phlogiston theory; for it was about a century later that the same observations which he had made served to silence the phlogistonists forever.

Alexis-Therese Petit

Alexis-Therese Petit was born in Vesoul, near Besancon, France. At ten he was ready for the Ecole Polytechnique, but the rules prohibited admission until the age of sixteen, and he had to wait until then. In the meantime he received additional instruction in a private school in Paris. Graduated from the E. P. with super-first rank, for the next man to him was given first rank, he was at once attached to the teaching staff. He stood for his doctorate in 1811, at the age of twenty, when he astonished his examiners by the ease with which he answered all the questions. He was the titular professor at the E. P. in 1815, aged 24 years. Shortly after, he married the daughter of a civil engineer, Mr. Carrier, but the young wife died two years later. Petit himself was attacked by an illness two years after this loss, and failed to rally; he died in Paris, aged 29 years.

...He published a memoir on the variations in the regrigerent power of bodies caused by the gradual application of heat. In 1818, he published the beginning of what was intended to be an extensive study of the motive power of heat. Then with Dulong, he made and published a study on the theory of heat. His last work, also with Dulong, on the determination of the specific heat of bodies, lead to the law which bears his name.

Gerhardt and Laurent

Gerhardt and Laurent were devoted friends and supported each other at crucial periods of their careers, so that to write the life of one is to write that of the other as well.

Charles Gerhardt originated from Alsace; he was born in Strasbourg in 1816. At fifteen he was sent to the polytechnicum at Karlsruhe, and from there in 1833, at the age of 17 years, to Leipzig, wher Erdmann was professor chemistry. While there he studied the formulas of natural silicates, completing a publication of his own at the age of 18 years; it is published in the Journal fur praktische Chemie, 4, 44 (1835). Soon after, he was recalled to Alsace, in order to put his newly acquired scientific knowledge into practice at his father's plant for making white lead, which was situated at Hangenbieten, near Strasbourgh.

...It is characteristic of Gerhardt's life that at all times he wrote a great deal for scientific magazines, making translations of German texts, and composing his own valuable books. At this time he tried to launch a foreign review, enlisting the help of Berzelius, Leibig, and Graham, who agreed to the use of their names as endorsers, but nothing came of it then, although later, in 1844, he did create such a journal with Laurent.

...Gerhardt corrected the formula which Laurent had assigned to draconic acid, and made it agree with the formula for the anisic acid of Cahours. Laurent was furious and sent his protest to Gerhardt; they soon became fast friends, and found their views the same in the many controversies of the day. Laurent's post was at Bordeaux, another provencial town out of touch with the world .

...Gerhardt's types, with additions and modifications by Kekule and others, had to give way to the structural formulas proposed by Frankland and Couper; Kekules tetravalency of carbon also helped to make them unnecessary. His work as well as Laurent's, had not been in vain, for it stirred thought, and caused experimentation which brought about a development of organic chemistry especially, which otherwise would have been slower. The work of Gerhardt, particularly, may be said to have been three-fold; his own investigations, his theories which stimulated thought, and by no means least, his labors as a compiler of books and as a translator of the works of others. [6]

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[6] Raymond Riegel, "Four Eminent Chemists Who Died Before Their Time," Journal of Chemical Education, III, (October 1926).

By subject and Chronology

The subject is discovery of the elements:
CHRONOLOGY
Seventeenth Century

Jan. 25, 1627	Birth of Robert Boyle in Ireland. Independent discoverer of phosphorus.
1630	Birth of Johann Kunckel, early writer on phosphorus.
1637	A chinese book entitled "Tien kong kai ou" describes the metallurgy and uses of zinc.
1645	Birth of Dr. John Mayow in London. Author of an early theory of combustion.
1649	Schroeder describes two methods of preparing metallic arsenic.
1665	Robert Hooke gives a theory of combustion in his book "Micrographia".
1669	Dr. John Mayow recognizes that the air has two constituents.
1669	The alchemist Brand of Hamburg discovers phosphorus.
1679	Death of Dr. Mayow.
1691	Death of Robert Boyle.
June 26, 1694	Birth of George Brandt, the discoverer of cobalt, at Riddarhytta, Vestmanland, Sweden.
1700	Lemery describes hydrogen.

Eighteenth Century

1701	A posthumous edition of Turquet de Mayerne mentions the inflammability of hydrogen.
1702	Death of Kunckel.
Mar. 3, 1709	Birth of Andreas Sigismund Marggraf at Berlin.
Dec. 23, 1722	Birth of Axel Friedrich Cronstedt, the discoverer of nickel, in Sodermanland, Sweden.
Oct. 10, 1731	Birth of Sir Henry Cavendish at Nice.
Mar. 13, 1733 (old style)	Birth of Joseph Priestly at Fieldhead, near Leeds.
1735	George Brandt isolates cobalt.
1737	Hellot prepares a button of metallic bismuthaand makes public the secret process for preparing phosphorus.
1740	J. H. Pott states that pyrolusite contains the oxide of a new metal.
July 1, 1740	Birth of Muller von Reichenstein, the discoverer of tellurium, at Nayszeben, Transylvania.
1740-41	Charles Wood finds platinum in Carthagena, New Spain.
Dec. 9, 1742	Birth of Carl Wilhelm Scheele at Stralsund, Swedish Pomerania.
Aug. 26, 1743	Birth of Lavoisier in Paris.
Dec. 1, 1743	Birth of Martin Heinrich Klaproth at Wernigerode in the Harz. One of the first to investigate uranium, titanium, and cerium.
Aug. 19, 1745	Birth of Johann Gottieb Gahn, the discoverer of manganese, at Voxna, South Helsingland, Sweden.
1746	Marggraf prepares metallic zinc by reduction of calamine.
Oct. 2, 1746	Birth of Peter Jacob Hjelm, the discoverer of molybdenum,

	at Sunnerbo, Harad, Sweden.
1748	Don Antonia de Ulloa describes platinum.
Nov. 3, 1749	Birth of Daniel Rutherford, the discoverer of nitrogen, at Edinburght.
1750	Dr. William Brownrigg describes platinum.
1753	Claude-Francous Geoffroy's research on "The Chemical Analysis of Bismuth" is published.
1754	Cronstedt isolates nickel.
Oct. 11, 1755	Birth of Don Fausto d'Elhuyar at Logrono, Spain. With His brother, Don Juan Jose, he isolated tungsten.
1755	Dr. Joseph Black of Edinburgh recognizes magnesia alba to be distinct from lime.
1759	Marggraf independently recognizes the distinction between magnesia and lime.
June 5, 1760	Birth of Johann Gadolin.., the discoverer of yttria, at Abo, Finland.
Nov 30, 1761	Birth of Smithson Tennant, the discoverer of osmium and iridium, at Wensleydale, Yorkshire.
Dec. 25, 1761	Birth of the Reverend William Gregor, the discoverer of titanium, at Trewarthenick, Cornwall.
May 16, 1763	Birth of L. N. Vauquelin, the discoverer of chromium and beryllium, at St. Andre des Berteaux.
Nov. 10, 1764	Birth of A. M. del Rio, discoverer of vanadium (erythronium), at Madrid.
About 1765	Birth of Charles Hatchett, the discoverer of columbium (niobium).
Aug. 19, 1765	Death of Cronstedt in Sater parish, near Stockholm.
Aug. 6, 1766	Birth of Dr. William Hyde Wollaston, the discoverer of palladium and rhodium, at East Dereham, Norfolkshire.
Dec. 28, 1766	Birth of Wilhelm Hisinger, the discoverer of the earth ceria. Berzelius, Hisinger, and Klaproth all investigated this earth, the latter independently.
Jan. 16, 1767	Birth of Anders Gustaf Ekeberg, the discoverer of tantalum, at Stockholm.
Apr. 29, 1768	Death of George Brandt at Stockholm.
1771	Scheele describes hydrofluoric acid.
1772	Daniel Rutherford discovers nitrogen. (Scheele, Priestly, and Cavendish discover it independently at about the same time).
Apr., 1774	Pierre Bayen prepares oxygen by heating mercuric oxide.
1774	Scheele publishes his famous treatise "Concerning Manganese and its Properties," which led to the discovery of three elements: manganes, barium, and chlorine.
Aug. 1, 1774	Priestly prepares oxygen (Scheele prepared it before this, but his results were not published until 1777).
1774	Gahn isolates manganese.
1775	Arfvedson publishes his doctor's dissertation defending Bergman's belief in the elementary nature of nickel. (This is not the Arfvedson who discovered lithium in 1817).
1775	Scheele isolates phosphorus from bones.
Aug. 2, 1776	Birth of Friedrich Sromeyer, the discoverer of cadmium, at Gottingen.
Feb. 8, 1777	Birth of Bernard Courtois, the discoverer of iodine, at Dijon.

1777	Lavoisier overthrows the phlogiston theory and demonstrates the true nature of combustion.
May 4, 1777	Birth of Jaques Thenard.
Aug. 14, 1777	Birth of Hans Christian Oersted.
1778	Scheele distinquishes between graphite and the ore then known as "molybdenum."
Dec 6, 1778	Birth of Gay-Lussac.
Dec. 17, 1778	Birth of Sir Humphry Davy at Penzance, Cornwall.
1779	Scheele distinguishes between lime and baryta.
Aug. 20, 1779	Birth of Berzelius at Wafversunda, Sweden.
1780	Birth of J. W. Dobereiner, the discoverer of the "Triads."
1781	Scheele discovers tungstic acid.
1781	Hjelm isolates molybdenum.
Aug. 7, 1782	Death of Marggraf.
1782	Discovery of tellurium by Muller von Reichenstein.
1783	Discovery of tungsten by the d'Elhuyar brothers.
May 21, 1786	Death of Scheele.
June 2, 1787	Birth of Nils Gabriel Sefstrom, the rediscoverer of vanadium, in Ilsbo Socken, Sweden. Although vanadium is now known to be identical with del Rio's "erythronium," the latter chemist did not distinguish clearly between chromium and the new element.
1789	Klaproth observes uranium in pitchblende, but does not isolate it. In the same year he discovers the earth zirconia.
1790	Crawford recognizes strontia as a new earth.
1791	The Rev. William Gregor discovers the oxide of a new metal, titanium.
Jan. 12, 1792	Birth of Johann August Arfvedson, the discoverer of lithium, a Dkagerholms-Bruk, Skaraborgs Lan.
May 8, 1794	Death of Lavoisier.
1794	Gadolin discovers the earth yttria.
May 29, 1794	Birth of A.A.B. Bussy at Marseilles. He obtained magnesium in coherent form.
1795	Klaproth re-discovers titanium, but does not succeed in isolating it.
Jan. 11, 1796	Birth of Karl Klaus, discoverer of ruthenium.
1797	Smithson Tennant proves that the diamond consists solely of carbon.
Sept. 10, 1797	Birth of Carl Mosander, the discoverer of lanthanum and didymium.
Feb., 1798	Vauquelin recognized beryllium and isolates chromium. Beryllium was first isolated in 1828 by Wohler.
Feb. 19, 1799	Birth of Ferdinand Reich, discoverer on indium, at Bernbury.
July 31, 1800	Birth of Friedrich Wohler at Eschersheim, Germany.

Nineteenth Century

1801	Del Rio recognizes the presence of a new metal "erythromium" (vanadium) in a lead ore from Zimapan, Mexico. He afterward confused it with chromium.
1801	Hatchett observes columbium (niobium) in and ore from New England.

1802	Ekeberg discoveres the earth tantala.
Sept. 30, 1802	Birth of A. J. Balard, the discoverer of bromine, at Montpellier.
Mar. 17, 1803	Birth of Carl Lowig, independent discoverer of bromine.
1803	Klaproth, Berzelius, and Hisinger analyze cerite and discover the earth ceria.
1803	Wollaston discovers palladium and rhodium.
Feb. 6, 1804	Death of Priestly.
1804	Smithson Tennant discovers osmium and iridium.
Oct. 6, 1807	Davy isolates potassium. A few days later he isolates sodium.
1808	Davy isolates barium, strontiu, calciu, and magnesium.
1808	Gay-Lussac and Thenard isolate boron. Davy isolates it independently.
1809	Dr. Wollaston makes the erroneous conclusion that tantalum and columbium are identical.
Feb. 24, 1810	Death of Cavendish.
Nov. 15, 1810	Davy announces his proof of the elementary nature of chlorine to the Royal Society.
1811	Courtois discovers iodine.
Mar. 24, 1811	Birth of Eugene Melchior Peligot, the first to isolate uranium.
Mar. 31 or May 31, 1811	Birth of Robert Bunsen at Gottingen.
Feb. 11, 1813	Death of Ekeberg at Upsala.
Oct. 7, 1813	Death of Hjelm at Stockholm.
1813	Clement confirms the discovery of iodine by Courtois.
1814	Fraunhofer discovers the dark lines in the sun's spectrum.
1814	Gay-Lussac publishes his classical research on iodine.
Feb.22, 1815	Death of Tennant at Boulogne-sur-Mer.
Jan. 1, 1817	Death of Klaproth.
Apr. 24, 1817	Birth of Jean Galissard de Marignac, the discoverer of ytterbia and gadolinia, at Geneva, Switzerland.
June 11 or July 11, 1817	Death of William George.
1817	Arfverson discovers lithium.
1817	Stromeyer discovers cadmium.
1818	Berzelius discovers selenium.
Mar. 11, 1818	Birth of Henri Saint-Claire Deville on the island of St. Thomas.
Dec. 15, 1818	Death of Gahn at Stockholm.
Dec. 15, 1819	Death of Daniel Rutherford.
1820	Birth of Beguyer de Chancourtois, the discoverer of the "telluric screw".
July 15, 1820	Birth of Claude August Lamy, France. He prepared thallium in the metallic state.
1823	Berzelius isolates amorphous silicon.
Mar. 12, 1824	Birth of Gustav Kirchhoff.
Nov. 21, 1824	Birth of Hiernoumus Theidor Richter, the first to observe the indigo line of indium.
1824	Berzelius isolates impure zirconium.
1825	Oersted isolates impure aluminum.
Oct. 12, 1825 (1826?)	Death of Muller von Reichenstein at Vienna.

1825	Berzelius prepares impure amorphous titanium.
1825	Carl Lowig isolates bromine.
1826	Balard isolates bromine. His results were published before Lowig.
1827	Wohler isolates aluminum.
1828	Wohler isolates beryllium. Bussy isolates it independently.
1828	Berzelius separates the earth thoria from thorite.
Dec. 22, 1828	Death of Dr. Wollaston in London.
1829	Dobereiner observes the triads.
May 29, 1829	Death of Davy at Geneva, Switzerland.
Nov. 15, 1829	Death of Vauquelin at the Chateau des Berteaux.
1830	Sefstrom discovers vanadium.
Aug. 19, 1830	Birth of Lothar Meyer at Varel on the Jade.
1831	Bussy obtains magnesium in compact form. (Davyisolated it in 1808.)
June 17, 1832	Birth of Sir William Crookes.
Jan. 7, 1833	Birth of Sir Henry E. Roscoe, the first to liberat metalic vanadium.
Jan 6, 1833	Death of Don Fausto d'Elhuyar at Madrid.
Feb. 7, 1834	Birth of Mendeleeff at Tobolsk, Siberia.
Aug. 18, 1835	Death of Stromeyer at Gottingen.
1837	Birth of J.A.R. Newlands, the discoverer of the law of octaves.
Apr. 18, 1838	Birth of Lecoq de Boisbaudran at Cognac.
Sept. 27, 1838	Death of Courtois in Paris.
Dec. 26, 1838	Birth of Clemens Winkler, the discoverer of germanium, at Freiberg
1839	Mosander discovers lanthana.
Feb. 10, 1840	Birth of Per Theodor Cleve, the discoverer fo thulium, at Stockholm.
May 27, 1840	Birth of Lard Fredrik Nilson, the discoverer of scandium, in Oster Gothland, Sweden.
1841	Peligot isolates uranium.
1841	Mosander discovers didymia.
Oct. 28, 1841	Death of J. A. Arfvedson at his Hedenso estate.
Nov. 12, 1842	Birth of Robert John Strut, England.
1843	Mosander separates terbia and erbia from gadolinite.
1844	Klaus discovers ruthenium.
Nov. 30, 1845	Death of Sefstrom at Stockholm.
Feb. 10, 1847	Death of Hatchett at Chelsea.
Aug. 7, 1848	Death of Berzelius at Stockholm.
Mar. 23, 1849	Death of del Rio in Mexico.
Mar. 24, 1849	Death of Dobereiner.
May 9, 1850	Death of Gay-Lussac in Paris.
Mar. 9, 1851	Death of Oersted.
Jan. 1, 1852	Birth of Eugene Anatole Demarcay, the discoverer of europium, at Paris.
June 28, 1852	Death of Hisinger.
Aug. 15, 1852	Death of Gadolin.
Sept. 28, 1852	Birth of Henri Moissan in Paris.
Oct. 2, 1852	Birth of Sir Henry Ramsay at Glasgow.
1854	David Alter observes that each element has a characteristic spectrum.

1854	Henri Sainte-Claire Deville perfects an industrial process for aluminum and prepares the first crystalline silicone.
June 20, 1857	Death of Thenard.
Sept. 1, 1858	Birth of Karl Auer, Baron von Welsbach.
Oct. 15, 1858	Death of Mosander.
May 15, 1859	Birth of Pierre Curie.
1860	Invention of the spectroscope by Bunsen and Kirchoff.
May 10, 1860	Bunsen and Kirchhoff announce the discovery of cesium.
Feb. 23, 1861	Bunsen and Kirchhoff announce the discovery of rubidium.
Spring, 1861	Crookes observes the green line of thallium.
Spring, 1862	Lamy isolates metallic thallium.
1862	Beguyer de Chancourtois draws his "telluric Screw".
1863	Birth of P.L.T. Heroult and of Charles Martin Hall, independent discoverers of the electrolytic process of preparing metallic aluminum.
Summer, 1863	Reich and Richter discover indium.
1864	Newlands and Lothar Meyer independently arrange the elements in series and families.
Mar. 12, 1864	Death of Klaus.
Nov. 7, 1867	Birth of Marie Sklodowska (Mme. Curie) at Warsaw, Poland.
1868	Janssen and Lockyer independently observe the D_3 line of helium in the sun's chromosphere.
June 16, 1869	Roscoe announces the isolation of vanadium.
1869	Lothar Meyer and Mendeleeff independently discover the periodic system.
1870	Birth of B.B. Boltwood, the discoverer of ionium.
Jan. 24, 1872	Birth of Morris Wm. Travers at London.
Apr. 12, 1872	Birth of Georges Urbain, the discoverer of Lutecium.
Sept. 1, 1873	Birth of B. Smith Hopkins, the discoverer of illinium, at Owosso, Michigan. This element was discovered independently by Luigi Rolla of Florence and by the American chemists, Cark, James, and Fogg.
Aug. 27, 1875	Boibaudran discovers gallium, the first element to be discovered with the aid of the spark spectrum.
1876	Death of Balard.
1878	Marignac separates ytterbia from erbia.
Mar. 20, 1878	Death of Lamy at Paris.
1879	Boisbaudran discovers samaria.
1879	Nilson discovers scandium (eka-boron).
1879	Cleve discovers holmia and thulia. The former had been discovered independently by Soret in 1878.
1881	Death of Henri Sainte-Claire Deville.
Feb. 1, 1882	Death of Bussy at Paris.
Apr. 27, 1882	Death of Ferdinand Reich.
Oct. 9, 1882	Death of Wohler.
1885	Birth of Georg von Hevesy in Budapest. Co-discoverer with Dirk Coster of the element hafnium.
June 18, 1885	Auer vin Welsbach announces his separation of didymia into praseodynia and neodymia.
1886	Death of Beguyer de Chancourtois.
1886	Boisbaudran discovers dysprosia and gadolinia, but finds that the latter is identical with an oxide discovered by Marignac in 1880.

Feb. 6, 1886	Winkler discovers germanium.
Feb. 23, 1886	Charles Martin Hall produces electrolytic aluminum. Dr. Heroult made the same discovery independently a few weeks' later.
June 26, 1886	Moissan isolates flourine.
Oct. 16, 1887	Death of Kirchhoff.
Nov. 23, 1887	Birth of Moseley at Weymouth, England.
1890	Death of Peligot in Paris.
1892	Lord Raleigh finds that stmospheric nitrogen is heavier than nitrogen from the decomposition of ammonia.
1894	Ramsay and Raleigh announce the discovery of argon.
Apr. 15, 1894	Death of Marignac.
1895	Ramsay and Cleve independently discover helium.
Apr. 11, 1895	Death of Lothar Meyer.
May 30, 1898	Ramsay and Travers discover krypton.
June, 1898	Ramsay and Travers discover neon.
July 1898	Ramsay and Travers discover xenon.
July, 1898	Mme. Curie discovers polonium.
July 29, 1898	Death of A. F. R. Newlands.
Dec. 1898	M. and Mme. Curie discover radium.
1898	Mme. and G. C. Schmidt independently discover the radioactivity of thorium.
May 14, 1899	Death of Nilson.
Aug. 16, 1899	Death of Bunsen.
1899	Debierne discovers actinium.
1900	Dorn discovers radon (radium emanation).
1900	Sir Wm. Crookes discovers uranium X_1.

Twentieth Century

1901	Demarcay discovers europium.
1902	Rutherford and Soddy discover thorium X.
Oct. 8, 1904	Death of Winkler.
1904	Death of Demarcy in Paris.
1904-5	Giesil and Godlewdki independently discover actinium X.
1905	Hahn discovers radiothorium and mesothorium I.
June 18, 1905	Death of Cleve at Upsala.
1906	Hahn discovers radiocatinium.
Apr. 19, 1906	Death of Pierre Curie.
1907	Boltwood discovers ionium. This element was independently discovered by Hahn and Marckwald.
Feb. 2, 1907	Death of Mendeleeff.
Feb 20, 1907	Death of Moissan.
1907	Urbain discovers lutecium.
1907	Von Bolton prepares a columbium regulus.
1909	E. Weintraub prepares pure fused boron.
1910	Mme. Curie and M. Debierne isolate radium metal.
1910	M. A. Hunter prepares titanium 99.9% pure.
1911	Antonoff discovers uranium Y.
May 28, 1912	Death of Boisbaudran.
1913	Fajans and Gohring discover uranium X_2 (element 91, eka-tantalum).
Dec.,1913 and Apr.,1914	Mosely publishes his papers on "The High Frequency Spectra of the Elements."

1914	T. W. Richards discovers a radioactive isotope of lead.
1914	Death of P. T. Heroult and C. M. Hall.
Aug. 10, 1915	Moseley killed at the Dardanelles.
Dec. 18, 1915	Death of Sir Henry Roscoe.
July 23, 1916	Death of Ramsay.
1917	Hahn and Meitner discover protoactinium. Soddy and Cranston discover it independently.
Apr. 4, 1919	Death of Sir Wm. Crookes.
June 30, 1919	Death of Lord Rayleigh.
1921	Hahn discovers uranium Z.
Jan. 1923	Coster and Hevesy discover hafnium (element 72).
June, 1925	Noddack, Tacke, and Berga announce masurium and rhenium (elements 43 & 75).
June, 1926	Hopkins, Harris, and Yntema announce the discovery of illinium (element 61).
July, 1926	Rolla and Fernandes announce the discovery of element 61, theirpreliminary results having been deposited in June, 1924, as a sealed package with the <u>Reale Accademia dei Lincei</u>.
1927	Death of Boltwood.
Aug. 5, 1929	Death of Auer von Welsbach at Welsbach castle in Carinthia.
1930	Allison and Murphy announce the discovery of element 87 (virginium), as a result of their magneto-optic method of analysis.
May, 1931	Allison, Murphy, Bishop, and Sommer announce the discovery of element 85 (alabamine).
Oct., 1931	Papish and Wainer obtain spextroscopic evidence of element 87.
1932	Urey, Brickwedde, and Murphy discover the hydrogen isotope of mass 2.
1932	Chadwick, and M. and Mme. Joliot-Curie demonstrate the existence of the neutron, which Harkins regards as the atom of an element "neutron" of atomic number zero.
1934	Colin G. Fink and P. Deren perfect a process for electroplating rhenium.
Jan. 15, 1934	M. and Mme. Joliot-Curie produce artificial radioactive elements by alpha-ray bombardment of light elements.
June, 1934	Enrico Fermi produces by neutron bombardment of uranium radioactive substances with half lives of 13 minutes and 90 minutes, which may possibly be elements of atomic numbers greater than 92.
July 4, 1934	Death of Mme. Curie.
Sept., 1934	A. V. Grosse liberates metallic prozctinium.[7]

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[7] Mary Elvira Weeks, <u>The Discovery of the Elements</u>, (New York, c1935), p.355.

FUN READING FOR STUDENTS

This can empress them with the fact that modern facts are often found in ancient writings.

...For I of Gods and Heaven will discourse
And shew whence all things else derive their source,
Whence Nature doth create, augment, and cherish,
To what again resolve them when they perish.
What things in our discourse we Matter call,
Prolifique bodies, and the seeds of all,
Of if such terms do not the things comprise,
Prime Bodies name them, whence all other rise.
Gods in their nature of themselves subsist
'Tis certain, nor may out of their peace molest
For ever, unconcerned with our affairs
And far remote, void of our grief or cares,
Need not our service, swim in full content,
Nor our good works accept, nor bad resent.
Whilst sometimes human life dejected lay
On earth, under gross superstitions sway,
Whose head aloft from heaven seem'd t'appear
And mankind with its horrid shape did scare,
With mortal eyes to look on her that durst
Or contradict; a Grecian was the first;
Him nor the fame of gods, nor lightnings flash,
Nor threatning bruit of thundering Skies could dash,
But rather did his courage elevate,
Natures remotest doors to penetrate;
Thus did he with his vigorous wit transpierce
The flaming limits of the Universe.
All that was great his generous soul had view'd
Whence what could be produc'd, what not be shew'd
And how each finite thing hath bounds, nor may
By any means from her fixt limits, stray;
Wherefore fond Superstition trampled lies
Beneath, we rear our Trophies to the Skies.
...Dark fears of mind, then banish quite away,
Not with the Sun-beans, or the light of day,
But by such species, as from Nature flow,
And what from right informed reason grow;
Which unto us this principle doth frame,
That out of nothing, nothing ever came.
'Tis onely thus, that men are aw'd with fear,
Because such things in Heaven and Earth appear,
Of which, since they a reason cannot find
To a celestial Author they're assign'd.
But when we find that nought of nought can be,
What we presume we shall more clearly see,
And shew, whence all things first produced were,
And yet the gods still unconcerned are;
For, if of Nothing form'd, no use of Seed,
Since every sort would from all things proceed.
Men from the liquid seas might then arise,

Fishes and Fowl, from Earth, Beasts from the Skies,
And other Cattel; Bruits uncertain birth
Would fill the waste, and cultivated earth.
Nor could from the same trees the same fruit spring
But all would change, and all things all would bring.
...Of nothing then Nothing we must conclude
Results, but each thing is wirh seed indu'de,
From which all that's created comes to light
And clearly manifest themselves to sight.
...Add unto this, Nature to their first state
Doth all dissolve, nothing annihilate,
For if in all parts any thing could fail,
Death over all things would in time prevail;
Nor needed there a force to discompose
Their parts, or their strict union unloose:
But since in all eternal Seeds reside,
Till such a blow it meers, which it divides
Or else dissolves by subtle Penetration,
Nature preserves it whole from dissipation.
Beside those things remov'd by ages past,
If time did kill, and all their matter easte
Whence doth sweet Venus give to souls new birth
Through all their kinds? how should the various earth
Augment each kind with proper diet fed?
Whence flow the Seas? whence have free Springs their head?
Whence do the far extended Rivers rise?
And Stars, how are they nourish'd in the Skies?
Since length of times, and daies so may past,
All mortal bodies had ere this defac'd.
If then from that large tract, ought hath remain'd
From whence the sum of things has been maintain'd
Sure an immortal nature doth inspire
Them, nor can any thing to nought retire:
All from like force and cause dissolv'd would be
Did not eternal matter keep it free:
And more or less them to their subjects bind,
One touch to them a cause of death they'd find
Had bodies no eternal permanence,
They would dissolve with the least violence:
But since the various bands of causes are
(Though matter permanent) dissimilar,
Bodies of things are safe 'till they receive
A force which may their proper thread unweave,
Nought then returns to nought, but parted fall
To Bodies of the prime Originals.
...Then nothing sure its being quite forsakes,
Since Nature one thing, from another makes;
Nor is there ought indeed which she supplies
Without the aid of something else that dies.
Since then I teach that nought of nothing breeds,
Or once produc'd, to nought again recedes,
Lest yet thou shouldst my Arguments disside
Because that Elements can not be spi'd
By human eyes; behold what bodies now

In things thou canst not see, yet must allow:'
First, mighty Winds, the rolling Seas incite,
Huge Vessels Wrack, and put the clouds to flight;
Rushing through fields, sometimes tall trees they crack;
And with their tearing blasts high mountains shake.
The Seas likewise in thund'ring billows rise.
And with their raging murmur threat the Skies.
Winds therefore unseen bodies are, which sweep
The fleeting clouds, the Earth, the Azure deep,
Bearing with sudden storm all thing away,
Yet thus proceeding, do they nought destroy
Other than as the yielding water flowed,
Augmented by large showers, or melted snows
Wch from deep clifts in Cataracts descend,
Whole trees they float, and prostrate winds they rend;
Nor can strong brides their approach sustain,
Whose rapid torrent do's all check disdain.
The River with immoderate showers repeat,
Against their Piles impetuously does beat;
Roaring in ruins, huge stones along it rolles,
All things it spoyles, and nothing it controles.
Even so the gusts of sturdy winds do tend
Like swiftest Rivers when they downwards bend,
And carrie all before with double might,
Sometimes they snatch, and hurry things upright
In rapid whirel. Therefore I add agen
The Winds are Bodies, and yet are not seen.
Since their effects and motions every where
Like Rivers be, whose bodies do appear.
Besides, of things we smell the various sents,
Which yet no substance to our sight presents;
We with our eyes see neither Heat nor Cold.
Nor can we any Voices found behold
Which of Corporeal nature yet consist,
For they the sense affect 'tis manifest.
Touch and be touch'd, nought save a body may;
Cloaths become moist, wch we on shoars display;
Spread in the Sun again they dry appear;
But neither how that humor entred there
Can we perceive: nor by what means it flies
The heat so soon, and consequently dries.
Therefore that which is humid separates
By minute parts, which no eye penetrates.
Thus at the bare return of sundry years
The Ring which one upon his finger wears
Diminisheth: Drops which do oft distill,
Hollow hard stones; and whilst the field we till,
The Coulter of the Plough is lessened:
And paved ways, wheron the people tread
Wear out we see: Brass Statues at our gates
Shew their right hand, wch frequent touch abates
Of such as visit oft, or pass the way;
Therefore things often worn the more decay:
But in each time, what bodies do discar'd

Is a fine sight from our gross eyes debar'd:
Lastly, what Nature by minute degrees
And time applies, our sharpest eye-sight flees:
Nor what through age or leanness do's decay,
Nor what from rocks as Sea time wears away
With gnawing salt consum'd, do we espy:
Nature with Bodies do's each thing inclose
On every side, for ther's a Voyd in things
Which rightly to conceive, much profit brings.[8]

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[8] Lucretius, "The Atomic Theory", Readings in the Literature of Science, (New York, 1959).

Another possible historical treatise is by subjects.

Origins of applied chemistry
Early applied chemistry; Early metals, glass; dyes.

Beginnings of chemistry
Four elements - chemical knowledge of the classical period- chemical papyri - Alexandria

Diffusion of Alchemy
Chemistry in Arabia - Hindu chemistry - chemistry in China - alchemy in Europe - Early European writers on alchemy - Roger Bacon - Arnald of Villanoua - Raymond Lully

Iatrochemistry, or chemistry in the service of Medicine
Paracelsus - Van Helmont on gas and on elements and on stone and Ferments - Syluius - Agricols - Basil Valentine - Libavius - Glauber - Lemery - Tachenuis - Kunkel - Summary

Early studies on combustion and the nature of the atmosphere
Combustion and calcination - Boyle on elements, Law, combustion, calcination, experiments - Hooke - Mayow - Jean Rey - Phlogiston Theory

Discovery of Gases
Hales - Black and alkalis - cavendish and gases - Scheele and air and oxygen - Priestly and air and oxygen

Lavoisier and the Foundation of Modern Chemistry
Lavoisier and quantitative method, experimantations, antiphlogiston theory - Theory of Caloric - chemical elements - Lavoisier and respiration - new chemical nomenclature - composition of water - Cavendish's synthesis of water - composition of nitric acid - water controversy [9]

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[9]Ibid., Sr. M. Xavier.

CHEMICAL SYMBOLS IN GREEK

By the demonstration of symbols students can develop interest in a subject.

vinegar	gold
ferment	silver
flask	lead lead ore
vapor	tin (later mercury)
crucible	copper
selenite	iron
juice	sulfur
stones	calcined copper
salt	calcined lead
arsenic	water

ALCHEMIST'S SYMBOLS

antimony	mercury
arsenic	salammoniac
vinegar	corrosive sublimate
spirit of wine	saltpeter
borax	alkali
calx	vitriol
realgar	fire
soap	water

HISTORY OF ASTRONOMY

Copernicus - 1473, Thorn Life's work was to solve the geometrical laws governing the motions of the planets in order to explain the apparent motions observed in the past, and to predict how the planets would move in the future. He established the system in which the earth rotates on its axis and revolves about the sun as one of the planets. His book De Revolutionibus (the third) describes various motions attributed to the earth. He explains the earth's equator as the reason for the earth's axis describing a cone in space. He constructed tables showing the earth, sun, and moons positions, and could be read easily for anytime.

Giordano Bruno 1548 - 1600, anticipated the discovery that the Sun rotates on its axis and that the earth is falttened at its poles, and foreshadowed the doctrine of conservation of energy, and influenced scientific invention.

Galileo Galilei - 1564, Pisa invented the telescope on the Dutch pattern, discovered Jupiter and its four satellites, Saturn and its spheres, forty fixed stars of constellation Plerades, Sun-spots. He measured longitude on land and sea, and wrote the Dialogue concerning the two chief Systems of the World, the Ptotemaic and the Copernican. Worked also on pendeular observations, projectiles, virtual velocities, dynamics of impact, hydrostatics, pneumatics, sound, light and magnetism, thermometer, and strength of beams. Galilei, Brahe, and Keplers work led to Newtons synthesis of the physics of the world.

Newton - 1642, England, discovered universal gravitation and described the Laws of Motion.

1. Every body perseveres in its state of rest, or of uniform

motion in a strait line, unless it is compelled to change that state by impressed forces;

2. Change of motion (i. e. rate of change of momentum) is propartional to the impressed force and takes place in the direction in which that force is impressed.

3. To every action there is an equal and opposite reaction.

Numbers 1 and 2 result partly from Galilei. Newton established theoretical mechanics, researched in optics discovered the composite nature of white light (laid foundations for spectrascopy). Wrote Principia and is the basis for astronomical and cosmological thought for 200 years.

Note how one scientist has entered many scientific fields.

Tycho Brahe - 1546 - 1601 Danish discovered star Cassiopeia, invented a giant quadrant for reading altitudes of object and other astronomical instruments. Developed accuracy of observation. Determined orbits of Sun and Moon, measured angular distances of planets to stars.

Johann Kepler 1571, German, believed in created harmony in the world and set out to prove it. Defined orbits of planets to the sun, established first two laws of planetary motion.

1. The planets describes an ellipse about the Sun in one focus;

2. The radius vector drawn from the Sun to the planet describes equal areas in equal times.

He speculated about the nature of gravity. Actual discoverer of Sun spots, described new star of 1604, and comets. [10]

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[10] A. Wolf, A History of Science, Technology and Philosophy in the 16th and 17th Centuries (New York, 1959).

HISTORY OF BOTANY

Theophrastus - "Father of Botany" - distinguished the position of the ovary of plants as to superior or interior, and described sympetally.

The greatest advances were made following with Dioscorides, author of Materia Medica,the herbalists such as Brownfells, L'Obel, and Caisalpinno. Brownfells recognized that flowers can be present or absent. L'Obel defined Monocots due to leaf venation as separate from Dicots in 1581. Caesalpinno did not depend on observation for his conclusions, rather, he depended on reasoning.

Tournefort established the genus concept followed by Linnaeus' system of binomial nomenclature, author of Species Planterum, 1753. He used classes, genera, species, and variety.

Brown and Hooker in 1873 described the gymnosperms in Genera Planterum, in 1873.

Eichler described the angiosperms in 1883. He likewise developed a concept of evolution starting from simple and moving to complex, namely, Thallophyta, Bryophyta, Pteridophyta, Spermatophyta (Gymnosperms and Angiosperms). These are a system of classification used even today.

HISTORY OF ANATOMY

Greeks to 50 B. C.

1. Prescientific Stage
   Knew area of hear in animals
   Knew surface muscles
   Knew internal organs

2. Schools of Sicily, Ionia, and Cos.
   550 B. C. - 400 B. C.
   Soul was a mixture of air, fire or water
   Vascular system attempted descriptions

3. Early Athenian Period
   Plato - man resembles the world.
   Microcosm and macrocosm
   Diocles 400 B. C. - 350 B. C. - heart
   principal organ and seat of intelligence
   Fertilize - two sexes

4. Later
   Aristotle 384- 322 B. C.
   Theophrastus 350 B.C. 290 B. C.
   Head lyceum - pupil of Aristotle
   Wrote on the Senses - good physiology

5. Aristotelian Philosophy in its bearing on anatomical thought
   Primacy of the heart
   Good description of large veins and arteries
   Placenta and birth

6. Great Alexandrians, 300 B. C. -250 B. C.
   Herophilus - Father of Anatomy- First to dissect human and
   animal bodies
   Erasistratus - Father of Physiology - recognized capillary
   system, main arteries, veins, and many nerves

7. Decline of the Alexandrian School
   250 B. C. - 50 B. C.

8. Human Vivisection at Alexandria
   Highly criticized by people, but Galen and others disregarded
   the issue.

9. Alexandrian Anatomists and the Wisdom Literature (Bible)
   Seat of Wisdom - the heart, liver
   Doctrine of four elements

10. Middle Ages and Renaissance
    1050 - 1543
    University of Bologna - early dissections
    William of Saliceto (1215-1280) implied dissection of a dead
    body in a treatise on surgery
    Thaddeus of Florence (1223-1303) translated Greek anatomical
    treatises into Latin.

Mondino de 'Luzzi (1300-1325) made a scientific step forward by establishing the disciplined study of anatomy

Leonardo da Vinci (1450 - 1550) drew accurate pictures of anatomical organs and relations

Vesalius (1543 - 1628) demonstrated dissection himself, and used both living and dead models. He drew many accurate plates and these can be seen today

Sanctorius, Van Helmont, and Harvey were later anatomical investigators who also interpreted physiological aspects of living systems[11]

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[11] Charles Singer, A Short History of Anatomy from the Greeks to Harvey (New York, 1959).

CHAPTER III

SAMPLE UNITS UTILIZING HISTORY

History of Science Semester Unit Plan

Objectives of this course in terms of its distinctive contribution to the total educational experiences of the students;

1. To introduce and explain the interrelations of scientific fields.
2. To introduce and explain scientific principles and attitudes.
3. To introduce and explain the scientific methods of research.
4. To help relate the study of science to the everyday life of the students.
5. To establish an appreciation of the efforts of early scientific endeavor.
6. To establish an orderly study of the sciences.
7. To relate scientific development to their proper historical eras.

Plan for Weekly Unit I

History of Science: The Early Greeks

General Objectives:

1. To introduce the student to ancient history
2. To develop an appreciation of previous ideas
3. To establish the start of fresh ideas
4. To establish a logical pattern for study

Specific objectives:

1. To point out
2. To explain
3. To show the role
4. To show relationships
5. To teach
6. to discuss

Approach:

Subject matter	Materials	Method
1.Introduction	text	Lecture
2.Outline	Blackboard	Questions & Answers

3. Analogies	Notes	Discussion
4. Comparisons	Students ideas	

Development of Unit

1. Assignment of reading
2. Write essay
3. Panel to discuss reasons for early Greek scientific conclusions
4. Organize note-taking of students by grading their work

Unit of History of Astronomy

General Object

1. Acquaint the student with basic instruments
2. Develop an appreciation for the original workers
3. Instill an enthusiasm for further study

Specific Objectives

1. Demonstrate the operation of certain instruments
2. Emphasize their modern importance
3. Enlarge the scope of the student's thinking

Approach:

Subject matter	Materials	Method
1. List of names	texts	lecture
2. Demonstration of astronomy pieces	instruments	discussion

Development of unit

1. Reading and reports to introduce the subject
2. Demonstrate equipment
3. Explain the development of the science
4. Have list of outside readings prepared

Unit on Anatomy

Demonstration of the obvious misinterpretation of early anatomists by dissection of either a cat or foetal pig. Demonstration can show true shapes of organs and compare these with historical sketches having errors. Errors regarding muscles, heart arteries and veins and uterus are most often made. These dissections with pictures of plates of da Vinci, Versalius, and others can be effective.

Unit on Medievalists

Read medieval morality plays to note superstitions, customs, and chemistry of the day. Have panels discussing validity of their beliefs and compare with present day thinking.

Unit on Botany

Demonstrate parts and types of flowers as they developed distinction historically.

1. Field trips
2. Demonstration
3. Debate on systems of classification

Unit on 16th, 17th, and 18th centuries

Give names and work. Develop demonstrations of their work, or a movie of their time and work.

CHAPTER IV

ULTIMATE CORRELATIVE ETC.

The ultimate ends of a study of the history of scientific ideas in general science ought to:

1. Clarify the basic principles and methods of science;
2. Build an appreciation of the work of previous scientists;
3. Correlate modern science to historical science;
4. Encourage new thinking and research on the part of the student;
5. Dispel false notions and superstitions about physical occurences.

The library or a source of historical texts are necessary to these types of units. The student will likewise need some instructions as to the use of library tools, and methods of preparation as requested by the individual teacher.

These students will be amazed and amused as they read historical annals and accounts. There will be group discussions by the student groups outside of class for these very reasons. Talking about science and scientists help in understanding and learning about them. If the student can enjoy and discuss these facts with his peers, his interest will not lag nor will his studies.

After such a general science course, and a good dose of historical data, the student, as he progresses, will recognize and use these names more freely in other courses, and will develop a more confortable acquaintanship with the science being newly studied, and the men who developed that particular science.

Even modern radio, television, and newspapers refer to the histories of scientific fields. We all hear references made of Newton's Principles, or Harvey's dissection, or Galileo's name regarding the telescope. If a student can elaborate on such phrases, not only he, but his listeners learn and reciate the man and his work more while the student is admired for his vast knowledge even though it might be scanty in reality.

CHAPTER V

SUMMARY

This report is only an instrument whereby ideas may be gathered to be used by a teacher of General Science. A vast number of subjects and their histories have not even been mentioned. But, it is hoped that a seed has been planted in the minds of those who read this, that the history of whatever is discussed be used to its full height of interest and purpose for the student.

History is far from being dull and lifeless. It is rather a master teacher and a guide for the future. Through history many new areas as yet undetermined may be developed and encouraged, finally stricking the world with a new scientific fact.

History is not only interesting, but also versatile. It can be used in a variety of teaching methods. History can encircle a demonstration, discussion, or field trip lesson. Its use depends entirely on the enthusiasm of the teacher. It is effective in the laboratory as well as in the classroom.

The student uses not only scientific instruments, but also library aids, and purposeful thinking.

It is hoped that this report will help teachers of General Science to better understand a historical introduction to the sciences, and in so doing, will result in more understanding and appreciation of the whole sphere of scientific endeavor.

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VITA

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Candidate for the Degree of

Master of Science

Report: AN INTRODUCTION TO GENERAL SCIENCE THROUGH HISTORY

Major Field: Natural Science

Biographical:

Personal Data: Born in Hancock, Michigan, August 16, 1940, the daughter of Ina Helen and Francis Damian Leonard.

Education: Attended elementary school in Hancock, Michigan, secondary school in Milwaukee, Wisconsin; graduated from Messmer High School in 1957, received a Bachelor of Science degree from Mount Mary College with a major in Biology, in June, 1961; attended Graduate School at Oklahoma State University during the summer, and fall of 1961; completed requirements for the Master of Science degree in May, 1962. Member of Biological Honor Society Tri Beta, recipient of National Science Foundation grant for 1961-62.