SURVEY COURSE *of the* PHYSICAL SCIENCES *for* COLLEGE FRESHMEN

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The fact that a majority of the students entering the university have their major interest outside of the field of physical sciences, led the University of Oregon to organize a survey course of astronomy, chemistry, geology, and physics into an integrated unit. The students through this course study the scientific method of approach, and acquire a brief acquaintanceship with science, without the necessity of devoting a full year to each of these fields. In this article the procedure used and the material covered are outlined. The emphasis is placed on the scientific method and not on details of subject matter.

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OBJECTIVES

AT THE University of Oregon, there are at present three distinct objectives for the survey course of the physical sciences:

1. To teach the student to think.
2. To acquaint the student with the scientific method of thought by tracing the development of the physical sciences.
3. To aid the student in his orientation by presenting some of the fundamental facts and principles of the physical sciences.

REASONS FOR A SURVEY COURSE

The recent advances in astronomy, chemistry, geology, mathematics, and physics are among the most prominent features of modern achievements. In a comparatively short time these branches of science have changed our entire mode of living. We now have transportation in all media, synthetic chemical compounds, rayon, radio and telephone, electrical conveniences of every description, geophysical methods of locating ore and oil, and a multitude of other developments, all of which are ours to use. Progress in the material world has gone forward beyond our wildest dreams.

At the same time social development has made little, if any, progress in solving such problems as political corruption, crime, the eternal struggle between capital and labor, marriage, and a long list of similar problems—these are only a few of the difficulties which students of today will have to face upon graduation. An astonishing contrast, therefore, confronts us—we have made rapid advancement in physical sciences and very little progress in social developments. Why does this situation exist? We believe that one answer partially touches the heart of the trouble; and that pertains to the essentially different way in which the problem has been approached. It is primarily the purpose of this course to acquaint the student with the method of approach known as the scientific method.

GENERAL ORGANIZATION

In the organization of a survey course of the physical sciences for college freshmen, the amount of the different materials which must be presented is enormous and each group of material must be given its own method of presentation. The selections for the purpose of instruction and the methods of presentation are among the first problems that must be solved. We have endeavored to approach each field in a scientific manner very much as our forerunners in science did during the past generations. We start with the earliest concepts found in nature and gradually develop these into our present theories and laws. The subject at first is handled as an integrated unit but is gradually broken up into the different sciences, each with its own theories and explanations.

In no way do we attempt to cover all the details of the physical sciences, but we select from astronomy, chemistry, geology, and physics, topics that are best adaptable to our method of presentation, and we try to instruct in the essentials of these different subjects. A short, condensed outline of subject matter is included in this article to illustrate the nature of the material used. See table appended.

The objectives of the course are accomplished not only by tracing the development of the physical sciences, but by aiding the student in his orientation so that he will think scientifically by applying the already proved scientific method. In order to illustrate this, we shall give in some detail one of the scientific developments as used in classroom lecture. The illustration will be the development of the periodic law. Wherever possible, each step is carried out in correlation with demonstration and is related to the historical record.

ILLUSTRATIVE LECTURE OUTLINE

Classification of the Elements

Experimental Work:

1. Combine with oxygen as many elements as possible, some metals and some non-metals.
2. Dissolve the soluble oxides in water, forming acids and bases.

3. Make tests of each solution to determine whether it is an acid or a base.

4. Illustrate by simple experiments the relative activity of the halogens (Cl, Br, I).

5. Give additional illustrations of the various possible relationships indicated by the periodic table. These can be shown either by diagrams or experiments.

Conclusions:

Based on the information given above the following development is pointed out in the steps indicated:

1. A division based on the fact that elements are metals or non-metals.
2. A division based on acid or basic properties.
3. Prout's (1815) attempt to classify the elements according to their atomic weights alone. Point out the fact that he considered all elements to be made of hydrogen, hence all elements must have integral atomic weights. Disprove this by showing that many elements have fractional weights.
4. Döbereiner's (1817) Triad Theory. This was an arrangement according to chemical properties, based on the atomic weights of each of three elements. The intermediate element having an atomic weight almost the arithmetical mean of the sum of the atomic weights of the other two. Use such groups as (Cl, Br, I), (Li, Na, K), or (Ca, Sr, Ba) to illustrate those that do agree, but also point out some that do not.
5. Newland's (1865) Law of Octaves. Show the series of eight elements which are related. This produces a general arrangement of elements, but is imperfect in such cases as H, Mn, Fe and others. It did prove to be the basis of a great law.
6. Mendeleéff's and Meyer's Periodic Law. This gave the relationship between both atomic weights and the periodic recurrence of chemical and physical properties.
7. Correct the relationship from atomic weights to atomic numbers, giving reasons.
8. Point out the value of such a classification.

THE SCIENTIFIC METHOD

In the illustration it will be noted that the scientific method was carried out very much as follows:

1. Observation and recording of the facts of nature and of experience.
2. Organization of these facts into laws by critical analysis.
3. Formulation of a theory to account for the observed laws or hypotheses.
4. Testing the theories by experimental work.

The last step usually produces new facts which require changes in the originally observed laws. A successful theory should lead to new laws and hence to a more perfect theory.

This kind of development is continued with the subject matter from the four major physical sciences, omitting as far as possible any mathematical proofs, in the endeavor to base our work on experimental evidence. In this way the student acquires, in addition to the scientific thought processes, a fair concept of the four fields and is able to adjust himself in this mechanical age by knowing the nature and origin of the ideas underlying these subjects. In no way do we feel that this work replaces, for the regular scientifically minded students, the usual first-year college course in any one of these subjects; but it actually adds to the sum total of human intellectual advancement by presenting to those students, who normally have their major interest elsewhere, a brief acquaintanceship with science.

AMOUNT OF CLASS WORK

We have for each student three lectures and one quiz period per week running throughout the school year. Allowing three one-hour examinations each term and the usual number of holidays, we have eighty-five lecture periods per year. At present this course requires six lecture sections conducted by the staff and fifteen quiz sections handled by both staff and qualified graduate assistants.

Originally we used different instructors from each of the various departments to give the lectures in their respective subjects, but after several years of intensive work we have decided that it is better to have a single instructor for each section handling the work in all fields because we have found that better results are obtained if the method of teaching is uniform throughout the year. As we place greater emphasis on the scientific method than on subject matter this is to be expected; however, it is very essential that the instructor have good training in each of these fields and, above all, that he have enthusiasm for the survey work. A schedule of the eighty-five lectures is approximately as follows:

Subject	*Lectures*
History of Science	8
Physics	20
Structure of Matter	9
Chemistry	20
Astronomy	11
Geology	17
Total per year	85

LECTURE DEMONSTRATIONS

We have found it well to use illustrations and lecture demonstrations, if possible, that were not used in regular first-year courses so that students who later take the regular courses may not find much of the material repeated. If this precaution is not taken these students may lose interest in the new course. By a little correlation with the various courses this is easily prevented.

Wherever possible with each lecture we have demonstrations, usually of quantitative nature, in order to approach the methods of a laboratory. In astronomy we have two observational periods, and in geology there are several field trips. Although there are no regular laboratories provided, the students have access to the equipment during quiz periods and outside hours. We find that many students make use of these periods.

READING AND TEXTS

The students are not required to purchase textbooks, but use those in our reserve library. We furnish a syllabus outlining the work of the entire year so that the student follows assigned reading from stated books upon a definite basis. In addition to the assigned readings we furnish a list of optional reading material that closely follows the lectures.

The assigned references are:

Introduction:
"The seven seals of science," by JOSEPH MAYER.

Physics:
"The development of human ideas concerning the physical world," by LEONARD B. LOEB.

Chemistry:
"Introduction to chemistry," by JOHN A. TIMM.

Astronomy:
"Astronomy," by ROBERT H. BAKER.

Geology:
"The earth and its rhythms," by SCHUCHERT AND LEVENE.

A partial list of optional readings follows:

Astronomy:
"The nature of the world and of man," by H. H. NEWMAN.
"Outline of science," by J. A. THOMSON.
"Astronomy for everybody," by SIMON NEWCOMB.
"Two thousand years of science," by HARVEY-GIBSON.

Chemistry:
Standard texts of college chemistry.
"A history of chemistry," by MOORE.
"A history of chemistry," by ARMITAGE.
"The romance of modern chemistry," by PHILLIPS.
"Classics of modern science," by KNICKERBOCKER.
"Creative chemistry," by SLOSSON.

Geology:
"Introductory geology," by PIRSSON AND SCHUCHERT.
"Earth features and their meaning," by HOOBS.
"Historical geology," by CHAMBERLAIN AND SALISBURY.
"Textbook of geology," by GRABAU.
"A shorter physical geography," by DE MARTONNE.

Physics:
"An outline of physics," by A. E. CASWELL.
"Physics for college students," by A. A. KNOWLTON.
"First principles of physics," by CARHART AND CHUTE.
"Matter and energy," by WENDT AND SMITH.
"A history of physics," by FLORIAN CAJORI.

The present outline of this course has been made possible through the joint efforts of Dr. W. D. Wilkinson of the department of geology, Dr. Leo Friedmann of the department of chemistry, and my own. I take great pleasure in acknowledging the helpful coöperation of my colleagues in this undertaking.

A SHORT OUTLINE OF SUBJECT MATERIAL USED IN THE SURVEY COURSE OF THE PHYSICAL SCIENCES

Fall Term

INTRODUCTION

Definition of science.
Purpose of the survey course.
The scientific method.

HISTORY OF SCIENCE

Early civilization to 600 B.C.
Science in the Golden Age of Greece (600 B.C. to A.D. 200).
The Dark Ages for science (A.D. 200 to A.D. 1400).
The revival of science, the Renaissance (after A.D. 1400).
The new astronomy.
Physics established as a science.
The rise of chemistry.
Introduction to geology.

PHYSICS

Energy and Matter
Matter.
States of matter.
Properties of matter.
Energy, potential and kinetic.

Statistics
Early developments.
Inclined plane and levers.
Units of measurement.

Dynamics
Early developments.
Galileo—falling bodies.
Newton—laws of motion.
Kepler—three laws.
Einstein—modern mechanics.

Nature of Heat
Development of temperature measurement devices.
Development of temperature scales.
Black—caloric theory.
Mechanical nature of heat, Rumford experiments.
Kinetic theory of heat.
Conservation theories.

Nature of Magnetism
A development based on the work of:

Gilbert and Cardana	Henry
Oersted	Maxwell
Ampère	Hertz
Faraday	Williams (modern trend)

Nature of Electricity
A development based on:

Early knowledge	Michelson and Carlisle
Frictional electricity	Franklin
The Leyden jar	Maxwell
Galvani	Planck
Volta	

Practical applications of today.

Nature of Light
A development covering reflection, refraction, theories of transmission, transverse waves and quanta, based on the experimental work of:

Ancient workers	Planck
Newton	Einstein
Huygens	Compton
Young	de Broglie
Fresnell	Schrödinger
Helmholz	

Velocity of Light
Methods of determination of the velocity of light as developed by:

Galileo	Foucault
Romer	Michelson
Bradley	

Nature of Sound
Early investigations.
Transmission of sound waves.
Velocity of sound waves.
Characteristics of musical sounds.

Winter Term

CHEMISTRY

Introduction
Transformation of matter.
Chemistry, an exact science.
Chemical and physical changes.

Matter from a chemical standpoint.
The nature of chemical processes.

Early Development of Chemistry

Chemistry among the ancients.
Chemistry in the Middle Ages (alchemy).
Chemistry in the Renaissance.
Paracelsus, Agricola, van Helmont, Glauber, Robert Boyle.
The phlogiston theory.
  Johann Becher and Stahl.
Lavoisier's work on combustion.
Modern chemistry.
  Starting with Cavendish, Scheele, and Priestley, through to present chemists.

Quantitative Studies of Chemical Reactions

Law of conservation of matter.
Law of definite composition.
Law of multiple proportion.
Law of combining weights.

The Atomic Theory

Dalton's atomic theory.
The shorthand of chemistry.
Chemical formulas and equations.
Weight relations from chemical equations.

Ideas Concerning the Structure of Matter

Gay-Lussac's law of combining volumes.
Avogadro's hypothesis.
Gas laws.
The kinetic theory of gases.
The structure of atoms and molecules.
Evidence of atomic complexity.

Acids, Bases, and Salts

Characteristics of each.

Classification of the Elements

As metals and non-metals.
As acids and bases.
Prout's hypothesis.
Döbereiner's triads.
Newland's law of octaves.
Mendeléeff and Meyer.
Periodic law. Value.

The Chemistry of Our Environment

The atmosphere.
Our fuel resources.
Iron and steel.
Organic chemistry.
  Chain compounds.
  Ring compounds.
  Organic derivatives.
Industrial chemistry.

Spring Term

ASTRONOMY

The Development of Astronomy

Introduction.
Early astronomy.
  Origin.
  Astrology.
  Greek astronomy.
  Astronomy of Middle Ages.
The place of astronomy among the sciences.
Practical aspects of astronomy.

The Solar System

The earth.
The moon.
The sun, our nearest star.
The planetary system.
Comets and meteors.
Eclipses.

Stars and Spiral Nebulæ

Constellations.
Designations.
Distances, magnitudes, temperatures.
Milky way.

The Structure of the Visible Universe

Nature of the problem.
Easton's theory.
Shapley's theory.

GEOLOGY

Early Development in Geology

Babylonians.
Early Greeks.
Romans and the Dark Ages.
Modern geology.

Structure and Earth Materials

Earth structure.
Theories of origin of the earth
The earth's spheres.
Earth materials.
  Minerals and rocks.

The Atmosphere

Composition.
Climate and weather.
Interaction of atmosphere, lithosphere, and hydrosphere.

Running Water

History of a river.
Weathering.
Transportation.
Corrosion and corrasion.

The Work of Ice—Glaciation

Types of glaciers.
Work of glaciers.
Comparison of glaciers and running water.

The Oceans and Their Work

Importance of oceans.
Work of oceans
  Destructive and constructive.
Circulations.

Volcanoes—Vulcanism

Types of volcanoes.
Work of volcanoes.
Causes of vulcanism.
Products of volcanoes.

Earth Movements and Mountain Building

Diastrophism.
Types of mountains.

Man's Changing Ideas Regarding Natural Processes

Development from primitive man to modern man.
Man's use of natural resources.

Life.

Relation of biology to physical sciences.
Classification of life forms.
The evolution of life.
Paleontology.
  Fossils.

Geologist's Time Table and the Age of the Earth

The Geologic Column.
  The Archeozoic era, no life.
  The Paleozoic era, beginning of life.
  The Mesozoic era, dinosaurs.
  The Cenozoic era, mammals.
  The Psychozoic era, man.