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ABSTRACT

In 1989, Oakton Community College (OCC) in Des Plaines, Illinois, began developing an honors core seminar in the sciences. The course was to be an interdisciplinary, laboratory-based science and humanities seminar, designed to explore the nature, process, and methods of science and the place of science in society. Rather than mastering a body of information, students would learn a process of inquiry. The course integrated two existing syllabi that had already been approved for credit transfer to four-year institutions, "Introduction to Physical Science," and "Culture and Science in the Western Tradition." An interdisciplinary team of nine faculty, working with two external consultants, spent 5 months developing the philosophy, objectives, and structure of the course. During the first 4 weeks of the course, a physicist taught students about concepts of motion. For the second 4-week unit, a chemist taught about the nature of matter. During the third 4-week unit, a geologist introduced students to plate tectonics. During each of the 4-week units, a historian related scientific concepts in their historical, economic, and cultural context. During the final 4 weeks of the course, all four instructors were present for discussions of contemporary research in their fields, and dominant paradigms. A copy of the course syllabus; a review of laboratory experiments, teaching methods, and other course activities (for students); sample lab problems; sample narrative responses provided by students on a follow-up questionnaire evaluating the course; detailed narrative examinations of each unit written by the different instructors; and a 68-item bibliography, are included. (PAA)

The Liberal Art of Science:

Science and History in an Honors Program

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Introductory Remarks for CCHC panel
Rinda West

A 1990 publication of the American Association for the Advancement of Science, The Liberal Art of Science, begins its section "Agenda for Action" with these words:

> Reforming undergraduate education in the natural sciences merits the highest priority on the national education agenda. The teaching of science to all college students must be imbued with a dynamic new philosophy. Science must fulfill its essential role as one of the liberal arts and it must be taught as it is practiced at its best.

This publication appeared syncronistically with the publication of Sheila Tobias's They're not Dumb, They're Different, an analysis of the difficulties encountered by non-science majors in college science courses. Both address the need to retool undergraduate science courses so as to promote scientific literacy in the general population. Within these concerns lives the spirit of C.P. Snow, whose two cultures have clearly not yet joined hands.

The local habitation for these issues at Oakton Community College anticipated their publication by about a year. In 1989, Honors Council, the governing board for the Honors Program, addressed the need for an Honors core seminar based in the sciences to complement our required history/humanities seminar. A faculty-administrative study group began to imagine what such a seminar might look like. After a year's worth of meetings, during which we determined that there was sufficient interest among scientists and humanists and support from the administration for us to develop such a course, we applied for and were awarded funds from the Oakton foundation to support our work, secured released time for planning from our vice-president for academic affairs, and convened the Honors Science Seminar Study Group (a body without acronym).

Thus in the fall of 1990 I found myself, a lone literary critic, spending every Friday afternoon with a physicist, a chemist, two geologists, a biologist, two philosophers (one doubling as a dean) and a historian, to develop an interdisciplinary, laboratory based science and humanities seminar, designed to expose students to the nature, process and methods of science and the place of science in the society. Rather than a body of information, the students would learn a process of inquiry, a new way of thinking and connecting ideas. Inspired by the Tobias and the AAAS, we hoped that coordinated assignments would allow the students to integrate what they have learned in each area; group discussion and projects would underline the interactive nature of scientific inquiry. Our pre-committee had determined that we would structure our course around paradigm shifts, and the transfer requirements of the Illinois Community College Board limited us to including only physical sciences in our seminar. In order to expedite our offering the course, we decided to use two syllabi already approved for transfer: NSC 102, Introduction to Physical Sciences, and HUM 175, Culture and Science in the Western Tradition. We would have preferred including biology among our subjects, because the paradigm shift effected by the theory of evolution would have taught so well.

For five months we developed the philosophy, objectives and structure of the course. The foundation funded our bringing to Oakton two consultants, Ezra Shahn of Hunter College who uses Labs for Liberal Learning conferences and Richard Burkhardt, of the University of Illinois, who teaches history of science and directs their Honors Program. Shahn has developed a year long, interdisciplinary science course for non-science majors at Hunter, and he brought us voluminous material, lab suggestions, readings, advice, and counsel. Burkhardt brought syllabi and some very useful support materials from the History of Science Society. Both men, Shahn fairly early in our planning process and Burkhardt near the end, were generous in their comments on our syllabus as it emerged and helpful to us in shaping our plans.

I will let my colleagues tell you in detail and with authority how they wove their fields into the tapestry of our course, but first I want to talk a bit about its structure and philosophy. For the first four weeks a physicist taught the students enough about motion that they could understand the significance of the work of Copernicus, Galileo, and to some extent, Newton. For the second four weeks, a chemist explored the nature of matter so that students could appreciate the discrediting of the phlogiston theory, the discovery of oxygen, and the development of the science of chemistry. For the third four weeks a geologist introduced the students to deep time and the theory of plate tectonics. In each of these units a historian anchored the developments in science in their historical, economic and cultural context. For the final four weeks of the semester, all four instructors were present for discussions of contemporary research in their fields and explorations of the paradigms currently dominant. We liked this model among other reasons because it demonstrated to students how the sciences study motion, matter and time, the distant, the tiny and the huge; they experienced the differences in scope, scale and measurability among the sciences as well as the similarities in method, assumptions and qualities of mind. Placing scientific discoveries in context let students understand the social nature of the scientific enterprise, the weight of the dominant paradigm and the consequent struggles of pioneers. All this humanized the sciences and the process of change.

Scientific understanding, like our course, itself, is recursive. The scientist observes, questions, and infers; then she tests, questions, and revises; he retests, resees, and confirms; then she tries it again, asks new questions, and come to modified conclusions, on and on. See; Ask; Think. Observe; Question; Infer.

Science implies thus a way of encountering the world, a process, a set of values; these are constant, though the subject matter varies from physics to chemistry to geology. Some of the nature of scientific understanding we address in reading and lectures; some we enact in the lab. There students must collect, organize and classify information. They learn to observe carefully, to measure precisely. Unlike the nature of literary understanding or historical understanding, scientific understanding entails the physical world. Students must learn to use equipment, they must learn safety, precision, accuracy.

In their experience with measurement, observation, and error students also learn some of the qualities of mind scientists must posses: patience, exactness, tolerance for frustration.

It's not enough that scientists know something, or believe they know it; they must know how and why they know it too. We concentrated on designing labs that would take students not only through illustrating principles covered in class, but also those that allow them to discover principles and devise models for themselves, as well as those that demonstrate the need to test hypotheses and allow for the falsifiability of scientific explanation.

As they manipulate data, students confront the need to ask multiple questions, to design experiments that isolate variables, to see information against a variety of backgrounds and from a number of points of view. Lab work helps students learn about the subject, whether it's acceleration or a chemical process, but it also emphasizes values and habits - such as initiative, creativity, or patience - that are in the seeker.

Like every field, the sciences have a specialized vocabulary students must master. In the sciences this vocabulary is mathematical as well as verbal, and students need to learn to use mathematical terms to model nature. Lab reports and essays allow students practice in using this vocabulary and provide an occasion for them to reflect on what they have done in the lab and on what Gene Carr calls "what if" questions. "What if we allowed twice as long?" "What if we raised the temperature?" Their written work also allows students to observe their own process and to contemplate the nature of scientific understanding.

Freshman students often come to us expecting to find the right answer in their labs. They must learn to deal with error as a source of information, as an essential part of the process of discovery. When they see science in its historical context, their own experience takes on new meaning; maybe the wrong answer isn't wrong. Maybe it's simply an indication of limits of equipment, method, or even of scientific knowledge.

The Liberal Art of Science includes four "integrative concepts" in science: scale and proportion, change and evolution, causality and consequences, and dynamic equilibrium. The recursive structure of our course allowed us to introduce these concepts as they appear in each science in turn, calling their attention to the structuring quality of these ideas. Scale and proportion appeared in physics as students studied the solar system; in chemistry they followed the development of the periodic table and saw scale and proportion at the atomic level; in geology they learned about scale at a planetary level and about deep orders of time. Lab work emphasized the differences in scale among the three sciences: physics experiments could reveal laws of motion that govern both balls rolling down inclined planes and planets; chemistry experiments allow scientists to study process directly; but geologists must model and extrapolate, because they cannot bring the entire earth into the lab. Ideas of change and evolution also appeared in each science. Physics studies changes in position and velocity; chemistry, changes in properties and composition; and geology, changes in the size, shape and position of continental masses and ocean basins on the face of Planet Earth. In a like manner, principles of causality and consequences appear in each of the sciences, as do those of dynamic equilibrium.

Oakton Community College
Course Syllabus

I.

Course Prefix	Course Number	Course Name	Credit	Lecture	Lab
HUM	175	Culture and Science in the Western Tradition - Honors	3	3	0
NSC	102	Introduction to Physical Science	4	3	3

II. Course Prerequisite:
Permission or Honors Status

III. Course Description:
HUM 175: The interrelation between culture and science and the impact of scientific advancement on philosophy, religion, art, architecture, mathematics and technology from ancient to modern times.
NSC 102: This course presents the basic elements of astronomy, physics, chemistry and geology. Topics include planetary motion, gravitation, conservation of energy, kinetic theory of matter, electricity and magnetism, theory of the atom, chemical reactions, and evolution of the universe.

IV. Learning Objectives:

1. To acquire a knowledge of some of the basic concepts of physics, chemistry and geology.
2. To become aware of the method of scientific reasoning.
3. To develop basic laboratory skills and acquire laboratory experience.
4. To demonstrate understanding of the use of models.
5. To understand the habits of mind and approaches to nature that the sciences share.
6. To understand what is unique to each of these sciences.
7. To identify selected key figures and describe their contributions to the development of Western Science.
8. To describe social and cultural conditions, ideas, attitudes and world views that contributed to the development of new knowledge, discoveries and technologies during various periods of Western development.
9. To describe significant turning points in the development of science and knowledge in Western development and evaluate their impact.

	SCALE	CHANGE	CAUSE & EFFECT	DYNAMIC EQUILIBRIUM
Physics	Solar System	Position, Velocity	Force, Gravity	Orbits
Chemistry	Atomic (Periodic Table)	Composition, Properties	Reagent	Reversible Reactions
Geology	Global	Location	Heat, Density	Isostasy

Introductory Remarks for NCHC Panel

Mike Matkovich - Professor of Physics
Oakton Community College
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The first five weeks of the tandem Humanities-Natural Science course were taught by Dr. Thomas Conway, Professor of History and myself. We tried to develop the historical context in which astronomy and physics developed. The roles of mathematics, philosophy, religion and technology and their relation to early science were discussed.

We began with a discussion of the origins of mathematics, astronomy and astrology from a cultural viewpoint. The contributions of Archimedes, Euclid, Aristotle, Ptolemy and Plato were discussed in the context of the era in which they lived. The nature of scientific understanding and the acceptance of certain assumptions was mentioned. Students were encouraged to participate and propose their own ideas as to why a particular idea took hold.

The need for accurate measurements of time and for an accurate calendar played a key role in the science of astronomy. The works of Copernicus, Kepler, and Galileo changed the way we viewed the universe forever. The theory of the paradigm shift is centered around the ideas which began to circulate around the late 1500's and early 1600's.

The historical approach to the discovery of new ideas was utilized throughout this part of the course. The emphasis was on the methods of discovery and the reasons for discovery. Radical new theories can be formulated only after there is a profusion of new experiments and /or observations which cannot be explained adequately by the present theory. The radical new theories are usually developed over decades or even longer by a small group of investigators.

Technology often serves to integrate several areas of science and to facilitate the occurrence of the paradigm shift. Students were provided with copies of several articles relating to the building the the great cathedrals and other aspects of Renaissance technology. Laboratory experiments were designed to reproduce the spirit and the difficulty of the times in which they were first performed.

A partial list of topics discussed in class includes selected readings from SCIENTIFIC AMERICAN, readings from the book "Discoveries and Opinions of Galileo" and readings from "The Origins of Modern Science " by Herbert Butterfield. Students were expected to have an appreciation of the following ideas and events.

"The Renaissance and the Birth of the Scientific Method" This very broad subject included the ideas of Sir Francis Bacon, Giordano Bruno, Dante and others. Much of the historical background was provided Dr. Conway.

"Copernicus and the Heliocentric Theory" Why did it take scholars over 1500 years to find serious fault with the Ptolemaic theory? The problem of retrograde motion of the planets was discussed in detail. It was demonstrated that the Ptolemaic theory did not offer the real solution to this problem.

"Tycho Brahe and His Long Series of Accurate Measurements" What is the role of accuracy, precision and uncertainty in physical measurements? It was shown that a new theory could not be accepted until new measurements and observations were made which contradicted the old theory.

"Kepler and His Three Laws of Planetary Motion" Kepler's analysis of the orbit of the planet Mars was studied in detail. Students were expected to appreciate the role of geometry and logic in approaching astronomical problems.

"Galileo and the Beginning of Experimental Physics" Galileo analyzed the motion of balls rolling down an incline and founded the science of kinematics. He used the telescope to gain new knowledge about the solar system.

"Isaac Newton and the Mechanical Universe" Newton came after Kepler, Galileo and Descartes. He combined the knowledge gained by these people with his own brilliant ideas to solve the problem of mechanical motion of "heavenly bodies".

Laboratory experiments were carefully chosen to coordinate with the lectures. The first experiment involved repeating measurements mentioned in the writings of Claudius Ptolemy of the angle of refraction of light. Students were asked to compare their measurements with those given by Ptolemy. They were then asked to develop a general rule relating the angle of incidence and the angle of refraction.

Additional laboratory experiments repeated many of the key experiments of Galileo.

NATURAL SCIENCE 102- HONORS

PROCEDURES, LABORATORY EXPERIMENTS, TEACHING METHODS AND OTHER ACTIVITIES

General Procedures:

The class met for two hours of lecture and discussion on Monday, Wednesday and Friday and for a three hour laboratory on Tuesday. The lecture/discussion sessions consisted of one hour of physical science which I taught and one hour of humanities taught by Tom Conway. I lectured the first hour and introduced new scientific ideas in a historical context. The logical thinking and sequence of discoveries were explained according to this approach. During the second hour, Tom discussed the cultural, philosophical, political and religious ideas of the era and showed how they impacted upon scientific thinking.

Both teachers were in the classroom for the entire two hours and actively participated by asking questions, answering questions and in general by acting as a valuable resource. We tried to unite the subjects we each teach to show that scientific and humanistic thinking each influence one another to some extent. For example, Galileo's ideas and writings were discussed with those of Dante, Aristotle and Shakespere. Original sources of information were used wherever possible. Students were exposed to the original works of Euclid, Newton and Galileo. They discovered that Euclid and Newton are very difficult to read, while Galileo is very readable.

Laboratory Experiments:

The three hour laboratory session was taught by Professor Matkovich, with Dr. Conway attending all of the sessions and performing all of the experiments along with the students. The experiments were carefully chosen so as to replicate original experiments as much as possible. The experiments blended nicely into the theme of the course. They were seen as a natural extension of the lecture portion of the course.

We began by repeating an experiment first mentioned by Ptolemy around 150 A.D. Students were asked to measure the refractive properties of light as it passes into water and compare their results with those of Ptolemy. We asked the students to work in groups of three in order create a team spirit and to utilize collaborative learning techniques. After taking the measurements, each team was asked to develop a theory of refraction of light. Each team appointed a spokesperson who then presented their theory and defended it before the entire class. We involved students in the process of doing science. Finally, I talked about Snell's Law of Refraction and its discovery 1500 years after Ptolemy.

We continued to use group activities to study the mechanics and optics experiments of Galileo and Newton. Students were asked to develop theories and to defend them based on repeatable experimental results. In the end, I always told them what the great minds had discovered.

Teaching Methods and Other Activities:

Since the class met six hours a week for lecture and three hours a week for laboratory, it was absolutely essential to create a friendly, cooperative atmosphere and to vary the activities so as to encourage student participation. Since we were studying astronomy, students were asked to record the time of sunrise and sunset, the position of the sun at sunrise and sunset, the phases of the moon and other easily observable phenomena for one month. As it turned out, only one student successfully completed the assignment. A typical excuse was that I forgot to get up on time and then it was too late to see the sunrise. This was a really good assignment, because it made students realize how dedicated you have to be to collect complete and accurate astronomical data for a long period of time. And then, even after you have the data, what do you do with it? How do you interpret it?

There were several field trips such as the one to Fermi National Accelerator Laboratory in Batavia, Illinois to get a feeling and some appreciation of the scope of modern physics.

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NSC 102-0H1 Spring 1991

LABORATORY PROBLEM

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The oldest recorded physical measurements of the properties of light can be found in the writings of Claudius Ptolemy (approximately 150 A.D.). He gave the following measurements for the angle of incidence (i) and the angle of refraction (r) for a light beam passing from air to water.

Angle of incidence i	Angle of refraction r
10 degrees	8 degrees
20 "	15 deg 30 min
30 "	22 deg 30 min
40 "	29 deg
50 "	35 deg
60 "	40 deg 30 min
70 "	45 deg 30 min
80 "	50 deg

Are these measurements accurate? What do they tell us about the properties of light? Can a general principle be determined from these measurements? If so, what is it?

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NSC 101 OH1 PART II: CHEMISTRY

SAN FRANCISCO, November 13-16.1991

1991 NATIONAL CONFERENCE "CREATING AND CONFRONTING CHANGE IN THE 90's" (CCHA)

LAST YEAR, IN OCTOBER 1990. TO BE MORE PRECISE. I ATTENDED THE COMMUNITY COLLEGE HUMANITIES ASSOCIATION 1990 ANNUAL MEETING. AT ROCK VALLEY COLLEGE IN ROCKFORD. ILLINOIS. I WAS ATTRACTED WITH SOME TOPICS OF THE MEETING, PARTICULARLY THE ONES DISCUSSING SOME INTERDISCIPLINARY COURSES. THAT WAS MY FIRST CONTACT WITH HUMANITIES ASSOCIATION. THE MEETING LEFT A PROFOUND IMPRESSION ON ME. AND I BECAME A NEW MEMBER OF THE HUMANITIES ASSOCIATION.

QUITE A FEW PEOPLE WERE MOST ENTHUSIASTIC: THE IDEAS PRESENTED WERE VERY CLOSE TO MINE, ALTHOUGH WE ARE WORKING IN DIFFERENT FIELDS. AND I FELT LIKE A PART OF THE GROUP. BOB SESSIONS. TOM SEARS, JACK WORTMAN AND STEVE GATES FROM KIRKWOOD COMMUNITY COLLEGE (IA) PRESENTED "CULTURE AND TECHNOLOGY: AN INTERDISCIPLINARY HUMANITIES COURSE" AND ROBERT BADRA WAS SUPPOSED TO TALK ABOUT :" SCIENCE. TECHNOLOGY AND THE HUMANITIES: MAKING CONNECTIONS".

AT THE TIME OF THE MEETING I DID NOT EXPECT THAT ONLY ONE YEAR LATER I WILL APPEAR IN FRONT OF ALL OF YOU. AND I MUST SAY THAT I AM EXTREMELY PLEASED TO BE HERE TODAY AND TO HAVE AN OPPORTUNITY TO SHARE WITH YOU OUR EXPERIENCES. HARD WORK, PERFORMANCES AND RESULTS OF A COMPLEX INTERDISCIPLINARY COURSE. I AM PLEASED FOR MANY REASONS, BUT MOST OF ALL BECAUSE I FEEL THAT AN INTERDISCIPLINARY COURSE IS APPLICABLE TO CURRENT EDUCATIONAL SYSTEM: SECONDLY. WE BELIEVE THAT WE HAVE FOUND AN APPROPRIATE APPROACH TO OUR GOAL. AND THAT THE RESULTS OF THIS. FIRST SEMESTER WITH THE COURSE WERE SATISFACTORY. THIRDLY, WE HOPE TO HAVE A CHANCE TO DISCUSS WITH YOU SOME OF THE PROBLEMS WHICH SHOULD NORMALLY BE OBSERVED AFTER THE FIRST EXPERIENCE OF TEACHING A NEW COURSE. FINALLY. AFTER SHARING OUR EXPERIENCE WITH YOU. WE HOPE THAT MORE COMMUNITY COLLEGES WILL CONSIDER INTERDISCIPLINARY COURSES OF THIS KIND IN THEIR CURRICULUM. WHAT

WOULD ONLY ACT TO FURTHER ENHANCE OUR EDUCATIONAL SYSTEM.

BUT. LET'S GO BACK TO LAST YEAR: DURING THE FALL OF 1990. OAKTON FACULTY MEMBERS FROM THE DEPARTMENTS OF PHYSICS. CHEMISTRY, GEOLOGY. BIOLOGY. PHILOSOPHY. HISTORY AND ENGLISH WORKED TO DEVELOP AN INTERDISCIPLINARY. LABORATORY BASED SCIENCE AND HUMANITIES SEMINAR. DESIGNED TO EXPOSE STUDENTS TO THE NATURE, PROCESSES AND METHODS OF SCIENCE AND THE PLACE OF SCIENCE IN THE SOCIETY. COMPLETION OF THIS SEMINAR WOULD SATISFY THE CORE SEMINAR REQUIREMENT FOR GRADUATION WITH HONORS AT OAKTON.

THE INTERDISCIPLINARY COURSE WAS PROJECTED TO INTEGRATE TOPICS IN PHYSICS. CHEMISTRY AND GEOLOGY WITH A STUDY OF THE IMPACT OF SCIENTIFIC IDEAS AND DEVELOPMENTS ON EVENTS. IDEAS AND SOCIAL INSTITUTIONS. THE PROFESSORS WOULD WORK WITH STUDENTS TO DISCOVER AND EXPLORE THE NATURE OF SCIENTIFIC UNDERSTANDING AS WELL AS INTEGRATIVE CONCEPTS IN SCIENCE AND THE HISTORICAL AND CULTURAL CONTEXTS IN WHICH SCIENTIFIC IDEAS HAVE DEVELOPED. RATHER THAN A BODY OF INFORMATION. THE STUDENTS WOULD LEARN A PROCESS OF INQUIRY. A WAY OF THINKING AND CONNECTING IDEAS. COORDINATED ASSIGNMENTS WOULD ALLOW THE STUDENTS TO INTEGRATE WHAT THEY HAVE LEARNED IN EACH AREA: GROUP DISCUSSION AND PROJECTS WOULD UNDERLINE THE INTERACTIVE NATURE OF SCIENTIFIC INQUIRY.

FOR FIVE MONTHS . FACULTY MEMBERS DEVELOPED THE PHILOSOPHY. OBJECTIVES AND STRUCTURE OF THE COURSE. MEANWHILE. MIKE MATKOVIC. PHYSICS PROFESSOR. ATTENDED THE NATIONAL COLLEGIATE HONORS COUNCIL. WHERE HE DISCOVERED AN INCREASING INTEREST IN DEVELOPING MATH AND SCIENCE HONORS COURSES NATIONWIDE. AND CONSIDERABLE EXCITEMENT ABOUT INTERDISCIPLINARY COURSES. BUT NO EXISTING MODELS THAT DO JUST WHAT WE WANTED TO DO.

AFTER THE VISIT OF PROFESSOR AZRA SHAHN AND RICHARD BURKHARDT. AS MENTIONED BY RINDA WEST AND LONG DISCUSSIONS. I HAD TO PREPARE THE SYLLABUS AND DECIDE ON THE CONTENT OF THE CHEMISTRY PART OF THE COURSE. THE FOLLOWING FACTS INFLUENCED THE DIRECTION OF MY THOUGHTS:

1. OUR COURSE IS INTERDISCIPLINARY INTRODUCTORY SCIENCE COURSE FOR NONSCIENCE MAJORS. THIS IS A NONSTANDARD COURSE IN MANY WAYS: I FELT THAT THE MATERIAL SELECTED SHOULD COVER SEVERAL TIME PERIODS IN WHICH PARADIGM SHIFTS TOOK PLACE: I TRUSTED THAT BY ANALYZING HISTORICAL EVENTS AND CIRCUMSTANCES THE PEOPLE LIVED IN. THE STUDENTS WOULD REALIZE THAT SCIENCE REPRESENTS A CONTINUOUS PROCESS OF OBTAINING KNOWLEDGE ABOUT THE WORLD. MATTER AND CHANGES AROUND US. LABORATORY EXPERIMENTS. BEING AN INTEGRAL PART OF THE COURSE HAD TO BE SELECTED AND WRITTEN IN SUCH A WAY THAT STUDENTS CAN GRASP THE WAY OF THINKING AND REASONING OF THE PEOPLE IN A GIVEN TIME PERIOD.

2. THE COURSE SHOULD UNABLE STUDENTS TO COME TO UNDERSTAND SCIENCE AS A PROCESS OF THOUGHT RATHER THAN A BODY OF FACTS.

3. PROFESSOR SHAHN USED THREE CROSS-CUTTING TOPICS TO HELP DEFINE THE SUBJECTS TO BE COVERED AND TO AID THE STUDENTS IN SEEING THE CONNECTIONS BETWEEN DIFFERENT BODIES OF LEARNING: (I) THE HELIOCENTRIC THEORY. (II) THE ATOMIC THEORY. INCLUDING NATURE AND PROPERTIES OF MATTER AND (III) THE EVOLUTIONARY THEORY. TO ILLUSTRATE THE PROCESS BY WHICH SCIENTIFIC UNDERSTANDING IS ACHIEVED. EACH OF THESE THEMES WAS FOLLOWED FROM ITS ORIGINS IN PRESCIENTIFIC EXPERIENCE TO THE EMERGE OF MODERN CONCEPTS.

4. UNIVERSITY OF CHICAGO HAS THE COURSE:" STRUCTURE AND FUNCTION IN THE NATURAL WORLD". IT BEGINS WITH THE STUDY OF ELEMENTARY PARTICLES AND THE WAYS THEY INTERACT AND THEN GOES ON TO CONSIDER THE STRUCTURE OF MATTER.

5. AT ST JONHN'S COLLEGE. . STUDENTS LEARN THE COPERNICAL REVOLUTION FROM COPERNICUS. NEWTONIAN PHYSICS FROM NEWTON AND THE THEORY OF RELATIVITY FROM EINSTEIN. IN THESE READINGS. STUDENTS ENCOUNTER SOME OF THE WORLD'S GREATEST MINDS AT MOMENTS OF INTENSE CREATIVITY. CONTROVERSY AND EXCITEMENT. THEY SEE SCIENTISTS ASKING QUESTIONS AND TRYING TO SOLVE PROBLEMS. ALL THE WHILE WORKING WITHIN THE LIMITS OF A PARTICULAR TIME - JUST AS THE STUDENTS THEMSELVES ARE.

6. TO BRING SCIENCE ALIVE. TO CAPTURE THE MOMENT OF SCIENTIFIC DISCOVERY AND DEMONSTRATION. SOME GENERAL EDUCATION COURSES HAVE

STUDENTS READ THE ORIGINAL WORDS OF GREAT SCIENTISTS. TO SEE HOW THEY THEMSELVES PRESENTED THEIR EVIDENCE. ARGUMENTS AND CONCLUSIONS TO THEIR CONTEMPORARIES. AT HUNTER COLLEGE OF THE CITY UNIVERSITY OF NEW YORK. THE STUDENTS STUDY THE FORMATIVE PERIOD OF CHEMISTRY BY READING CLASSIC PAPERS BY BOYLE. LAVOISIER AND DALTON.

7. LABORATORY COMPONENT HAS THE PURPOSE TO ENCOURAGE STUDENTS TO SEE THE CONNECTION BETWEEN THEORY AND EXPERIMENT AND SEE HOW SCIENTIFIC CONCEPTS ARE VALIDATED THROUGH OBSERVATION.

THROUGH LECTURES AND DISCUSSIONS. STUDENTS SHOULD COME TO SEE THAT SCIENCE IS NOT A CLOSED CATALOGUE OF RESULTS. BUT A CONTINUING PROCESS OF INQUIRY. IN LABORATORIES. WHERE THIS IDEA IS GROUNDED ON EXPERIENCE, THEY CAN MOVE STILL FARTHER BEYOND RECEIVING KNOWLEDGE TOWARD ACTIVE UNDERSTANDING OF THE NATURAL WORLD.

HAVING IN MIND THE CONCEPTS MENTIONED ABOVE. SOME OF WHICH I LIKED MORE OR LESS. I PREPARED AN ORIGINAL. RELATIVELLY DIFFERENT SYLLABUS. IT COVERED FIVE TIME PERIODS. SUBDIVIDED WITH AN APPEARING PARADIGN SHIFT. I SUPPLIED STUDETS WITH BASIC RESEARCHED MATERIAL FOR THE COURSE. WHICH INCLUDED. BESIDES TRANSLATIONS OF ARTICLES AND CHAPTERS OF NUMBER OF BOOKS INTERNATIONALLY PUBLISHED. ORIGINAL LECTURES. LABORATORY EXPERIMENTS. BIOGRAPHIES OF THE PHILOSOPHERS. ALCHEMISTS AND SCIENTISTS MENTIONED IN THE COURSE. ETC.

THE INTRODUCTION OF THE DAWN OF SCIENCE, BY R.TARTON (REF 8) INSPIRED ME TO DEVOTE THE FIRST LECTURE TO THE ANCIENT MEN. THE AUTHOR SAID. IN A PART OF INTRODUCTION. SOME OF THE FOLLOWING:" NO HISTORY OF SCIENCE CAN IGNORE THE ACHIEVEMENTS OF PREHISTORIC MAN.THOUGH HE APPEARED ON THE EARTH ABOUT MILLION YEARS AGO. WE KNOW NEXT TO NOTHING OF HIS MENTAL DEVELOPMENT DURING THE FIRST HUNDREDS OF MILLENNIA. WHEN HIS ONLY IMPLEMENTS WERE CHIPPED STONE TOOLS. THEN. QUITE SUDDENLY. DURING THE LAST PART OF STONE AGE. MAN BEGAN TO BUILD BURIAL GROUNDS AND TO PRODUCE CARVINGS. PAINTINGS AND SCULPTURES. THIS PERIOD COVERS NO MORE THAN THE

LAST 50.000 YEARS. HOWEVER. IT WAS ONLY IN THE COURSE OF THE LAST 10.000 YEARS THAT MAN HAS DISCOVERED AND PERFECTED ALL HIS GREATEST SKILLS: FROM THE POTTER'S WHEEL TO THE EXPLORATION OF NUCLEAR ENERGY.

PREHISTORIC MAN WAS THE FIRST CREATURE TO APPLY THE ACTIONS TO THE SATISFACTION OF HIS EVERYDAY NEEDS. HENCE THE HISTORY OF SCIENCE BEGINS WITH THE HISTORY OF TECHNOLOGY...THE EARLIEST METALLURGISTS. WHO MELTED COPPER SOME 8.000 YEARS AGO. HAD NO IDEA OF THE DISTINCTION BETWEEN OXIDES. CARBONATES AND SULFIDES. BUT THEY MANAGED TO FIND AND TO USE THE ORE FROM WHICH THEY COULD OBTAIN PURE COPPER.

THE DETAILS DEALING WITH PARTS 1-5 ARE GIVEN IN THE ENCLOSED SYLLABUS.

AFTER THE COMPLETION OF THE COURSE. THE STUDENTS WERE ASKED TO COMMENT THE FOLLOWING QUESTIONS:

QUESTION 1: WHAT FOR YOU WAS MOST IMPORTANT IN WHAT YOU LEARNED THIS SEMESTER?

QUESTION 2: WAS THE COURSE WHAT YOU EXPECTED?

QUESTION 3: WHAT UNDERLYING SCIENTIFIC PRINCIPLES, THEMES, ATTITUDES AND/OR VALUES INTEGRATED THE 3 SCIENCES YOU STUDIED?

QUESTION 4: IN WHAT SIGNIFICANT WAYS WERE THEY DIFFERENT?

QUESTION 5: WHAT WOULD YOU LIKE TO CHANGE/IMPROVE THE COURSE

SOME OF THE ANSWERS ARE GIVEN BELOW:

QUESTIONS 1:

- SINCE I'VE HAD NO CHEMISTRY. I FOUND THE BIT WE COVERED VALUABLE AS WELL AS VERY INTERESTING. I REALLY ENJOYED THE TALK OF PARADIGM SHIFTS AND CONSIDER THE EVOLUTION OF SCIENTIFIC METHOD FROM ANCIENT TO MODERN TIMES IMPORTANT INFORMATION I LEARNED. ALSO THE GEOLOGY SECTION WAS VERY INFORMATIVE AND INFO IS VERY USEFUL: I'D LIKE TO SEE MORE EMPHASIS ON NATURE.

- THAT SCIENCE HAD BEEN A CONSTANT PROGRESSION OF IDEAS. OF INFORMATION AND OF ATTITUDES. THE NAMES THAT WE SEE IN SCIENCE

TEXTBOOKS WERE REAL PEOPLE WHO DEVOTED THEIR LIVES TO THEIR WORK AND IDEAS: NO ONE IS TO SMALL OR INSIGNIFICANT AND CONCEPTS THAT WE NOW CONCEIVE AS BEING ARCHAIC. REQUIRED GREAT SHIFTS IN THOUGHT IN ORDER TO PROGRESS.

- PREPARE ME FOR HARDER UNIVERSITY COURSES. THE SHEER BULK OF INFO WAS MORE THAN I HAVE EXPERIENCED BEFORE IN ANY OTHER COURSE.

- THE AMOUNT OF TIME NECESSARY TO PROGRESS. IN SOME CASES. HOW HARD THE SCIENCE HAS TO FIGHT TO HAVE THEORIES ACCEPTED AND HOW DIFFICULT IT IS TO BE THE SCIENTIST WITH THE NEW THEORY/ HYPOTHESIS. ACCEPTANCE SOMETIMES SPANNING CENTURIES.

- TO BE ABLE TO STAND UP FOR MYSELF IN THE CLASS AND AS WELL IN LIFE. I LEARNED THAT IT'S OKAY TO BE DIFFERENT. AND I HAVE TO GO THROUGH LIFE MY OWN WAY. SOMEHOW THOSE WAYS ARE VERY SIMILAR TO EACH OTHER!!! ALSO THIS COURSE DEEPENED MY FAITH. MOST OF THE PEOPLE WE TALKED ABOUT IN CLASS HAD TO STRUGGLE WITH DIVINITY QUESTIONS.

- WHAT WAS THE MOST IMPORTANT FOR ME WAS TO LEARN THE TREMENDOUS STRUGGLE INVOLVED IN ADVANCING SCIENCE IN WHAT WE HAVE TODAY AND EXCITEMENT OVER WHAT WE MAY GET IN THE FUTURE.

- I ENJOYED THE BASIC HISTORICAL BACKGROUND. THE DIFFERENT PEOPLE WHO CREATED THE GREAT CHANCES IN THOUGHT. I WAS SOMEWHAT IGNORANT BEFORE. BUT NOW I FEEL MUCH STRONGER IN UNDERSTANDING.

QUESTIONS 2: WAS THE COURSE WHAT YOU EXPECTED:

- YES. AND MORE.

- NO. I EXPECTED A MORE HUMANITIES FOCUSED COURSE AS THE COURSE DESCRIPTION LED ME TO BELIEVE.

- YES. SCIENCE AND THE HISTORY OF SCIENCE WERE BROUGHT TOGETHER QUITE WELL - AT FIRST IT DIDN'T CONNECT FOR ME BUT AS WE GOT INTO IT. IT SEEMED TO COME TOGETHER.

QUESTION 3: WHAT UNDERLYING SCIENTIFIC PRINCIPLES. THEMES. ATTITUDES AND/OR VALUES INTEGRATED THE 3 SCIENCES YOU STUDIED?

- THE MOST PROMINENT SIMILARITY BETWEEN THE 3 SCIENCES WAS THE CONCEPT OF THE PARADIGM SHIFT. THE INDIVIDUALS WHO WERE ABLE TO MAKE THE GREAT BREAKTHROUGHS IN SCIENCES. WERE THOSE WHO WERE

ABLE TO BREAK FREE FROM CONVENTIONAL THOUGH - INDEED IT HAS BEEN SHOWN THAT "SCIENTIST" ARE AND HAVE TO BE CREATIVE IN NATURE.

- HUMANISM. CURIOSITY. NEVER STOP QUESTIONING. DO NOT MAKE ANYTHING FOR FACE VALUE OR FOR GRANTED. STICK TO OWN IDEAS. STILL THAT HAS TO BE INTERTWINED WITH OPENMINDEDNESS. FLEXIBILITY. COOPERATION.

- SCIENCE IS A PROCESS THAT BUILDS FROM ONE DISCOVERY TO THE NEXT. THE ORIGINATOR RARELY GETS CREDIT.

QUESTION 4: IN WHAT SIGNIFICANT WAYS WERE THEY DIFFERENT?

- THEY WERE LIKE THREE STEPS ON A LADDER IN STUDYING UNIVERSE. CHEMISTRY DEALT WITH THE SMALLEST PART OF MATTER. GEOLOGY DEALT WITH THE SYSTEM OF THE MATTER AND ENERGY TO STUDY OUR PLANET. ASTRONOMY COVERED THE INTERSECTION OF PLANETS. STARS, ETC. THAT FORM THE UNIVERSE. THE CHIEF DIFFERENCE WAS THE SCALE OF WHAT WAS BEING STUDIED.

- EACH DEALS WITH DIFFERENT PART OF OUR WORLD. EACH EQUALLY IMPORTANT TO UNDERSTANDING HOW WORLD OPERATES AND THEY RELATE TO EACH OTHER.

- CHEMISTRY IS MUCH MORE DEMONSTRATIVE SCIENCE/MORE HANDS ON. A LOT OF LAB WORK COULD ACCOMPANY IT. GEOLOGY IS THE "NEWER" SCIENCE AND PHYSICS VERY ANCIENT.

QUESTION 5: WHAT WOULD YOU LIKE TO CHANGE/IMPROVE THE COURSE

- DEAL WITH HALF AS MANY SUBJECTS. PERHAPS TWO EIGHT WEEK SESSIONS DEALING WITH EACH. DEAL WITH THE HISTORICAL IMPACT OF SCIENCE AS A CHANGING FORCE IN HISTORICAL PERSPECTIVE. FIND A BETTER WAY OF CONNECTING SCIENCE AND HUMANITIES AS THIS COURSE LACKED.

- TIME WILL BE NEEDED TO BEST DEVELOP THE PROPER CURRICULA AND METHOD OF EXPRESSING IT. THERE IS A GOOD BASE HERE WITH THE LAB. LECTURE AND READING. ORGANIZATION AND CONTINUITY OF MATERIALS NEED SOME IMPROVEMENT.

- I AM GLAD THAT YOU CHANGED COURSE LITTLE BIT. TOO BAD I WON'T BE ABLE TO TAKE IT. I GUESS THAT I CAN'T TAKE THE SAME ROAD

TWICE. I WILL BE AROUND TAKING OTHER COURSES. I AM GLAD THAT I MET ALL THOSE WONDERFUL PEOPLE.

AS THE FINAL CONCLUSION OF THE SPRING SEMESTER 1991 TEACHING, DISCUSSING WITH STUDENTS AND ANALYZING THE DETAILS. IT APPEARED THAT THE SCIENCE MAJORS AMONG THE STUDENTS EXPRESSED GREAT SATISFACTION IN LEARNING THE HISTORICAL CONTEXT OF SCIENCE, THE GREAT STRUGGLES NECESSARY TO CHANGE SCIENTIFIC THINKING AND THE CREATIVITY THAT PRACTICING SCIENCE REQUIRES. ON THE OTHER HAND, SOME LIBERAL ART MAJORS EXPRESSED DISSATISFACTION WITH THEIR LEARNING OF SCIENCE. FEELING THAT THEY WERE NOT ABLE TO PURSUE ANY ONE SUBJECT IN SUFFICIENT DEPTH TO ACHIEVE CONFIDENCE.

FACULTY MEMBERS STARTED TO ANALYZE THE POSSIBILITY OF PLANING A SECOND SEMINAR THAT WOULD INCLUDE BIOLOGY. IN THIS CASE. THE SECOND TANDEM WOULD BE DEVELOPED, PAIRING ENVIRONMENTAL SCIENCE, TO INCLUDE GEOLOGY AND BIOLOGY. WITH INTRODUCTION TO LITERATURE. THE NEW SEMINAR WOULD EXPLORE SIMILARITIES AND DIFFERENCES IN THE WAYS SCIENTISTS AND WRITERS VIEW NATURE. AT THE SAME TIME, THIS WOULD MAKE IT POSSIBLE TO REDESIGN THE PHYSICAL SCIENCES CLASS TO INCLUDE TWO SCIENCES ONLY, CHOSEN FROM AMONG PHYSICS. CHEMISTRY AND GEOLOGY: THOSE TWO SCIENCES WOULD BE TAUGHT IN TANDEM WITH HISTORY. THUS SIMPLIFYING THE STUDENT'S EXPERIENCE AND ALLOWING THE FACULTY MEMBERS TO TEACH THEIR SUBJECTS IN GREATER DEPTH.
THIS IS WHERE WE ARE NOW.
THE SYLLABUS FOR CHEMISTRY PART OF THE COURSE CAN BE AVAILABLE FOR THE COLLEAGUES INTERESTED IN IT. AND WE WILL BE MOST HAPPY TO ANSWER ANY QUESTIONS. IF WE HAVE AN AVAILABLE CLUE.

NSC 101 OH1 CHEMISTRY PART

REVIEW OF THE SYLLABUS

THE MATERIAL IS SUBDIVIDED IN FIVE PARTS: EACH PART IS DEALING WITH A TIME PERIOD CHARACTERIZED BY THE SPECIFIC GOALS AND EXPERIENCES, AS WELL AS OF INTERPRETATIONS OF THE MATTER AND ITS CHANGES.

PART ONE

THE FIRST PART IS COVERING ANCIENT TIMES. IT IS PRESENTING THE CROSS SECTION OF THE DEVELOPMENT OF HUMAN SKILLS. THE BEGINNING OF METALLURGY. THE DEVELOPMENT OF THE CONCEPTS OF MATTER AND THE PHILOSOPHICAL UNDERSTANDING OF THE CONCEPT OF CHEMICAL ELEMENTS. THE COMPOSITION OF MATTER AND THE CHANGES OF MATTER. AS SEEN IN THOSE TIMES ARE ALSO DISCUSSED.
IN ANCIENT TIMES, MANY IMPORTANT CONCLUSIONS RESULTED FROM THE OBSERVATIONS AND PHILOSOPHICAL MEDITATION. THE WORK OF TALES, ANAKSIMENES, ARISTOTLES. DEMOCRITUS AND SOME OTHERS IS ENLIGHTENING THE TIME THOSE GREAT MEN LIVED IN.
AT THIS POINT. THE NON SCIENCE STUDENTS HAVE A CHANCE TO HAVE THE FIRST LABORATORY EXPERIMENT. WHICH IS DEVOTED TO THE CONCLUSIONS BASED ON OBSERVATIONS. THEY WILL OBSERVE THE SAMPLES OF DIFFERENT KINDS OF MATTER. AND DESCRIBE THEIR PROPERTIES (STATE OF MATTER, COLOR, MELTING AND /OR BOILING POINT, CRYSTALLINE FORM, SUBLIMATION, MISCIBILITY, ODOR, ALLOTROPIC FORMS ETC) .
BASED ON THE OBSERVATIONS AND SOME NEW EXPERIENCES. STUDENTS WILL DETERMINE THE PROPERTIES OF A SAMPLE AND CONSEQUENTLY IDENTIFY IT.
THIS KIND OF EXPERIMENT CAN BE SUCCESSFULLY PERFORMED WITHOUT ANY PREVIOUS LABORATORY OR SCIENCE EXPERIENCE AND IS, MOST OFTEN, FASCINATING FOR THE BEGINNERS.

PART TWO

TIME PERIOD: END OF ANCIENT TIMES THROUGH MIDDLE AGES.
EGYPTIAN " SACRED SKILLS" AND THE TRANSFORMATION TO ALCHEMISTRY.
THE PERIOD OF ALCHEMISTRY UP TO APPROX. XVI CENTURY.

SECOND PART CONTINUES WITH THE FOLLOW-UP OF THE EVENTS, GOALS, ACHIEVEMENTS, PHILOSOPHIES AND EDUCATION IN THE PERIOD STARTING SOMEWHERE AT THE END OF ANCIENT TIMES AND PROCEEDING THROUGH MIDDLE AGES (UP TO THE APPEARANCE OF IATROCHEMISTRY). MANY FASCINATING EXPERIENCES ARE ACCUMULATED: NUMEROUS NAMES HAVE TO BE MENTIONED IN ORDER TO UNDERSTAND THE GOALS AND IDEAS AND TO APPRECIATE THE VARIETY OF THE RESULTS OBTAINED.
THE PERIOD OF ALCHEMISTRY IS FULL OF HARD WORK, MAGIC, SECRETS AND ACHIEVEMENTS, BUT THE MAIN GOAL, GOLD AND THE STONE OF WISDOM WAS NEVER REACHED.
SECOND LABORATORY PART PROCEEDS WITH THE STUDY OF MATTER BASED ON PREVIOUS EXPERIENCE. HOWEVER, THIS TIME, IN ORDER TO DESCRIBE A PURE SUBSTANCE, STUDENTS HAVE TO ISOLATE THE SUBSTANCE FROM A MIXTURE WITH OTHER COMPONENTS. USING DIFFERENT TYPES OF SAMPLES , SOME MOST BASIC ANALYTICAL PROCEDURES ARE INTRODUCED.
THE EXPERIMENTS INCLUDE:
- DISTILLATION, WHICH IS USED FOR THE SEPARATION OF A LIQUID FROM THE SOLUBLE COMPONENT; SEPARATION OF DIFFERENT MISCIBLE LIQUIDS.
- CHROMATOGRAPHIC SEPARATION OF THE COMPONENTS FROM THE DIFFERENT MIXTURES (ORGANIC COMPOUNDS, METALLIC IONS ETC).
- DECANTATION, CRYSTALLIZATION, SEPARATION OF THE IMMISCIBLE LIQUIDS, ETC.

PART THREE

TIME PERIOD: XVI - XVIII CENTURY

SOMEWHERE IN THE XVI CENTURY, IT APPEARED THAT ALCHEMISTRY AND ITS GOALS CAN NOT PROCEED TO BE THE LEADING POWER IN CHEMISTRY LABORATORIES AND HUMAN LIVES. IATROCHEMISTRY CAM AS THE RESULT OF A NEW ENTHUSIASM AND INSPIRATION. NEW THEORIES APPEAR. ONE OF THE LEADING ONES BEING PHLOGISTON THEORY. NUMEROUS QUESTIONS ARE RAISED. MANY ANSWERS WERE GIVEN AND THE COMPLEXITY OF THE COMBUSTION CONCEPT AND THE COMPOSITION OF AIR REQUIRED CLARIFICATION.

THE THIRD LABORATORY SESSION IS DEVOTED TO SOME MOST IMPORTANT QUESTIONS WHICH WERE RAISED IN THIS PERIOD OF TIME:

- COMBUSTION (THE WEIGHT OF DIFFERENT SAMPLE RESIDUES AFTER COMBUSTION).
- COMPOSITION OF AIR AND
- THE COMPOSITION OF WATER.
- OXYGEN AND HYDROGEN AND THE CONCEPT OF CHEMICAL ELEMENTS.

LABORATORY WORK PROCEEDS WITH SOME MORE SOPHISTICATED TEST: SAMPLES OF METALLIC MAGNESIUM AND IRON, AND SAMPLES OF CARBON AND SULFUR AND BURNED IN THE AIR AND IN PURE OXYGEN. OBSERVATION AND CONCLUSIONS ARE WRITTEN BY THE STUDENTS. AND DATA USED FOR THE FINAL INTERPRETATION OF THE EXPERIMENTS.

COMPOSITION OF AIR IS OBSERVED BY BURNING PHOSPHORUS IN A BELL GAR PLACED IN A WATER BATH, AND BY MEASURING THE LEVEL OF WATER IN THE JAR. AFTER OXYGEN WAS USED FOR THE COMBUSTION.

COMPOSITION OF WATER IS OBSERVED THROUGH THE EXPERIMENT WITH THE ELECTROLYSIS OF WATER AS WELL AS OF SYNTHESIS OF WATER FROM THE ELEMENTS.

THE STUDENTS USE ALL THE EXPERIMENTAL DATA FOR THE PAPERS DEALING WITH A) PHLOGISTON THEORY B) COMPOSITION OF AIR C) COMPOSITION OF WATER.

PART FOUR

TIME PERIOD: XVIII CENTURY

BEGINNING OF A NEW. MODERN PERIOD OF CHEMISTRY.

AT THAT TIME. THE GREATEST CHEMISTS OF THE PHLOGISTON' ERA ACCUMULATED MOST OF THE DATA THAT WOULD BE REQUIRED FOR THE REFORM OF CHEMISTRY. THEY COULD. UNFORTUNATELY. NOT PERFORM THIS GREAT TASK SINCE THEY WERE TOTALLY DEVOTED TO THE THEORY OF PHLOGISTON. WHICH MISLEAD THEM FROM THE RIGHT WAY. SOMEONE WITH VERY STRONG PERSONALITY. WHO COULD PLAY THE ROLE OF A REFORMER. HAD TO ACHIEVE TWO GOALS: 1. TO DEFEAT THE WELL ESTABLISHED AND STRONGLY DEFENDED PHLOGISTON THEORY AND 2. TO SET NEW PRINCIPLES OF CHEMISTRY.

THIS IS A MOST INTERESTING SET OF EVENTS. THE LEADING PERSONS OF WHICH HAD UNUSUAL. OFTEN TRAGIC DESTINIES.

IN THE FOURTH LABORATORY SESSION. STUDENTS ARE INVOLVED IN MEASUREMENTS: PRECISION AND ACCURACY ARE THE LEADING CONCEPTS. AND THE FEELING OF OBTAINING REPRODUCIBLE RESULTS IS MOST VALUABLE FOR UNDERSTANDING THE COMPLEXITY OF THE EXPERIMENTAL WORK THAT HAS TO PRECEDE THE DECLARATION OF ANY CONCLUSION. SCIENTIFIC THEORY OR SCIENTIFIC LAW.

THE STUDENTS ARE MEASURING LENGTH. VOLUME. MASSES AND DETERMINING DENSITIES OF DIFFERENT SAMPLES. NOW. AFTER ACCUMULATING SOME EXPERIENCES. STUDENTS ARE PREPARED TO PERFORM SOME. MORE SOPHISTICATED EXPERIMENT.

LAW OD CONSERVATION OF MASS: EXPERIMENT WITH BURNING CANDLE ON THE BALANCE PERFORMED IN 2 DIFFERENT WAYS.

LAW OF DEFINITE COMPOSITION: FORMATION OF MGO AND CUS FROM THE ELEMENTS.

PART FIVE

TIME PERIOD: STARTS IN ANCIENT TIMES AND CONTINUES UP TO MODERN TIMES.

CHEMICAL ELEMENTS AND THEIR SMALLEST PARTICLES: ATOMS. REVIEW OF THE THEORIES USING ATOMS AS FUNDAMENTAL UNITS. NAMING CHEMICAL ELEMENTS. CHEMICAL SYMBOLS AND FORMULAS. CLASSIFICATION OF CHEMICAL ELEMENTS AND THE PERIODIC TABLE.

RADIOACTIVITY. MODERN ATOMIC THEORIES.

LABORATORY PART DEALS WITH THE APPLICATION OF PERIODIC TABLE AND THE ABILITY TO PREDICT THE PROPERTIES. TYPES OF COMPOUNDS AND REACTIVITY OF THE ELEMENTS BASED ON THEIR POSITION IN PERIODIC TABLE. AFTER UNDERSTANDING AND ACCEPTING THE DATA OF THE LAST LECTURES. STUDENTS SHOULD BE ABLE TO CORRELATE ELECTRON CONFIGURATIONS OF ELEMENTS WITH THEIR PROPERTIES AND POSITION IN PERIODIC TABLE.

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HONORS SCIENCE/HUMANITIES SEMINAR

GEOLOGY UNIT

The third unit of the Honors Science/Humanities (NSC 102/HUM 175) Seminar afforded the students the opportunity to study the revolutionary developments which have occurred in the geological sciences over the last half century. Fortunately, the students had already been exposed to the sciences of physics/astronomy and chemistry; the geology unit allowed the class to see how principles and concepts from these physical sciences could be applied to the study of Planet Earth.

The major themes weaving through this third unit were time and change, with a special emphasis on the changes in the size, shape and position of the ocean basins and continental masses as a result of plate tectonic activity. Students were given a brief tour of Earth's physical and chemical evolution through its 4.5 billion year plus lifespan. Throughout the unit, emphasis was placed not on what we do know, but rather why do we know it. The multidisciplinary nature of the geological sciences allowed the participants to see how scientists from all areas of expertise have teamed together as participants in one of the greatest paradigm shifts in the history of the science, that being the birth and development of the theory of plate tectonics.

Following an introductory presentation on the nature of the interaction of energy and materials within natural systems, students were introduced to earth materials, with a special emphasis on the igneous and metamorphic rocks. This brief study allowed the students to apply their knowledge of natural elements and chemical bonding to the understanding of the formation of solid natural materials. The group was then shown how these earth materials could be utilized by geologists to determine time, both from relative and absolute perspectives. This study then lead to an understanding of the chronology of geologic time, with the ultimate result being the establishment of a geologic time scale. This time scale, as expressed in a geologic calendar of Earth history, gave the students a temporal framework from which to study the movements of the crustal materials of Planet Earth through time.

Motion, a concept introduced in the physics unit, was next applied to the present day Earth through the study of earthquakes. Through the analysis of the characteristics of seismic waves created by an earthquake, students learned to locate the epicenter of a distant earthquake in a laboratory exercise. A plotting of many years of seismic activity demonstrated present day global zones of weakness and movement in the crustal materials. Students came to appreciate that Earth was "alive" and moving. Further, these zones could be used to delineate boundaries between Earth's great tectonic plates. The depths of the earthquake foci, coupled with a study of first motions of primary seismic waves, helped students see possible directions of movement of crustal masses. The time limitation encountered was that seismic data in various forms has only been recorded for a limited number of years. What information could be found to support Earth movement prior to the observation of and recording of such motions by humankind?

The answer was to be found from the study of a property of crystalline Earth materials of igneous origin containing iron-bearing minerals, that being magnetism, more specifically the paleomagnetism preserved in ancient rocks. The rocks studied now were the crystalline basaltic bedrock layers of the ocean floors. Magnetic anomalies preserved in these ocean floor rocks were plotted on ocean floor base maps. Absolute dates, obtained from radiometric analysis of the rocks, were similarly plotted. Analysis of this data revealed the movements of the ocean floors with the passage of time. In addition, rates of seafloor spreading could be calculated. Students soon discovered that the oldest rocks on the ocean floors were less than 200 million years, yet rocks from the central regions of the continental masses of Earth were much older. Could the movement have only begun coincident with the formation of the oldest rocks found in the oceanic realm? Was critical data missing? What additional data could students now examine to determine if motions had truly occurred earlier in time.

A detour of sorts was taken now to allow students to study the work of Alfred Wegener, the often called 'father of continental drift'. Students were asked to piece together a jigsaw puzzle of continental masses in an attempt to duplicate some of the ideas proposed by Wegener as he postulated the existance of the supercontinent of Pangaea. Students were challenged to determine what evidence in the rocks supported the presence of the supercontinent some 225 million years ago. They discovered that evidence was drawn from physical, chemical, as well as paleontological data. A lab exercise dealing with the drifting of continental masses over the face of a small globe again brought back the application of paleomagnetic data, only this time as a means of showing continental motions prior to the formation of the oldest known oceanic bedrock. In this laboratory exercise dealing with apparent polar wondering data, students were again given the chance to calculate rates of and directions of motion.

A concluding segment of this unit was to demonstrate to these new travelers through time how, assuming they knew the present and past positions of the continents, and then if they knew the present rates and directions of motions, they could project how continents and ocean basins will change and move in time. Students were amazed to see the possible world geology 50 million years hence.

In summary, through the geology unit of the Honors Science/Humanities Seminar, students were introduced to plate tectonics as a unifying model of the geological sciences. This relatively recent theory has provided earth scientists, as well as scientists from all disciplines, the most comprehensive model for the understanding of the way the world works. As a result of this study of the development of the plate tectonics theory, students could experience how scientists work and think. They were exposed to how scientific hypotheses are proposed, tested, modified; accepted, discarded, or revised. Students also gained an appreciation for the fact that they live on a dynamic Earth, one that has been undergoing change since its birth nearly 5 billion years ago. They further saw that through their study of earthquakes, volcanic activity, the opening and closing of ocean basins and the rise, fall and split of continents that their world is still evolving!

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HONORS SCIENCE/HUMANITIES SEMINAR

Geology Unit
Laboratory Investigations

The laboratory investigations used in the geology unit of the honors science/humanities seminar were designed to show students how earth scientists investigate their global home. As Planet Earth is too large to bring into the laboratory, students were introduced to mapping and modeling skills as a means of representing their home in a smaller, more workable format.

The first laboratory introduced the students to solid earth materials, especially the igneous and metamorphic rocks. Students were shown how earth scientists 'read' rocks to reveal clues into their origin and subsequent past history. The second lab, an earthquake lab, showed students how we know Earth is a dynamic body and where, via being able to locate the epicenters of earthquakes, the major zones of motion are located. The third and fourth labs both concentrated on the use of paleomagnetic data preserved in the rocks as a source of information regarding continental and seafloor motions.

The first paleomagnetism lab utilized data for ocean floor basaltic bedrock as a means of showing seafloor spreading. This lab investigation concentrated on magnetic anomalies preserved in ocean floor bedrock which show a periodic reversal of Earth's magnetic field.

The subsequent lab utilized data from continental rocks to verify movement of continental masses prior to the ages of the oldest known oceanic bedrock materials. This lab presented students with data taken from rocks samples of varying ages from the continents of Africa and South America. For each sample, a radiometric age was given, as well as the apparent position (latitude and longitude) of the South Magnetic Pole at the time of the rocks solidification as revealed by the paleomagnetism. Students first plotted data taken from the continent of Africa on a small plastic globe. The data plot revealed the apparent position of the South Magnetic Pole taken from these African rocks, and a connecting of the points with respect to time revealed an apparent polar wandering (migration) across the face of the planet with the passage of time. A plotting of similar data taken from South American rocks was completed on a clear plastic hemisphere overlay. This curve also showed an apparent movement of the South Magnetic Pole, however, the data taken from the two continents located in their present position appeared to support the notion of two separate and distinct South Magnetic Poles. Students were challenged with some thought questions dealing with the possibility of two poles, and they were asked to propose alternative explanations for their observations.

Students were then instructed to "drift the continents". As continental motion could now be accomplished through the sliding of the clear plastic hemisphere containing the South American data over the base globe having the African data, students could now match up the continental shapes and, to their surprise, the apparent polar wandering curves also came together, forming a single curve for the majority of the length of the plotted data. However, after a specific date, the now single curve separated again into two distinct segments. Students were now presented with a new set of problems. When the continents did fit back together, the curves likewise did, but as the curve was plotted represented an apparent motion with the passage of time, how could they explain the apparent motion even when the curves were joined? How could they explain the split of the two curves, even though the continents were joined. Were there now two poles at a unique point in time, or could there be another explanation?

Having seen how paleomagnetic evidence could be used as a guide in the joining of two continental masses, the lab exercise concluded with the students being asked to assemble a jig-saw puzzle consisting of several continental shapes. Continental outlines containing a variety of geological, paleontological, and paleoclimatic data were to be reassembled into a single supercontinent. This exercise was an attempt to duplicate some of the work of Alfred Wegener; those students who were careful in their observation and interpretation of the data before them did manage to piece together a reasonable representation of Pangaea. Those who had not yet honed they puzzle solving skills produced maps of an even stranger and foreign world. This final exercise hopefully provided more fun than frustration to the students, but it did tend to demonstrate how different people might interpret the same data in various ways to obtain very different results!

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