Natural Sciences 1:
Laws and Models in Chemistry

Natural Sciences 1: Laws and Models in Chemistry, traces the efforts in Western thought to understand what makes up the physical world—what remains the same in the midst of change. At its most basic level, Natural Sciences 1 addresses the questions: What is "stuff"? How does "stuff" behave? How do we know that?

The story spans the insights of the natural philosophers before Plato through the chemists of the nineteenth century, who began to think that electricity and "stuff" were the same thing. As a part of understanding the answers to this question, we will learn some of the methods used—ancient and modern—and the ideas produced by these efforts.

The methods are important. Because science is in large measure a technical activity, we have to acquire some technical language and practice in order to discuss and evaluate it. In this way it is like baseball. We might be amused or annoyed—but certainly not enlightened—by a person who held forth on the strengths and weaknesses of baseball if that person didn't even understand a ground ball, a home run, a steal, or a double play. On the other hand, we might respect their ideas if they had knowledge gained from both theory and practice. In Natural Sciences 1 we gain our knowledge by following the developing scientific explanations of burning, of heat, and of the nature of the atmosphere.

As part of the learning process, we will be performing a few simple experiments. You will be asked to reflect in some depth on the experiments in which you participate.

Table of Contents

The contents of this syllabus are as follows:

Texts

Required

The following works are required:

Aristotle, *Physics*
Bacon, *Novum Organum*, Book 2
Boyle, "Touching the Spring of the Air"
Boyle, "Boyle's Law"
Cannizzaro, *Sketch of a Course of Chemical Philosophy*
Joule, "On the Mechanical Equivalent of Heat"
Lucretius, *On the Nature of Things*
Periodic Table
Pascal, *Scientific Treatises*:
"New Experiments Concerning the Vacuum"
"Account of the Great Experiment"
"On the Equilibrium of Liquids. . ."
"On the Weight and Mass of the Air"
Wheelwright, *The Presocratics* (selections)

Also required are selected articles by the following authors, listed in approximate chronological order:

Leibniz, Stahl, Macquer, Priestley, Lavoisier, Black, Thompson, Dalton, Gay-Lussac, Avogadro, Berzelius, Dulong and Petit, and Mendeleev

Course Readings

A list of the books and articles used in this course follows in the order in which they are read. Additional assignments will be announced in class.

Aristotle, *Physics*
Bacon, *Novum Organum*
Shamos, *Great Experiments in Physics*
Lucretius, On *the Nature of the Universe*
Wheelwright, *The Presocratics*
Shimer College Reprints:
Avogadro, *A Manner of Determining the Relative Masses . . .*
Berzelius, *Electrochemical Theory, Chemical Symbols and Formulas*
Black, *Lectures on the Elements of Chemistry*
Cannizzaro, Sk*etch of a Course of Chemical Philosophy*
Dalton, 1810 Extract, *Absorption of Gases, Atomic Principles of Chemistry,* "Letter to Nicholson," 1808 Extract
Dulong and Petit, *Atomic Weights and Specific Heat*
Gay-Lussac, *On the Combination of' Gaseous Substances . . .*
Lavoisier, *Memoir on the Calcination of Tin . . .*, *Elements of Chemistry* (selections)
Macquer, *A Dictionary of Chemistry, The Theory and Practice of Chemistry* (excerpts)
Mendeleev, *The Relation between Properties and Atomic . . .*
Modern Periodic Table
Pascal, *Scientific Treatises*
Priestley, *On Dephlogisticated Air*

Stahl, *On Sulfur* (excerpts)
Thompson, *Source of the Heat Which Is Excited by Friction*

Pitfalls

Being born in the twentieth century, we have a distinct disadvantage in this class. Even non-scientists today know much about modern scientific answers. However, in class discussions we will operate on the assumption that being born in the twentieth century should not be confused with having wisdom. We will remember that each author is an intelligent, insightful investigator. The elements of an author's work which appear rustic or silly to us probably appear so because we have failed to understand what is significant to the author. Rather than trivialize an author's work by treating it as an outdated opinion that we have advanced beyond, we will bring the authors and ourselves into genuine conversation by searching for the integrity of their contributions, even if what they say seems strange or just plain wrong at first. We seek to converse and engage in a dialogue with the author

The same skill of energetic open-mindedness which we apply to the readings we should also apply to one another. We can work together and develop this skill carefully following the thread of each conversation and by sympathetically understanding each person's position in the conversation—particularly when we disagree with that position. You should be able to repeat each person's argument with precision and force. In addition to thinking through the evolution of our culture's ideas about the material world, a fundamental objective of the course is the development of our dialogal abilities, the abilities that enable us to inquire together as a group.

Course Requirements

At the beginning of each class period, certain pre-selected members of the class will distribute a very short (one-paragraph) *focus statement* concerning the readings for that period. Focus statements consist of a few sentences that state what you would like the class to focus on during that class period. You might have a question, a place in the text you want us to discuss, or an issue you wish to bring up. These will provide the class with an initial focus and a way to set the agenda for that day's discussion.

During the first class, responsibility for a *written summary* of each class session for the next several weeks will be assigned to individual students. Your summaries should concentrate on the class discussion. What questions were raised? What questions were answered? What were left unanswered? The summary should be helpful to anyone who has missed a class. Summaries should consist of a single double-spaced typed page and are to be distributed at the beginning of the following session.

Each of you will also write at least *two short papers* (typed, double-spaced, about four pages) on a relevant topic you choose. The first paper will describe a system that explains what changes and what remains the same when we observe change in the physical world. The second paper will be on a relevant topic of the student's choosing. (See the syllabus below for the due dates of these papers.) If you have what you think is a good topic but you're unsure, ask me.

Finally, each student will receive additional problem-oriented assignments, one of which will serve as a final exam. The *final examination* will include some problems and a short essay on an assigned question. Students are encouraged to discuss the exam questions with each other, as long as they do their actual writing alone.

Grades for late papers will be dropped 5 percent per calendar day late (*calendar* day, not *class* day). I am happy to comment on drafts submitted to me at least one week before the due date. You can also submit one rewrite for each paper after it is graded; the final grade for the paper will be an average of the grade for the original and the rewrite.

Your course grade will be based upon the following: class participation (quality as well as quantity), 40 percent; papers, 40 percent; focus statements and summaries, 10 percent; problems and final exam, 10 percent.

If you have any difficulty with the class or the readings, or if you have any suggestions, please talk with me. Don't wait.

Student Competencies

The heart of the Shimer educational method is the encouragement and practice of those skills that will make lifelong learning possible. To this end, certain commitments and competencies are expected to be developed in Natural Sciences 1. These include:

- Commitment to one's own learning. This is measured by your attending classes, letting others know what you *do* and *don't* understand, and identifying for yourself issues of safety in the class discussion.
- Reading the source materials for the class carefully and completely
- Asking genuine questions within the discussion
- A growing ability to recapitulate someone else's point of view. This is demonstrated by the other person agreeing that you have done full justice to his or her position.
- The ability to understand and express your emotional reactions to the readings and to the process of learning
- The ability to write effectively

Syllabus

September

5	Wheelwright	*The Presocratics*, pp. 31–63
6		*The Presocratics*, pp. 64–89
10		*The Presocratics*, pp. 90–119
12		*The Presocratics*, pp. 120–136, 143–154
13		*The Presocratics*, pp. 200–229
17	Lucretius	*On the Nature of Things,* Bk. 1

19		*On the Nature of Things*, Bk. 2
20	Aristotle	*Physics*, Bk. 2, ch. 1–7
24		*Physics*, Bk. 3, ch. 1–3
26		*Physics*, Bk. 4, ch. 1–9
27	Pascal	"New Experiments Concerning the Vacuum" "Account of the Great Experiment"

October

1		"On the Equilibrium of Liquids"
3		"On the Weight and Mass of the Air"
4	Boyle	"Touching the Spring of the Air" "Boyle's Law" FIRST PAPER DUE
8	Bacon	*Novum Organum,* Bk. 2 (through aphorism 22)
10		*Novum Organum*, Bk. 2 (through aphorism 22)
11	Lavoisier	*Elements of Chemistry* (to p. 15)
17	Black	*Lectures on the Elements of Chemistry*
18	Thompson	*Source of the Heat Which Is Excited by Friction*
22		LAB
24	Joule	"On the Mechanical Equivalent of Heat"
25	Stahl Macquer	*On Sulfur* (excerpts) *A Dictionary of Chemistry* (excerpts)
29	Macquer	*Theory and Practice of Chemistry* (excerpts)
31	Priestley	*On Dephlogisticated Air*

November

1	Lavoisier	*Memoir on the Calcination of Tin . . .*
5		*Memoir on the Calcination of Tin . . .*
7		*Memoir on the Calcination of Tin . . .*
8	Dalton	*Theory of the Absorption of Gases* *Atomic Principles of Chemistry*
12		"Letters to Nicholson" 1808 Extract
14	Gay-Lussac Dalton	*On the Combination of Gaseous Substances* 1810 Extract
15	Avogadro	*A Manner of Determining Relative Masses . . .*
19	Dulong/Petit	*Atomic Weights and Specific Heat*
21	Berzelius	*Electrochemical Theory*
22		*Chemical Symbols and Formulas* SECOND PAPER DUE
26	Cannizzaro	*Sketch of a Course of Chemical Philosophy*

December

3		*Sketch of a Course of Chemical Philosophy*
5	Mendeleev	*The Relation between Properties and Atomic . . .*
6		*The Relation between Properties and Atomic . . .*
10		Modern Periodic Table FINAL EXAM DUE