

## NATURAL SCIENCES 1 (NS1) *Laws and Models in Chemistry*

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### Introduction

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, Nat Sci 1 addresses the questions:

What is "stuff"?  
How does "stuff" behave?  
How do we know that?

The story includes the insights ranging from the natural philosophers before Plato through the chemists of the 19<sup>th</sup> 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 NS 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 practice, we will be performing a few simple experiments. You will be asked reflect in some depth on the experiments in which you participate.

### Dialog

Being born in the 20<sup>th</sup> century, we have a distinct disadvantage in this class. Even the non-scientists today know much of 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 Rather than trivialize an author's work by treating it as an outdated opinion that we have advanced beyond, we will bring the authors and ourselves into genuine conversation by searching for the integrity of their contributions,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 dialog 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.

### Student Competencies

The heart of the Shimer educational method is the encouragement and practice of those skills that will make possible lifelong learning. 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*  
Demonstrated by the other person agreeing that you have done full justice to his/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*

In addition to the above, certain competencies are specific to Nat Sci 1. These include the ability to:

- *Describe the different types of causes and identify what type or types science uses.*
- *Balance the notions of change and constancy in a description of the world.*
- *Describe the basic behavior of air, especially its weight, pressure and volume.*
- *Explain what atoms are and describe experiments to support your position.*
- *Explain what heat is and describe experiments to support your position.*
- *Explain what a chemical equation means.*

Finally, these represent the key and basic objectives identified by the teacher. No list of objectives is rich enough to exhaust these readings, and I hope that you will identify your own objectives that go beyond these.

### **Grading**

At the beginning of most class periods, preselected members of the class will distribute a short (about one page) *written 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 set of questions, 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.

You will also write a short paper, about four to six pages double-spaced. It will describe a system of natural philosophy of your own creation that explains *what changes* and *what remains the same* when we observe change in the physical world. In it, you will describe a world view in which you balance two issues: *if we observe change in the world around us, why isn't the world chaotic*, and *if the world is orderly and consistent, why isn't it rigid and unchanging?* It will be due Midnight, **9/18**. I encourage students to email their papers to me; putting it in my mailbox is also OK. Either way, it **MUST** be on-time. I allow rewriting of on-time papers, so it's better to hand it in 'imperfect' and fix it later than to get no credit at all.

You will also receive additional problem-oriented assignments, one of which will serve as a final exam. The final 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. Your course grade will be based upon the following: class participation (quality as well as quantity) 40%, paper 30%, problems and final exam 20%, focus statements 10%.

### **Class attendance**

Each student is expected to attend every class session on time—*every tardiness or absence from class counts against your participation grade*. Further, you are subject to failing the course if you miss four (4) class sessions. The instructor will warn the student after two (2) such absences. After four absences, the student may continue and pass the course under a rigorous contractual agreement with the instructor. If you must miss a class, please let me know in advance.

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

## Course readings

Aristotle, The Physics

Bacon, The 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
Curie	1911 Nobel Lecture, On Radioactivity
Cannizzaro	Sketch of a Course of Chemical Philosophy (to p. 34)
Clausius	On the Nature of the Motion that We Call Heat
Dalton	1810 Extract, Absorption of Gases, Atomic Principles of Chemistry, Letter to Nicholson, 1808 Extract
Dulong & 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	Excerpts from A Dictionary of Chemistry, The Theory and Practice of Chemistry
Mendeleev	The Relation Between Properties and Atomic . . . , The Periodic Table
Pascal	Scientific Treatises
Priestly	On Dephlogisticated Air
Stahl	Excerpts from On Sulfur
Thompson	Source of the Heat Which is Excited by Friction

## CALENDAR

<b>Aug</b>	22	Presocratics	pp. 31-63	15	Thompson (Rumford)	Source of the Heat Which is Excited by Friction	
	25		pp. 64-89	20	Joule	On the Mechanical Equivalent of Heat (Shamos)	
	27		pp. 90-119	22	Lab		
	29		pp. 120-136, 143-154	24	Dalton	Theory of the Absorption of Gases Atomic Principles of Chemistry	
<b>Sep</b>	3		pp. 200-229	27		Letters to Nicholson (one each by Bostock and Dalton) 1808 Extract	
	5	Lucretius	On the Nature of The Universe Book I	29	Gay-Lussac	On the Combination of Gaseous Substances. . .	
	8		On the Nature of The Universe Book II		Dalton	1810 Extract	
	10	Aristotle	<i>Physics</i> , II 1-7,	31	Avogadro	A Manner of Determining the Relative Masses...	
	12		<i>Physics</i> , III 1-3, IV 1-5	<b>Nov</b>	3	Dulong-Petit	Atomic Weights and Specific Heat
	15		<i>Physics</i> , IV 6-9		5	Clausius	On the Nature of the Motion that We Call Heat, Sections 1-15
	17	Pascal	New Experiments Concerning The Vacuum (including the Preface) Account Of The Great Experiment		7	Berzelius	Electrochemical Theory
	18		<i>First paper due</i>		10		Chemical Symbols and Formulas
	19		On The Equilibrium Of Liquids		12	Cannizzaro	Sketch of a Course of Chemical Philosophy (to p. 34)
	22		On The Weight And Mass Of The Air		14		Sketch of a Course of Chemical Philosophy (to p. 34)
	24	Boyle	Touching the Spring of the Air (in Shamos) -- Boyle's Law		17	Mendeleev	The Relation Between Properties and Atomic. . .
	26	Bacon	<i>Novum Organum</i> - Book II through aphorism #20		19		The Relation Between Properties and Atomic. . .
	29		<i>Novum Organum</i> - Book II through aphorism #20		21		The Periodic Table
<b>Oct</b>	1	Lavoisier	Elements of Chemistry (to p. 15)		23		Final Exam due
	3	Black	Lectures on the Elements of Chemistry		24	Curie	1911 Nobel Lecture <i>On Radioactivity</i>
	6	Macquer	Excerpts from A Dictionary of Chemistry Theory and Practice of Chemistry				
	8	Priestly	On Dephlogisticated Air				
	10	Lavoisier	Memoir on the Calcination of Tin...				
	13		Memoir on the Calcination of Tin...				