Philosophy of Nature

Course Guide for PHIL 3013

John G. Brungardt

First Edition
Spring 2026

The School of Catholic Studies, Newman University

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Colophon
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Nature loves to hide.

– Heraclitus

Contents

In memory of

Fr. Benedict M. Ashley, O.P.

Fr. William A. Wallace, O.P.

Fr. James A. Weisheipl, O.P.

Requiescant in pace.

Newman University

Phil 3013 A – Philosophy of Nature

Spring 2026 (16 Weeks)

Time: MWF 1:00pm–1:50pm **Place:** Eck Hall 136

Instructor:	**John G. Brungardt, Ph.D.**
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Office Hours:	MWF 10–11am; TR 1–2pm (OBA)

Caritas Christi Urget Nos
Newman University is a Catholic university named for
St. John Henry Newman and founded by the Adorers of the Blood of Christ
for the purpose of empowering graduates to transform society.

Course Description: Explores fundamental questions about the nature of the cosmos, focusing on the tradition of Aristotelian-Thomistic philosophy of nature and science, along with the engagement of alternative views (e.g., Platonism, materialism, or scientific naturalism), as a groundwork for higher systematic studies. Topics include physical substance, the natural vs. the artificial, causality and change, space and time, the intelligibility of motion, and the place of humanity in the cosmos.

Prerequisites: None. **Instructional Methods:** Face-to-face modality. Lecture by way of Socratic discussion; written assignments; (possible) quizzes or oral exams, & (definite) final exam.

Course Goals: The goal of this course is to introduce students to the principles of the perennial philosophy of nature in the Arisotelian-Thomistic tradition. **By the end of this course, the diligent and attentive student should:**

(1) understand the scope and range of the philosophy of nature and its desire to know the cosmos;
(2) know and be able to articulate and apply the fundamental principles of the philosophy of nature, especially those set forward by the Aristotelian-Thomistic tradition;
(3) be more familiar with the basics of and understand key principles and methods in the logic of scientific discovery and proof as exemplified in the history of the natural sciences;
(4) appreciate and be able to articulate details about the order of the cosmos and various philosophical approaches to modeling and theorizing about the cosmos.

Course Materials:

- Aristotle. *Physics, or Natural Hearing*. Translated by Glen Coughlin. St. Augustine's Press, 2004.
- Augros, Robert, and George Stanciu. *The New Biology: Discovering the Wisdom in Nature*. Principle Source Publisher, 2013.
- Brungardt, John G. *Natural Philosophy: An Introduction*. Catholic Handbooks Series. ECT Press, 2025.
- Plato. *Timaeus*. Translated by Peter Kalkavage. 2nd ed. Focus, 2016.
- Shelley, Mary. *Frankenstein*. Edited by Joseph Pearce. Ignatius Press, 2008.

– Wallace, William A. *The Modeling of Nature: Philosophy of Science and Philosophy of Nature in Synthesis*. The Catholic University of America Press, 1996.

Course Parameters:

This class requires diligent, daily preparation. It is better to do a little bit every day towards the following major categories for assessment. The completion of all work assigned in the following categories is required to pass the course.

Course Requirements	Value
Attendance and Participation	15%
Four Essays	25%
Written Exams (3)	30%
Final Exam	30%

The essays and exams are weighted differently; please see Canvas for more details.

All assignments must be completed. If one or more of these are not completed, then the class attendance and participation grade will be a zero.

Participation: Classes are a mix of lecture, Q&A, and discussion of the assigned reading and the topic material. Active, quality participation is expected and will be encouraged.

Attendance means showing up to class, bringing all assigned readings, and paying attention. Participation means taking notes, contributing to class discussion, and asking questions. To encourage participation, the instructor may divide the class into discussion sections.

Participation cannot be earned if students are distracted during class (e.g., on their cell phones). Besides, the use of electronic devices are not allowed in class.

Details about the written assignment will be provided both in class and via Canvas.

Essay	Subject	Date Assigned	Date Due
(1)	Timaeus Essay	Mon, Feb 9	Fri, Feb 20
(2)	Aristotle Essay	Fri, Mar 6	Fri, Mar 27
(3)	Wallace Essay	Mon, Mar 30	Fri, Apr 17
(4)	Cosmos Essay	Mon, Apr 20	Wed, May 6

Examinations: All examinations are written, in class, and cumulative. For the final examination, the time is scheduled by the University and cannot be changed.

Final Exam: Monday, May 11, 1:00pm–2:50pm

Grading Scale: For a detailed qualitative description of the grading scale at Newman University, please refer to the University 2020–2021 catalog. The scale is as follows:

Letter	Numerical	GPA	Qualitative
A =	90–100	4.0	Extraordinary
B =	80–89	3.0	Good
C =	70–79	2.0	Average
D =	60–69	1.0	Marginal
F =	59 or less	0.0	Failure

Course Parameters: Policies

Instruction: The instructor is committed to your educational successes when taking this course. Please contact him or attend office hours (or set up an appointment), for all questions and concerns related to this course.

Attendance & Absences: This is mandatory, since a large part of philosophy consists of discussing and defending your views. Five or more unexcused absences may lower your grade by one full letter. Missing more than ten classes, whether as excused or unexcused absences, will typically result in failure of the course. The instructor will consider excusing an absence only if students communicate in a timely fashion the reason for their absence and request that the absence be excused. Student athletes must email the instructor a playing schedule at the start of the semester.

Attendance in person: Roll will be taken at the beginning of every class period. A late arrival occurs when a student arrives after roll has been completed, and an early leave occurs when a student leaves class before class has been dismissed by the instructor. Students who arrive late must see one of the instructors after class so as to be marked present. A student who leaves early without permission obtained prior to beginning of class will be marked absent.

Attendance via web/video: Only when applicable due to extraordinary circumstances. Cameras must be on for the duration of class, and students must have working microphones.

Assignments: These are announced primarily via Canvas. The student is entirely responsible for completing assignments and turning them in to the instructor on time. All reminders are a courtesy.

Late Work: All late work is subject to a penalty of one letter grade per class day beyond the due date.

Examinations & quizzes: All such can only be made up due to grave reasons (e.g., due to illness with a doctor's note—interference with holiday travel plans is not a reason). The date and time of the final examination, which is scheduled by the University, can be changed only under certain stringent conditions.

Reading: A philosophical text requires attention to order, discrimination of detail, and much thought, because the philosophers we are reading make deep claims about reality. The average assignment in this course, if read with due diligence, will take from one to two hours.

Class Conduct: Students are expected to be disciplined, decorous, and diligent. Class decorum includes the use of the polite form of address (e.g., "Mr." or "Miss" with surname), and follow other

customs of etiquette. The Catholic tradition witnesses to the dignity of each human person. This entails respect for the human person who expresses his or her identity within a diverse range of perspectives (race, gender, culture, age, religion, socioeconomic level, experience, etc.). Exposure to diverse points of view is encouraged as they may contribute to the overall wealth of this community of learners.

No food is permitted in class; drinks in containers are allowed. The use of cell phones (unless for authorized class activities) is prohibited; the use of laptops is not permitted.

Academic Integrity: As a student, especially in a philosophy course where the aim is truth, academic integrity is an issue of the highest importance. Academic dishonesty in any form (e.g. plagiarism, cheating, lying, improperly collaborating on work) will not be tolerated. The work you turn in must be your own, and any use of the ideas of others must be properly cited.

In this course, the default penalty for academic dishonesty is a final grade of "F" on that assignment, and all such incidents are reported to the Provost. However, penalties will be assessed according to circumstances; the maximum penalty for academic dishonesty is failure of the course (see details below).

Please also note that the University may dismiss a student for ethical infractions. Please see the Course Catalog for further details, set forth in the University's "Ethics Code." If you have any questions about what constitutes academic dishonesty, please do not hesitate to ask the instructor.

Details: The automatic penalty for plagiarism is a complete loss of points for that assignment and its being reported to the Provost for an ethical infraction. If the assignment is a relatively minor one (typically: worth 3% or less of the total grade for the course) *and* it is the student's first infraction in the course, then the automatic penalty will be applied and will serve as a warning. However, if the assignment is not a minor one *or* it is not the student's first infraction in the course, then the default penalty will be failure of the course.

Use of Artificial Intelligence: The use of any artificial intelligence (AI) tools to generate the final product of any assignment in this class is prohibited. The use of AI tools as aids for preparatory work is permitted, but students must inform the instructor of this in writing, describing and attesting to how the tools were used.

Ethical Code: Each member of the Newman University community is expected to conduct themselves according to the Newman Code. The class will follow the "Ethical Code" Both may be found in the current Student Planner Handbook.

Accommodations: If any member of this class feels that he or she has a disability of any nature whatever, the instructors and the Office of Disabled Student Services will work with you to provide reasonable accommodations to ensure that you have a fair opportunity to perform in this class. Please advise the instructors of such a disability and the desired accommodations at some point before, during, or immediately after the first scheduled class period.

Opportunities for Academic Assistance: The Newman University community is committed to your academic success. **At any time that you feel a need, you may access the following support services directly from the Student Success Center, Dugan Library and Conference Center, Ext. 2318:**

- Tutoring with subject tutors across multiple disciplines
- Online tutoring through TutorMe (found on Canvas)

- Confidential Project Care referrals
- Disability Support Services
- International Student Services
- Career Services and support
- Make-up Exams (found at: https://newmanu.accudemia.net/login)
- **Opportunities for Counseling Services:** Twelve free in-person counseling sessions per year (Dugan Library and Conference Center, Ext. 2318); Or unlimited Telehealth Sessions: UWill Mental Health and Wellness: register with NU email address at https://app.uwill.com/

Libraries: Dugan Library provides a print book collection as well as access to millions of full-text articles for immediate download. Print books may be checked out for 30 days. The research databases can be accessed at any time from both on and off campus. You will need your campus login to access the online resources. LibGuides provided on the library website contain specific information on accessing and using resources: newmanu.libguides.com.

In addition to the print books and full-text online articles, all students have access to interlibrary loan at no charge. Books not owned by Dugan Library may be borrowed from a network of thousands of libraries across the country. Copies of articles that are indexed but not available full-text in the databases can also be requested at no charge to students.

Our librarians are able and willing to assist you through the research process. They are available to answer questions about the library, its resources and how to use them effectively. Individual appointments for research are available. Email, phone or stop-by the library for assistance.

Wesley Cornett, cornettw@newmanu.edu or 316-942-4291 ext. 2107

Disclaimer: The above policies are not meant to be exhaustive by foreseeing every exigency that can arise during the conduct of the course. The instructor reserves the right to use his prudential judgment to best meet the needs of students for the successful completion of the course. The following course outlines may be modified according to the instructor's prudential judgment so as to best meet the concrete needs of the students in the course. In either circumstance, students will be informed should such changes be necessary.

Notes on the Reading of Philosophical Texts

(*with thanks to Dr. V. B. Lewis*)

(1) **You haven't read a book once until you've read it twice.** First read a book or assignment quickly through to get a sense of the overall argument and architecture. Reread it slowly for details and consistency.
(2) **Be naïve.** When you begin to study a great book, try to understand it as its author did. Put aside—at least initially—questions of historical context and biography and try to understand the argument as if it were addressed to you by a wise and honest friend. Treat the author as your teacher. Begin with the assumption that you have something important to learn. Criticism and evaluation are pointless if one does not first establish the most complete and plausible meaning of the author's argument.
(3) **Treat nothing as an accident.** Read a great book as if every word were essential. Often the most important statements elude us because we read past them due to carelessness or complacency. This is especially important in cases where one detects what appears to be an obvious contradiction or lapse in logic. Often, such apparent or intentional blunders are intended to point the careful reader to more sustained thought about the matter under consideration.
(4) **Read actively (mentally).** Great books mean to educate us about the world, so keep the world in mind when reading. Treat the question being discussed as a live question, one that it is important for you to resolve or at least to clarify.
(5) **Read even more actively (physically).** Read with pencil and paper ready. Mark up you texts, make lists, take notes, and construct summaries and outlines. It is often useful to make one's own index while reading so that specific passages can be easily recalled and compared. Scribbling down definitions of key terms that are peculiar to the author or text is also useful.
(6) **Read in a thinking-friendly environment.** Read in a quiet place, where you will not be distracted or disturbed. Take a short break every 45 minutes or so in order to recharge and allow for renewed concentration.
(7) **Keep a Reading Notebook.**

"[The Greek writers] took it for granted that the reader would actively think; and the writer's sentences were to serve as so many blazes to enable him to follow the track of that writer's thought." (C. S. Peirce, *The New Elements of Mathematics*, vol. 4, p. 236)

"The worst readers are those who proceed like plundering soldiers: they pick up a few things they can use, soil and confuse the rest, and blaspheme the whole thing." (Friedrich Nietzsche)

Course Reading Schedule

In the table below, *CG* refers to this *Course Guide*. Various materials in and around the indicated sections of the *Course Guide* should be read alongside the assigned sections. This is clear from context.

Week	Mon	Wed	Fri
1	Jan 19: **MLK Day**	Jan 21: Introduction	Jan 23: *CG*, ch. 1
2	Jan 26: *CG*, 2.1–2	Jan 28: *CG*, 2.2	Jan 30: *CG*, 2.3–4
3	Feb 2: *CG*, 3.1–2	Feb 4: *CG*, 3.3–4	Feb 6: *CG*, 4.1–2
4	Feb 9: *CG*, 4.3	Feb 11: *CG*, 4.4–5	Feb 13: *CG*, 5.1–2
5	Feb 16: **Exam 1**	Feb 18: *CG*, 5.3	Feb 20: *CG*, 5.4
6	Feb 23: *CG*, 5.5–6	Feb 25: *CG*, 6.1–2	Feb 27: *CG*, 6.3
7	Mar 2: *CG*, 6.4	Mar 4: *CG*, 6.5	Mar 6: *CG*, 6.6
8	Mar 9: *CG*, 6.7	Mar 11: **Exam 2**	Mar 13: *CG*, 7.1–2
	Spring Break March 16–22		
9	Mar 23: *CG*, 7.3	Mar 25: *CG*, 7.4–5	Mar 27: *CG*, 8.1–2
10	Mar 30: *CG*, 8.3	Apr 1: *CG*, 8.4	Apr 3: **Easter Break**
11	Apr 6: **Easter Break**	Apr 8: *CG*, 8.5	Apr 10: *CG*, 8.6
12	Apr 13: *CG*, 8.7–8	Apr 15: *CG*, 9.1–2	Apr 17: **Exam 3**
13	Apr 20: *CG*, 9.3	Apr 22: *CG*, 9.4	Apr 24: *CG*, 9.5
14	Apr 27: *CG*, 9.6	Apr 29: *CG*, 9.7	May 1: *CG*, 9.8
15	May 4: *CG*, 9.9–10	May 6: *CG*, ch. 10	May 8: **Scholar's Day**
16	May 11–14: **Final Examinations**		

For reference, other dates are below:

Key Dates: MLK Day, January 10; Last day to add/drop is January 26;
Spring Break, March 16–22; Easter Break, April 3–April 6; Scholar's Day, May 8
Final Exam: Monday, May 11, 1:00pm–2:50pm

Dates for the four essays:

Essay	Subject	Date Assigned	Date Due
(1)	Timaeus Essay	Mon, Feb 9	Fri, Feb 20
(2)	Aristotle Essay	Fri, Mar 6	Fri, Mar 27
(3)	Wallace Essay	Mon, Mar 30	Fri, Apr 17
(4)	Cosmos Essay	Mon, Apr 20	Wed, May 6

Protrepticus

> The perfection of contemplation is found in moral philosophy, which is concerned with the ultimate end. The fullness of contemplation is possessed by natural philosophy, which considers things as proceeding from God. Among the physical sciences, the height of contemplation is found in metaphysics.
>
> – St. Thomas, *Super Iohannem*, prooem., n. 9

The comparison St. Thomas makes between the major parts of philosophy in the passage quoted above is striking. To moral philosophy (*scientia moralis*) is attributed perfection because it studies the end-goals of human actions, the goods we can achieve or do that make us more perfect as human individuals. Metaphysics is given the height of contemplation because it studies the highest things—especially God. However, natural philosophy (*scientia naturalis*) has a fullness of contemplation because it studies the things that proceed from God, the creatures we found in the universe. Such is the part of philosophy we intend to study in this course.

Prolegomena

The sequence of studies here at Newman for the Philosophy for Theological Studies major is designed with a long tradition of philosophical and theological education in mind. The purpose of this protrepticus* is to inform you, the students, about some of this background, how it orders the sequence of courses overall, and to exhort you to the study of this particular course.

Now, there are certain preparations required for the study of philosophy, or the love and pursuit of wisdom. Foundational requirements include proper dispositions of imagination, experience, desire for the truth, and intellectual wonder. These cannot be taught. However, they can be recognized and emulated.

The formal preparatory requirement for philosophy, long recognized since the time of Aristotle, is the study of logic. Logic is the

* The word means "a piece of writing or speech intended to persuade or instruct, via late Latin from Greek *protreptikos* 'instructive', from *pro-* 'before' + *trepein* 'to turn'." (New Oxf. Am. Dictionary) Aristotle's own "protrepticus" exhorting his students to the study of philosophy was lost, and now exists only in fragmentary quotations in other ancient authors.

art or science of right reasoning. Habituation in logical thinking enables you to reason well, easily, and without error.

The informal preparation is the study of the history of philosophy. Philosophy's own history introduces you to various traditions of philosophical inquiry (note the plural). Despite the many perspectives or systems we encounter, do not despair at finding the truth. Rather, study the history of philosophy to see agreement about key questions and principles for finding an answer; we ought not focus on studying the details of disagreements among philosophers as if such a study were philosophy itself. These courses use philosophy's own history to motivate you towards a more disciplined, attentive wonder about resolving philosophical questions, for philosophy is not easy.

What about studying philosophy itself? The most fundamental division of philosophy follows from the nature of the pursuit of wisdom. Since wisdom is knowledge in virtue of first and fundamental principles, and knowledge must be of the truth, the divisions of wisdom and of its pursuit arise from the distinction of the truths knowable through first principles.

On the one hand, some truths we seek to know for their own sake. For instance, the mathematician delights in knowing that lines cannot be represented by rational numbers, or the physicist marvels at the idea that mass and energy are convertible. On the other hand, some truths we seek to know for the sake of doing something or acting well. For example, through careful reflection upon our own experience and those of others, we learn about friendship, we can begin to see its goodness, and then seek ways to bring it about in our lives.

If we seek truth for its own sake, this is a sort of contemplative knowledge, or "speculative" knowledge, in an older sense of that word. If we seek truth for the sake of doing or acting, this is a sort of practical knowledge. Consequently, philosophy is divided into speculative and practical parts. Speculative philosophy studies the order of things and their causes that exists already, before any knowledge or activity on our part. Practical philosophy, by contrast, studies an order of things and their causes that depend upon our knowledge and are only brought about through our activity.

Consider the courses in the Philosophy for Theological Studies major according to these distinctions. They are arranged as follows. (Note: The Philosophy of the Human Person is included in both divisions because the content of the course includes aspects of both speculative and practical philosophy, although the course is primarily speculative.)

- Preparatory Sequence
    - PHIL 1023 Logic
    - PHIL 2023 Ancient Philosophy
    - PHIL 2033 Medieval Philosophy
    - PHIL 2063 Modern Philosophy
- Practical Philosophy Sequence
    - PHIL 3023 Philosophy of the Human Person
    - PHIL 3053 Virtue Ethics
    - PHIL 3073 Catholic Social & Political Philosophy
- Speculative Philosophy Sequence
    - PHIL 3013 Philosophy of Nature
    - PHIL 3023 Philosophy of the Human Person
    - PHIL 4013 Thomistic Metaphysics
    - PHIL 4033 Thomistic Epistemology
    - PHIL 4063 Natural Theology

We can now consider how this course in particular fits within the major as a whole.

Why Study the Philosophy of Nature?

The philosophy of nature is the study of the cosmos, full of changeable, intelligible, and wonderful things that human beings did not put there. It is worthy of study most of all because studying the world of natural things is the home for the human mind, its first school in the truth, and its enduring foundation for contemplating higher, eternal realities (n.b.: Aquinas even calls metaphysics one of the *physical sciences*, since it studies realities we do not make). Without the philosophy of nature, the natural sciences would be lost in mere details and technicalities, metaphysics full of logically valid platitudes, and ethics emptied of all that is good. As St. Thomas writes in the epigraph above, natural philosophy truly does possess a fullness of contemplation.

Here, it would be opportune to review, based upon the course syllabus (p. x), the objectives of the course. **By the end of this course, the diligent and attentive student should:**

(1) understand the scope and range of the philosophy of nature and its desire to know the cosmos;
(2) know and be able to articulate and apply the fundamental principles of the philosophy of nature, especially those set forward by the Aristotelian-Thomistic tradition;
(3) be more familiar with the basics of and understand key principles and methods in the logic of scientific discovery and proof as exemplified in the history of the natural sciences;

(4) appreciate and be able to articulate details about the order of the cosmos and various philosophical approaches to modeling and theorizing about the cosmos.

For more reasons to study the philosophy of nature, see the first readings of this course (*CG*, ch. 1), as well as the introduction to Brungardt, *Natural Philosophy*.

The Order & Content of the Course

Students should familiarize themselves with this *Course Guide*, especially the table of contents and the introductory sections to each chapter. Beyond that, what follows are some brief comments about what to expect as one progresses through this course of study.

Searching for Nature's Secret's?

The philosophical movements of the course track the three parts of the *Course Guide*:

- **Part I: Wondering About the Cosmos**
  - This part of the course focuses on the reasons why we study natural philosophy, some of its history, and also features a study of Shelley's *Frankenstein* as an intellectual appetizer for our imaginations.
  - The philosophers studied during this part of the course include the Pre-Socratics (crucial to understanding Aristotle later and important in their own right), as well as Plato's *Timaeus*, a wonderful dialogue about making images or models of the cosmos.
- **Part II: The Search for Nature's Principles and Causes**
  - During this part of the course, we study Aristotle's *Physics*, focusing on Books I–III. This is the "founding document," as it were, for natural philosophy.
  - Our study of this text will allow us insights into the necessary conditions for change in the cosmos, what nature is, the various causes at work in the world, as well as the nature and intelligible structure of motion.
- **Part III: Finding the Wisdom of the Cosmos**
  - In this final part of the course, we read from two very helpful books (see below) to concretize and specify our natural philosophical inquiries. This is necessary not only to understand the natural sciences better but also the more fully appreciate the order and beauty of the cosmos.

Reading for This Course

Reading well in this course (see the Syllabus, p. xv) is as essential overall and as complementary to the lectures and in-class discussions as a laboratory is to a science course, or studio to an art course, or a clinic practicum to a medical course. That is, just as these components are integral to the intellectual and technical objectives of the course, so too is reading well in a philosophy course.*

There are various reasons why this is true of reading well in a philosophy course. The principal ones are the following:

(1) **Texts as teachers:** The primary texts chosen for the course have been written by master philosophers who serve as paradigms of the philosophical act, and all secondary texts have been chosen first and foremost for their pedagogical clarity.
(2) **Texts as sources:** The texts in this course, especially the primary ones, are some of the greatest examples of their kind written on this subject.
(3) **Texts as guides:** The texts for this course have been chosen because of their ability to form and order the mind. Sometimes, this takes place by raising difficulties, or by resolving them. Other texts or readings serve other purposes.
(4) **Texts as models:** The arguments and conclusions contained in the course texts are the exemplary means by which we can hope to arrive at knowing something of the subject of this course for ourselves.

As a consequence, students should take the reading for this course as seriously as science majors take labs, art majors take studio, or pre-med or nursing majors take clinic. Let's look at some of the course books and readings in a bit more detail.

The Books for This Course

Our primary sources for the course are Plato's *Timaeus* and Aristotle's *Physics*. The former aids us especially when it comes to making theories about the whole cosmos; the latter provides us with necessary tools to begin that work. The secondary sources for the course (again, see the Syllabus), have been chosen for different reasons, ranging from the systematic to the historical. Without being exhaustive, here are the main reasons:

– **Shelley, *Frankenstein***, will help our imaginations grasp what natural philosophy is, its importance, its dangers, and how it helps us to find our place in the cosmos. Besides, it is also a thrilling novel!

* Again, what is meant by reading well is described in the Syllabus, see p. xv.

– **Wallace, *The Modeling of Nature***, is a learned book about the philosophy of nature and the philosophy of science. We will learn a lot from it, especially about the role of natural philosophy in the history of science.
– **Augros and Stancius, *The New Biology***, provides us with a wealth of examples to discuss so that we can apply and concretize the principles we will be studying throughout the course. The book also includes several insightful and important arguments about the natural world.

Overall, these texts have been chosen to serve the ulterior purposes of avoiding the pedagogical monotone of hearing from only one teacher (myself), and to help illustrate the perennial character of this topic. It's a well-trodden road, and these authors are all reliable guides. There are futher texts we will read, all included in Appendix II of this *Course Guide*.

There are various other secondary sources that have been chosen for particular purposes, to be explained when they are assigned. The *Course Guide* itself has various selected passages and quotations that are aimed at rounding out the narrative of the course's argument.

Speaking of the *Course Guide*, it is itself a bit more than a map to the course, and yet far from being an answer key. The aim of this *Course Guide* is to provide some order to a long and complicated course of study, and to avoid running the risk of reading like an "answer key" that students can simply memorize and thereby "learn" the material. Thus, you will notice that there are *many* questions in each chapter. A such, you should be forewarned that the *vast majority* of what I hope you will learn in the course by using this *Course Guide* is not itself written in down categorically or in the indicative mood in this book.

Conclusion:

In this course, we will learn from a fictional monster, from Newton and Einstein, from ancient Greek philosophers, and especially from our own experience about the natural world. The philosophy of nature relies upon principles that were present at the infancy of the natural sciences, and these principles are perennial ones, truths not merely old but foundational. This perennial philosophy of nature is a tradition of inquiry able to dialogue with the advances of the modern natural sciences even as it sheds light on their findings. What Pope Leo XIII wrote long ago is still true: "Between certain and accepted conclusions of modern physics and the philosophic principles of the schools there is no conflict worthy of the name" (*Aeterni Patris*, no. 30). The philosophy of nature is part of "our

heritage of knowledge and wisdom" that "has indeed been enriched in different fields" (John Paul II, *Fides et ratio*, no. 91).

Let us begin!

Part I

Wondering About the Cosmos

The Intelligibility of Nature | 1

> Wisdom is one thing. It is to understand the mind by which all things are steered through all things.
>
> – Heraclitus, DK 41

1.1 Introduction

The philosophy of nature seeks to understand the natural world; in this respect, it is akin to the natural sciences. Our first step is to consider why we should want to take up such an inquiry. Why study physics? We should also consider a bit of the history of natural philosophy and contrast it with the natural sciences.

Goals for this chapter

(1) To introduce the appeal of natural philosophy
(2) To compare and contrast natural philosophy and the natural sciences

Readings for this chapter

– Simplicius, "On the Interest of Physics"
– Dear, *The Intelligibility of Nature* (excerpt)
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Introduction

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

The Chapter Questions are collected for review in Appendix I, see p. 79.

– What desires shape the beginnings of the study of natural philosophy?
– What is instrumentalism and to what is it opposed?
– What is mechanism and what are some examples in early modern natural philosophy?

1.2 What's So Cool About Physics?

This section corresponds to the reading of Simplicius, "On the Interest of Physics". See Appendix II, pp. 82ff.

Reading questions

Before you read, consider the following: ***Why is the sky dark on a clear night?***

As you read, consider the following questions:

- How many reasons does Simplicius give for why physics (*physiologia*) is interesting?
- What parts of philosophy are related to physics?
- What aspects of human life is related to physics?

Post-reading questions

What desires are related to beginning the study of physics? Is it natural to want to study physics? Also, look up the Greek root of *physiologia* as used in this excerpt.

1.3 How We Go About Understanding Nature

This section corresponds to the reading of Dear, *The Intelligibility of Nature* (excerpt). See Appendix II, pp. 85ff.

Reading questions

Before you read, consider the following: ***What is the origin of the word "scientist"? (Hint: Look it up.)***

As you read, consider the following questions:

- What are the "two faces of science"?
- What is "instrumentality"? Be able to provide examples.
- Why is science an amalgam? What are implications of this fact?
- What does Dear mean by "intelligibility"? Be able to provide examples.
- What does it mean to compare the world to a machine? To what is the mechanical view opposed?
- Be able to give examples of mechanical explanations (hint: consider Descartes and Huygens).
- What are some problems with mechanism?
- In what ways did Newton use mechanical explanations? In what ways did he not use them?

Post-reading questions

Do Dear's explanations of natural science provide the same sorts of reasons to study nature as Simplicius did? Does he introduce new types of desires underlying why one might want to study nature?

1.4 Conclusion

Isaac Newton's masterpiece, *Philosophiae Naturalis Principia Mathematica*—or, *The Mathematical Principles of Natural Philosophy* (first edition, 1687; third edition, 1726)—is famous for its introduction of calculus as well as its argument for universal gravitation. Newton's mathematical-and-physical method, as we will find out later in this course, has an ancient lineage.

At present, however, consider the following passage from Newton's "Preface to the Reader," in which he expresses a certain desire:

> I wish we could derive the rest of the phænomena of nature by the same kind of reasoning from mechanical principles; for I am induced by many reasons to suspect that they may all depend upon certain forces by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from each other; which forces being unknown, philosophers have hitherto attempted the search of nature in vain; but I hope the principles here laid down will afford some light either to this or some truer method of philosophy.

Newton, *Principia*, Motte trans.; text from Wikisource.

What sort of desire is this? How would you characterize it? Is this desire a reasonable one?

Natures and Monsters 2

I hate all the gods,
Because, having received good at my hands,
They have rewarded me with evil.
Proves thee stark mad!

– Aeschylus, *Prometheus Bound*

2.1 Introduction

In the previous chapter, we considered not only reasons to study physics, or natural philosophy, but some of the desires as well. In this part of the course, we consider some of these desires in more depth, especially in regard to the power of nature that knowledge can afford. For starters, consider this question: Who was Prometheus and why did he "hate all the gods"?

Goals for this chapter

(1) To consider the relationship between human nature, knowledge of nature, and power over nature
(2) To study and form our imaginations through Shelley's novel, *Frankenstein*

Readings for this chapter

– Mary Shelley, *Frankenstein*
– *Supplemental reading:* Consider reading some of the appended essays in our edition of the novel.

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

The Chapter Questions are collected for review in Appendix I, see p. 79.

– What is a "monster"? How is the idea of a monster related to nature and the natural?
– What can *Frankenstein* (the novel) teach us about natural philosophy?

2.2 Frankenstein, Philosopher of Nature?

This section corresponds to the reading of Shelley's *Frankenstein*, Volume I.

Reading questions

Before you read, consider the following: ***Who was Paracelsus? Of what is Albertus Magnus the patron saint?***

As you read, consider the following questions:

- Who are the main characters of the novel?
- Be able to tell some of the details of Frankenstein's upbringing and education.
- How does natural philosophy play a role in this part of the novel?

Space below for notes

2.3 The Education of the Creature

This section corresponds to the reading of Shelley's *Frankenstein*, Volume II.

Reading questions

Before you read, consider the following: ***Why is Milton's* Paradise Lost *famous?***

As you read, consider the following questions:

- What sort of life does the creature lead?
- Be able to describe the sort of education that the creature receives.
- What progress or changes are significant about the Victor or his creature?

Space below for notes

2.4 Who Is the Monster?

This section corresponds to the reading of Shelley's *Frankenstein*, Volume III.

Reading questions

Before you read, consider the following: ***What is the ancient Greek notion of a "tragedy"? (Hint: Look it up.)***

As you read, consider the following questions:

- What are the significant events in this part of the novel?
- Is there any resolution to the conflict between Victor and his creature?
- Is the novel a tragedy?

Space below for notes

2.5 Conclusion

Shelley's *Frankenstein* is justly famous, not only in the literary world but also for its influence upon our cultural imagination when it comes to mankind's power over nature through scientific knowledge. A comparable novel with such a theme, among others, is C. S. Lewis's *That Hideous Strength*. We would do well to consider one of the paradigmatic statements of the project of natural science to "master and possess" the natural world:

> As soon as I had acquired some general notions in physics and had noticed, as I began to test them in various particular problems, where they could lead and how much they differ from the principles used up to now, I believed that I could not keep them secret without sinning gravely against the law which obliges us to do all in our power to secure the general welfare of mankind. For they opened my eyes to the possibility of gaining knowledge which would be very useful in life, and of discovering a practical philosophy which might replace the speculative philosophy taught in the schools. Through this philosophy we could know the power and action of fire, water, air, the stars, the heavens and all the other bodies in our environment, as distinctly as we know the various crafts of our artisans; and we could use this knowledge—as the artisans use theirs—for all the purposes for which it is appropriate, and thus make ourselves, as it were, the masters and possessors of nature. This is desirable not only for the invention of an infinity of devices which would facilitate our enjoyment of the fruits of the earth and all the goods we find there, but also, and most importantly, for the maintenance of health, which is undoubtedly the chief good and the foundation of all the other goods in this life. . . . We might free ourselves from innumerable diseases, both of the body and of the mind, and perhaps even from the infirmity of old age, if we had sufficient knowledge of their causes and of all the remedies that nature has provided.

René Descartes, *Discourse on Method*, Part VI, in *The Philosophical Writings of Descartes: Volume 1*, translated by J. Cottingham, R. Stoothoff, and D. Murdoch (Cambridge: Cambridge University Press, 1985), pp. 142–43, translation slightly modified (JGB).

Descartes goes on to note that this is the principal reason why he is publishing his work, and how he needs the help of others not only to fund the necessary research, but to carry on the work itself:

> Intending as I did to devote my life to the pursuit of such indispensable knowledge, I discovered a path which would, I thought, inevitably lead one to it, unless

Ibid., p. 143.

> prevented by the brevity of life or the lack of observations. And I judged that the best remedy against these two obstacles was to communicate faithfully to the public what little I had discovered, and to urge the best minds to try and make further progress by helping with the necessary observations, each according to his inclination and ability, and by communicating to the public everything they learn. Thus, by building upon the work of our predecessors and combining the lives and labors of many, we might make much greater progress working together than anyone could make on his own.

When contemplating such a project, we would do well to remember what Lewis has one of his characters say in the aforementioned novel: "Man's power over Nature means the power of some men over other men wth Nature as the instrument." While the ethical implications of natural philosophy are not a central point of study of this course, we should not ignore them in our study or discussions.

The Pre-Socratics and Nature | 3

> Fools. For they have no far reaching minds who think that what before was not comes to be or that anything dies and is destroyed utterly in every way.
>
> – Empedocles, DK 11

3.1 Introduction

We now begin in earnest our study of natural philosophy properly speaking. Our first step is to consider the opinions of the predecessors of Aristotle. In this chapter, we study some of the Pre-Socratics; in the next chapter, we study a work of Plato.

Goals for this chapter

(1) To consider the opinions of the Pre-Socratic philosophers about nature
(2) To learn about reasonable and sufficient guesses and the method of inquiring into nature

Readings for this chapter

– Pre-Socratic fragments (see Appendix II)
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter I

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

– What are reasonable guesses? What are sufficient guesses?
– How do the Pre-Socratics provide guesses about matter and motion in the natural world?
– How do the Pre-Socratics provide guesses about order and necessity in the natural world?

The Chapter Questions are collected for review in Appendix I, see p. 79.

3.2 Matter and Motion

This section corresponds to the reading of Berquist's translation of Pre-Socratic fragments (see Appendix II, pp. 107ff). Read the excerpts from Thales, Anaximander, Anaximenes, Pythagoras, Heraclitus, and Empedocles.

Reading questions

Before you read, consider the following: ***What sorts of things change? List examples. What sorts of things do not change? What is the reason for the difference between changing and unchanging things?***

As you read, consider the following questions:

- For the short group of fragments from Thales, Anaximander, Anaximenes, and Pythagoras, what sorts of things do these opinions explain?
- When reading the fragments of Heraclitus, what sort of overall "theory" of the universe does he have?
- What are the main reasons that Empedocles gives for why things change?

Post-reading questions

Logicians like to distinguish between necessary and sufficient conditions. (What is that difference?) We should also distinguish between reasonable guesses and unreasonable guesses, on the one hand, and between sufficient explanations and insufficient ones, on the other hand. How might these distinctions apply to the Pre-Socratic philosophers and their early inquiries into the natural world?

3.3 Mind and Atoms

This section corresponds to the reading of Berquist's translation of Pre-Socratic fragments (see Appendix II, pp. 107ff). Read the excerpts from Anaxagoras, Leucippus, and Democritus.

Reading questions

Before you read, consider the following: ***Recall the idea of "mechanism" and "instrumentality" from earlier discussions. Might they apply to the Pre-Socratics?***

As you read, consider the following questions:

- Why does Anaxagoras think that the other Greek philosophers have insufficient theories about nature? What is his explanation for why things change?
- Anaxagoras discusses "mind" in some of his fragments. What is mind and what does it do?
- Leucippus and Democritus are atomists. Why does Democritus talk about "custom"? What do fragments DK 34 and DK 154 tell us about the human place in the cosmos?

Post-reading questions

The contemporary Thomistic philosopher Edward Feser writes: "There can be no more conclusive reason for judging that some science gives us only an incomplete description of reality than that it fails to account for the existence of scientists and scientific practice themselves." Do Anaxagoras or Democritus run afoul of this philosophically crucial test of self-reference?

Feser, *Aristotle's Revenge*, 128.

3.4 Conclusion

As we study the Pre-Socratics and Plato, we should guard against the idea that we are merely studying the history of philosophy.

> But why rehearse these famous moments in the history of the human mind? The reason is that we must not allow ourselves to view this history as achieved once and for all. . . . My point, then, is that *the Presocratics are always with us*. We do not have to look far to find positions taken which resemble those reported by Plato and Aristotle. We need to rehearse the history because rehearsing the history may serve to awaken contemporary Presocratics from their dogmatic slumber.

Lawrence Dewan, "The Importance of Substance," in *Form and Being*, pp. 100–101.

In other words, the sorts of ideas that the Pre-Socratics had are frequently natural or intuitive guesses or hypotheses. They can be formed into "systems" of thinking about nature, and these systems can still be found among contemporary natural scientists. Some scientists are materialists (like Empedocles or Democritus); other scientists believe in the ubiquity of process in nature (like Heraclitus); finally, some scientists are Platonists (like, well, Plato).

Plato and Cosmology 4

> And when the mind began to move things, it was separated from everything; and as much as the mind moved, all this was separated. As things were being moved and separated, the revolution made them separate even more.
>
> – Anaxagoras, DK 13

4.1 Introduction

We now turn to consider one of the most intriguing of the Platonic dialogues, the *Timaeus*. As we consider this work, we should keep in mind the ideas learned from previous chapters and see how Plato puts them into practice when thinking about the cosmos as a whole. Indeed, is it possible to really think about the cosmos without thinking about it *as a whole*?

Goals for this chapter

(1) To study Plato's *Timaeus*
(2) To consider the nature of the cosmos and theories about it

Readings for this chapter

– Plato, *Timaeus*

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

The Chapter Questions are collected for review in Appendix I, see p. 79.

– What is the nature of a "likely story" about the cosmos in the *Timaeus*?
– What are the main features of the cosmos founded by intellect and its principles?
– Why is the cosmos in the *Timaeus* also founded by necessity? (Bonus: How does the human being fit into such a cosmos?)
– What shortcomings does the theory of the cosmos in the *Timaeus* have? What are its strong points?

4.2 Timaeus and the Demiurge

This section corresponds to the reading of Plato, *Timaeus*, 27A–47E. The story of Atlantis (20E–26E) should also be read, but do not focus as heavily on it.

Reading questions

Before you read, consider the following: ***What is the difference between the history of a given family and its family tree (i.e., its genealogy)?***

As you read, consider the following questions:

- When Timaeus begins to build the cosmos, who is the craftsman and what is the model that it uses?
- What are the key ideas or principles that the craftsman uses when making the cosmos?
- What is the soul of the cosmos? What is it like?
- How does Timaeus put time into the cosmos? Why does he do this?
- Who are the inhabitants of the cosmos? Where do they come from? Does Timaeus explain the origin of human beings?

Post-reading questions

Try to draw Timaeus's cosmos.

4.3 The Cosmos and Necessity

This section corresponds to the reading of Plato, *Timaeus*, 47E–69A. The final stage of the dialogue (69A–92C) is optional but highly recommended reading.

Reading questions

Before you read, consider the following: ***Think about making something from wood or paper (e.g., a wooden box, or folding a paper airplane). Are the lines perfectly straight? Are the corners perfectly square? Why not?***

As you read, consider the following questions:

- At 47E–48A, Timaeus introduces a new stage in the construction of the cosmos. What is the relationship between intellect and necessity in this passage?
- What is space or the "receptacle," and why does Timaeus introduce it?
- How many elements are they? What are they made from?
- How do the elements change? How are the elements related to human sensation?

Post-reading questions

In class, we will discuss the three stages of Timaeus's construction of the cosmos. Why are there three? What does that tell us about the cosmology that Timaeus is proposing?

4.4 Plato and the Astronomers

This section corresponds to the reading of the Kalkavage's translator's Appendices (A: Music; B: Astronomy; C: Geometry), which can be found on pp. 157–169.

Reading questions

Before you read, consider the following: ***What celestial objects go both east and west in the sky?***

As you read, consider the following questions:

- When reading Appendix A on music, consider what the nature of harmony in music tells us about Timaeus's cosmos.
- When reading Appendix B on astronomy, consider why mathematics must be used in cosmology.
- When reading Appendix C on geometry, consider why incommensurability is imporant for understanding matter.

Post-reading questions

Why does Timaeus use number and shape when telling his "likely story" about the cosmos? Is this instrumentalism or is Timaeus realistically describing the world?

4.5 Conclusion

The *Timaeus* introduces many themes in natural philosophy (and beyond), and we will not be able to talk about all of them in class. Consider this (incomplete) list of further questions that the dialogue inspires:

- What is the relationship between human art and the natural order?
- Is purpose in the cosmos compatible with necessity?
- Is the cosmos made or is it created?
- Can we discover the account of cosmogony from inside the cosmos, instead of telling a "likely story" from outside the cosmos, as Timaeus did?
- Is the human soul *part* of the cosmos or is it independent from it in important ways?
- What is the role of the human being in the cosmos?
- What is the relationship between natural history and scientific theory?
- Is it possible to have a final theory about the cosmos or can we only give likely stories?

Part II

The Search for Nature's Principles and Causes

How Is Change Possible? 5

> The Greeks do not rightly take coming into being and perishing. Nothing comes to be or perishes, but is mixed and separated from existing things. And thus they would be right to call coming to be, mixing and perishing, separating.
>
> – Anaxagoras, DK 17

5.1 Introduction

After the preparatory part of our course, we now begin the study of natural philosophy a bit more formally by taking Aristotle as our teacher. His book *Physics, or Natural Hearing* is as it were the founding document of Western thought about nature. Over the next three chapters, we will study change and its principles, nature and the four causes, and motion.

Goals for this chapter

(1) To learn about the natural path in our study of nature
(2) To wrestle with the problem or *aporia* about change
(3) To resolve the *aporia* and discover the principles of change

Readings for this chapter

– Aristotle, *Physics*, Book I
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter II

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

– What is the natural path in human thought?
– What is the problem about change? Why must natural philosophy address this problem?
– What are the principles of change? How are they distinct from each other in order to explain change?

The Chapter Questions are collected for review in Appendix I, see p. 79.

5.2 The Natural Path

> We should not act and speak like those asleep. For the waking there is one world, and it is common; but when men sleep, each one turns aside into a private world. Therefore, we ought to follow what is common. Although reason is common to all, the many live as if having a private wisdom.
>
> – Heraclitus, DK 73; 89; 2

This section corresponds to the reading of Aristotle, *Physics*, I.1.

Reading questions

Before you read, consider the following: ***If you see something far off in the distance, how would you be able to tell if it were alive or not?***

As you read, consider the following questions:

- What is the argument in the first paragraph of the book (184a9–a16)?
- What is the natural path?
- Aristotle gives three examples at the end of the chapter. What are they supposed to explain or illustrate?

Post-reading questions

After class discussion, students are encouraged to read the Coughlin's translator's essay, "Appendix 1: Method in Aristotelian and Modern Natural Philosophy."

5.3 Ancient Opinions Against Change

This section corresponds to the reading of Aristotle, *Physics*, I.2–3.

Reading questions

Before you read, consider the following: ***Is it reasonable to doubt that motion exists? Is it reasonable to doubt that a self-contradictory thing exists?***

As you read, consider the following questions:

- What is the division of principles that Aristotle provides in the first paragraph of *Physics*, I.2?
- What position about principles do Parmenides and Melissus take? Is it part of the job of the physicist or natural philosopher to consider their views? Why or why not?
- What does Aristotle say must be granted due to experience or induction?
- Throughout *Physics*, I.2–3, what sorts of arguments does Aristotle make against Parmenides and Melissus?

Post-reading questions

The following quotations from Parmenides and Melissus might help with the reading.

- "One should both say and think that Being Is; for To Be is possible, and Nothingness is not possible. This I command you to consider; for from the latter way of search first of all I debar you. But next I debar you from that way along which wander mortals knowing nothing, two-headed, 1 for perplexity in their bosoms steers their intelligence astray, and they are carried along as deaf as they are blind, amazed, uncritical hordes, by whom To Be and Not To Be are regarded as the same and not the same, and (for whom) in everything there is a way of opposing stress." (Parmenides, DK 6)
- "For this (view) can never predominate, that That Which Is Not exists. You must debar your thought from this way of search, nor let ordinary experience in its variety force you along this way, (namely, that of allowing) the eye, sightless as it is, and the ear, full of sound, and the tongue, to rule; but (you must) judge by means of the Reason (Logos) the much-contested proof which is expounded by me. (Parmenides, DK 7)

– "There is only one other description of the way remaining, (namely), that (What Is) Is. To this way there are very many sign-posts: that Being has no coming-into-being and no destruction, for it is whole of limb, without motion, and without end. And it never Was, nor Will Be, because it Is now, a Whole all together, One, continuous; for what creation of it will you look for? How, whence (could it have) sprung? Nor shall I allow you to speak or think of it as springing from Not-Being; for it is neither expressible nor thinkable that What-Is-Not Is. Also, what necessity impelled it, if it did spring from Nothing, to be produced later or earlier? Thus it must Be absolutely, or not at all. Nor will the force of credibility ever admit that anything should come into being, beside Being itself, out of Not-Being. So far as that is concerned, Justice has never released (Being) in its fetters and set it free either to come into being or to perish, but holds it fast. The decision on these matters depends on the following: it is, or it is not. It is therefore decided—as is inevitable—(that one must) ignore the one way as unthinkable and inexpressible (for it is no true way) and take the other as the way of Being and Reality. How could Being perish? How could it come into being? If it came into being, it Is Not; and so too if it is about-to-be at some future time. Thus Coming-into-Being is quenched, and Destruction also into the unseen." (Parmenides, DK 8)
– "That which was, was always and always will be. For if it had come into being, it necessarily follows that before it came into being, Nothing existed. If however Nothing existed, in no way could anything come into being out of nothing." (Melissus, DK 1)
– "Since therefore it did not come into being, it Is and always was and always will be, and has no beginning or end, but it is eternal. For if it had come into being, it would have a beginning (for it would have come into being at some time, and so begun), and an end (for since it had come into being, it would have ended). But since it has neither begun nor ended, it always was and always will be and has no beginning nor end. For it is impossible for anything to Be, unless it Is completely." (Melissus, DK 2)
– "If Being is divided, it moves; and if it moved, it could not Be." (Melissus, DK 10)

5.4 Working Through the Dialectic About Change

> The opposite [is] useful, and from those differing [comes the] most beautiful harmony and all things come to be by strife.
>
> – Heraclitus, DK 8

This section corresponds to the reading of Aristotle, *Physics*, I.4–6.

Reading questions

Before you read, consider the following: ***Recall the "Square of Opposition" from the logic course. If four people each defend one corner of the Square, is it ever the case that three people could be right? two? one? or none?***

As you read, consider the following questions:

- Why does Aristotle argue against Anaxagoras? What are his main reasons?
- At the beginning of *Physics*, I.5, what evidence from our readings can you find that "all thinkers . . . make the contraries principles? Why does Aristotle emphasize this?
- In *Physics*, I.6, Aristotle discusses whether the principles of change are two or three. What does he conclude?

Post-reading questions

Why does Aristotle think that it "poses much difficulty" whether the principles of change are two or three?

5.5 The Principles of Change

> For it is impossible that anything comes to be from what in no way is, and that what-is should perish completely is not accomplished or heard of. For it will always be there where anyone ever puts it.
>
> – Empedocles, DK 12

This section corresponds to the reading of Aristotle, *Physics*, I.7–9.

Reading questions

Before you read, consider the following: ***Is it possible there to be a change without some thing that is changing? If my son grows taller than me, then have I changed? Also, recall the role that Timaeus gives to the Receptacle or Space. What was its purpose?***

As you read, consider the following questions:

- In *Physics*, I.7, what is the underlying, and why does Aristotle think it is necessary?
- In *Physics*, I.8, what is "the difficulty of the ancients"? How does Aristotle think that he has solved it?
- *Physics*, I.9, whom is Aristotle addressing? What is "the enduring"? What is "material"?

Post-reading questions

Our class discussion will focus on finishing our discussion of the principles of change.

5.6 Conclusion

In a translator's essay, Coughlin makes the following statement:

> Can the phenomenon of change be explained without suggesting the primacy of potency, or is Aristotle right to claim that he has actually discovered the solitary solution to Parmenides' difficulty? ... Any physics, then, which does not, explicitly or at least implicitly, acknowledge the primacy of the potency of matter in the explanation of physical change is bound to go wrong, and to constitute, despite what may be appearances to the contrary, philosophical regression.

Coughlin, "Appendix 2: Matter and the Reality of the Physical World," 227. This Appendix would make for good reading after we finish the discussion of Book I of the *Physics*.

Indeed, can the following be true and still maintain Aristotle's solution to the Eleatic dilemma?

(1) Substantial wholes (e.g., dogs) exist and truly come-into-being when not existing before.
(2) The form of a higher-level entity is the form of a substance, not the form of an accident.
(3) The matter of a lower-level entity (or entities) does not possess the form it has when separated from a higher-level whole.
(4) A substance is not composed of substances actually separate; a substance can be composed of substances separate in potency.
(5) There is only one substantial form for one substance.

In order to avoid pre-Socratic reductive materialism (*Physics*, II.1, 193a24–27), one must posit the reality of prime matter—pure physical potentiality for substances of all kinds; itself without form, "one" (191a11) and "indestructible and ingenerable" (192a29), knowable by analogy to what has form (191a8). Is this "prime matter' still plausible today? This about the above questions with the following table in mind.

		Parts		Wholes
Form (a "part" of the composite)		**SUBSTANTIAL FORM**		
⬆ Going up: 'more' actual	**Going down: 'more' potential ⬇**	organs	*composes* ⟹ *is composed of* ... *or* ... *generates* ⟹ *decomposes to* ⟸	**an organism (e.g.: a dog)**
		tissues		organs
		cells		tissues
		proteins, organelles, etc.		cells
		biochemicals		proteins, organelles, etc.
		inorganic compounds		biochemicals
		elements		inorganic compounds
		subatomic particles		elements
		elementary particles		subatomic particles
Matter (a "part" of the composite)		**PRIME MATTER**		

What Are Nature's Causes? 6

> Let us not guess at random about the greatest things.
>
> – Heraclitus, DK 47

6.1 Introduction

Now that that we have established the principles of change (the basics for natural philosophy), it is time to consider more adequate principles for our inquiry. Even Aristotle says at the end of *Physics*, Book I, that we must "speak again beginning from another beginning." What is that beginning? The principle that Aristotle calls "nature." In this chapter, we consider the famous Aristotelian definition of nature, the four causes, and other crucial principle of natural philosophy.

Goals for this chapter

(1) To learn Aristotle's definition of nature
(2) To understand the basics of the four causes and their modes
(3) To distinguish chance, purpose, and necessity

Readings for this chapter

– Aristotle, *Physics*, Book II
– Augros, "Nature Acts for an End"
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter III

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

The Chapter Questions are collected for review in Appendix I, see p. 79.

– What is the Aristotelian definition of "nature"?
– What are the four causes? How can the causes be described in different ways?
– What is the definition of chance?
– What evidence is there that nature acts for an end? Are natural ends (teleology) compatible with chance and necessity in nature?
– What are the kinds of necessity that we find in nature?

6.2 The Definition of Nature

> Changing, it rests.
>
> – Heraclitus, DK 84a

This section corresponds to the reading of Aristotle, *Physics*, II.1. Also read Wallace, *Modeling of Nature*, 1.1.

Reading questions

Before you read, consider the following: ***What are some of the differences between a natural thing and an artificial object?***

As you read, consider the following questions:

- What is Aristotle's definition of nature? What are its parts?
- Why does Aristotle discuss someone doctoring himself?
- Can you prove that natures exist?
- Why does Aristotle discuss Antiphon's odd sayings about a bed?
- Is nature better thought of as material or as form? Consider carefully the final three paragraphs of the chapter.

Post-reading questions

Aristotle says that nature is "in" the natural thing. What is the meaning of this preposition in the definition? How many senses of "in" are there? For some help on the difference senses of "in," see *Physics*, IV.3, 210a14–24.

Can we understand Aristotle's definition of nature in light of Heraclitus DK 84a? Or vice-versa?

6.3 Nature in Physics and Mathematics

> The harmony of the octave comes from the ratio of two to one.
>
> – Pythagoras

This section corresponds to the reading of Aristotle, *Physics*, II.2. Also read Wallace, *Modeling of Nature*, 1.2.

Reading questions

Before you read, consider the following: ***When you hear about statistics about "the average American" or "the typical adult male," does this mean you can pick any random American or adult male and prove the statistic to be true? Also, is it truthful to represent a light ray by using a straight line?***

As you read, consider the following questions:

- Why is Aristotle talking about astronomers and mathematicians?
- What is the difference between "the more natural of the mathematical sciences" such as optics or harmonics or astronomy, and what "the student of nature" is concerned with?
- Is the student of nature concerned with knowing matter, form, or both?
- What does Aristotle mean that "nature is among things relative" (194b9)?

Post-reading questions

Consider our discussion of Descartes, Newton, and mechanism back in Chapter 1 of this *Course Guide*. Is Aristotle's student of nature pursuing a mechanistic explanation of the natures of things?

6.4 Speaking About the Four Causes

This section corresponds to the reading of Aristotle, *Physics*, II.3. Also read Wallace, *Modeling of Nature*, 1.3.

Reading questions

Before you read, consider the following: ***What is the difference between "one half," $\frac{1}{2}$, and 0.5?***

As you read, consider the following questions:

- Find in the text where Aristotle talks about the four causes. What are the examples that he gives to illustrate each of the four?
- Is it possible for many to be the cause of one thing? Can things be causes of each other? Is it possible for the same thing to be the cause of many things?
- What are the "modes of the causes"? How many modes are there? Pay attention to Aristotle's examples.

Post-reading questions

Think about the "likely story" about the cosmos in Plato's *Timaeus*. Did Plato make uses of the four causes?

6.5 Luck and Chance Among Nature's Causes

> The most beautiful universe is a heap piled up at random.
>
> – Heraclitus, DK 124

This section corresponds to the reading of Aristotle, *Physics*, II.4–7. Also read Wallace, *Modeling of Nature*, 1.4.

Reading questions

Before you read, consider the following: ***If you roll two snakeyes in a row, is this luck or just a random event? What does it mean when we say that something "happened randomly"?***

As you read, consider the following questions:

- In *Physics*, I.4, what are the opinions about luck and chance that Aristotle brings up?
- In *Physics*, I.5, what is the definition of luck? What causes does Aristotle appeal to in order to explain it?
- In *Physics*, I.6, what is the definition of chance? What examples of chance does Aristotle give?

Post-reading questions

Is chance a cause or an effect, according to Aristotle? Why does he discuss chance among the other causes?

6.6 Finality in Nature

> Many things were born with two faces and two breasts, offspring of cattle with faces of men, others the reverse, born of men with the heads of oxen, mixed in part from men and in part female by nature, adorned with dark limbs.
>
> – Empedocles, DK 61

This section corresponds to the reading of Aristotle, *Physics*, II.8. Also, begin reading Augros, "Nature Acts for an End," which can be found in Appendix II (see pp. 118ff). As supplemental reading, see Wallace, *Modeling of Nature*, 1.5.

Reading questions

Before you read, consider the following: ***What is the final cause of rain falling?***

As you read, consider the following questions:

- What is the difficulty that Aristotle raises towards the beginning of the chapter? How does Aristotle answer this difficulty?
- What arguments does Aristotle give to defend the idea that nature is among causes that act for the sake of something?
- Why does Aristotle bring up mistakes of a grammarian or a doctor?
- Who "wholly does away both with the things which are by nature and with nature"? Why does Aristotle think this?
- When reading Augros's article, pay attention to the various "Objections" that he raises. What are the main positive argument that he provides? Can you find them in Aristotle's text?

Post-reading questions

Think about the "likely story" about the cosmos in Plato's *Timaeus*. Do any of the parts of Timaeus's cosmos act for the sake of something? Are some parts for the sake of other parts? Is the cosmos for the sake of something? Does Aristotle give any indication that he thinks the entire cosmos is for the sake of something?

6.7 The Types of Necessity in Nature

> Nothing happens at random; but everything comes to be from reason and by necessity.
>
> – Leucippus, DK 2

This section corresponds to the reading of Aristotle, *Physics*, II.9. Also, finish reading Augros, "Nature Acts for an End," which can be found in Appendix II (see pp. 118ff). As supplemental reading, see Wallace, *Modeling of Nature*, 1.6.

Reading questions

Before you read, consider the following: ***A dropped stone must fall to the ground. To pass a test, students must study. Is "must" the same in both sentences?***

As you read, consider the following questions:

- What is the difference between "necessary by hypothesis" and necessary "simply"?
- What are Aristotle's examples in this chapter? What sorts of necessity do they illustrate?
- Which of the four causes are responsible for what type or types of necessity?

Post-reading questions

What sort of "necessity" was present in Timaeus's cosmos? Does it match one of the senses of necessity that Aristotle speaks of in this chapter?

6.8 Conclusion

Aristotle's account of nature, especially of final causality or teleology, is of central importance to his natural philosophy. Consider the following two excepts about purpose or ends in nature. The first is from Immanuel Kant; the second is from Friedrich Nietzsche.

———— ❖ ————

Kant, *Critique of Judgment*, §77 (Bernard trans.).

We have brought forward in the Remark peculiarities of our cognitive faculties (even the higher ones) which we are easily led to transfer as objective predicates to the things themselves. But they concern Ideas, no object adequate to which can be given in experience, and they could only serve as regulative principles in the pursuit of experience. This is the case with the concept of a natural purpose, which concerns the cause of the possibility of such a predicate, which cause can only lie in the Idea. ... Absolutely no human Reason (in fact no finite Reason like ours in quality, however much it may surpass it in degree) can hope to understand the production of even a blade of grass by mere mechanical causes. As regards the possibility of such an object, the teleological connexion of causes and effects is quite indispensable for the Judgement, even for studying it by the clue of experience. For external objects as phenomena an adequate ground related to purposes cannot be met with; this, although it lies in nature, must only be sought in the supersensible substrate of nature, from all possible insight into which we are cut off. Hence it is absolutely impossible for us to produce from nature itself grounds of explanation for purposive combinations; and it is necessary by the constitution of the human cognitive faculties to seek the supreme ground of these purposive combinations in an original Understanding as the cause of the world.

———— ❖ ————

Nietzsche, *Genealogy of Morals*, Second Essay, §12, 77–78 (Kaufmann trans.).

However well one has understood the utility of any physiological organ (or of a legal institution, a social custom, a political usage, a form in art or in a religious cult), this means nothing regarding its origin: however uncomfortable and disagreeable this may sound to older ears—for one had always believed that to understand the demonstrable purpose, the utility of a thing, a form, or an institution, was also to understand the reason why it originated—the eye being made for seeing, the hand being made for grasping. Thus one also imagined that punishment was devised for punishing. But purposes and utilities are only signs that a will to power has become master of something less powerful and imposed upon it

the character of a function; and the entire history of a "thing," an organ, a custom can in this way be a continuous sign-chain of ever new interpretations and adaptations whose causes do not even have to be related to one another but, on the contrary, in some cases succeed and alternate with one another in a purely chance fashion. ... The form is fluid, but the "meaning" is even more so.

7 What Is Motion?

It is not possible to step twice into the same river.

– Heraclitus, DK 91

7.1 Introduction

Aristotle has uncovered the principles of change as well as nature's causes. Why do we need to define motion? Aristotle tells us at the beginning of *Physics*, Book III. In this chapter, we will consider motion and some of the implications of Aristotle's definition.

Goals for this chapter

(1) To understand Aristotle's definition of motion
(2) To consider action, passion, as well as some basics about place and time
(3) To discuss theories of motion and Zeno's paradoxes

Readings for this chapter

– Aristotle, *Physics*, Book III
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter IV

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

– What is motion? Why is Aristotle's definition of motion unique?
– What is the difference between action and passion? What is place? What is time?
– What are Zeno's paradoxes? Why must motion be continuous?

The Chapter Questions are collected for review in Appendix I, see p. 79.

7.2 What Is Motion?

> It is wholly impossible to define motion in another way through the prior and more known, except as the Philosopher here defines it.
>
> – St. Thomas, *In Phys.*, III.2.3

This section corresponds to the reading of Aristotle, *Physics*, III.1. Also read Berquist, "A Summary of Different Views about Motion and How It Is to Be Defined," which can be found in Appendix II (see pp. 160ff).

Reading questions

Before you read, consider the following: ***Why did Parmenides and Melissus deny the reality of motion?***

As you read, consider the following questions:

- What distinctions does Aristotle make in the beginning of his discussion of motion (200b26–201a9)?
- What is the definition of motion?
- Carefully consider Aristotle's examples: hot and cold, bronze, and house building.
- When reading Berquist, make an outline of the schema of the various definitions of motion.

Post-reading questions

How does the definition of motion relate to the four causes?

7.3 Action, Passion, and Paradoxes of Motion

This section corresponds to the reading of Aristotle, *Physics*, III.2–3 and VI.9.

Reading questions

Before you read, consider the following: ***If a professor is lecturing in a classroom and there are no students in the room, is the professor teaching? What if five people walk into the room—is the professor teaching then?***

As you read, consider the following questions:

- In *Physics*, III.2, what does Aristotle establish about the subject of motion?
- In *Physics*, III.3, what is the relationship between motion, action (doing), and passion (suffering)?
- When reading *Physics*, VI.9, try to put the four paradoxes of Zeno into your own words.

Post-reading questions

Consider the passage from David Hume below:

> When we look about us towards external objects, and consider the operation of causes, we are never able, in a single instance, to discover any power or necessary connexion; any quality, which binds the effect to the cause, and renders the one an infallible consequence of the other. We only find, that the one does actually, in fact, follow the other. The impulse of one billiard-ball is attended with motion in the second. This is the whole that appears to the *outward* senses. The mind feels no sentiment or *inward* impression from this succession of objects: Consequently, there is not, in any single, particular instance of cause and effect, any thing which can suggest the idea of power or necessary connexion.
>
> From the first appearance of an object, we never can conjecture what effect will result from it. But were the power or energy of any cause discoverable by the mind, we could foresee the effect, even without experience; and might, at first, pronounce with certainty concerning it, by mere dint of thought and reasoning.

David Hume, *An Enquiry Concerning Human Understanding*, Section VII, Part I, n. 50 (Project Gutenburg ed.).

Is Hume correct? How might Aristotle's discussion of motion, action, and passion help?

7.4 Theories About Motion

This section corresponds to the reading of Aristotle, *Physics*, IV.4, and IV.11. Also read Augros, "A 'Bigger' Physics," which can be found in Appendix II (see pp. 164ff).

Reading questions

Before you read, consider the following: ***Is it possible to think of motion without thinking about where a moving thing is or when it is moving? Is it possible to imagine such things?***

As you read, consider the following questions:

- What is Aristotle's definition of place?
- What is Aristotle's definition of time?
- When reading Augros, focus on his fourth example as well as the two appendices. How does this example include Augros's distinction between general concepts and specific concepts about nature?

Post-reading questions

First, recall the natural path from *Physics*, I.1. How does it relate to the main thesis of Augros's lecture?

Second, think about our discussion of *Physics*, II.2, as well as Kalkavage's appendices to the *Timaeus*. Do you see any reasons why mathematics is useful or even necessary for studying motion?

Consider also the quotation from St. Thomas Aquinas below:

> By its very nature motion is not in the category of quantity, but it partakes somewhat of the nature of quantity from another source, namely, according as the division of motion derives from either the division of space or the division of the thing subject to motion. So it does not belong to the mathematician to treat of motion, although mathematical principles can be applied to motion. Therefore, inasmuch as the principles of quantity are applied to motion, the natural scientist treats of the division and continuity of motion, as is clear in the *Physics*. And the measurements of motions are studied in the intermediate sciences between mathematics and natural science: for instance, in the science of the moved sphere and in astronomy.

St. Thomas Aquinas, *Super Boethium de Trinitate*, q. 5, a. 3, ad 5 (Aquinas Institute translation).

7.5 Conclusion

> The way up and down is one and the same.
>
> – Heraclitus, DK 60

Aristotle's discussion of motion, action, and passion in the *Physics* have far-reaching implications, and this is true not only in the natural sciences but in other areas as well. Consider the passage below from Aquinas. It is from his theological treatise on the Holy Trinity, considering the relations of the Persons to each other and to the divine nature.

> It would seem that the divine relations are not really distinguished from each other. For things which are identified with the same, are identified with each other. But every relation in God is really the same as the divine essence. Therefore the relations are not really distinguished from each other.

St. Thomas, *Summa Theologiae*, Ia, q. 28, a. 3, obj. 1 (Aquinas Institute translation).

Here is St. Thomas's reply to the objection:

> According to the Philosopher (*Physics* III), this argument holds, that whatever things are identified with the same thing are identified with each other, if the identity be real and logical; as, for instance, a tunic and a garment; but not if they differ logically. Hence in the same place he says that although action is the same as motion, and likewise passion; still it does not follow that action and passion are the same; because action implies reference as of something *from which* there is motion in the thing moved; whereas passion implies reference as of something *which is from* another. Likewise, although paternity, just as filiation, is really the same as the divine essence; nevertheless these two in their own proper idea and definitions import opposite respects. Hence they are distinguished from each other.

Ibid., ad 1.

The way up and the way down are *not* the same when it comes to motion and real relations.

Part III

Finding the Wisdom of the Cosmos

Scientific Discovery and Modeling Nature

8

I would rather discover one cause than be master of the kingdom of the Persians.

– Democritus, DK 118

8.1 Introduction

Now that we have completed our study of the fundamental principles of the philosophy of nature, we must develop our understanding by applying them in more challenging circumstances. First, we will consider Aristotle's ideas in the context of the history and philosophy of the natural sciences. In subsequent parts of the course, we examine the order of nature as a whole.

Goals for this chapter

(1) To study natural substances in more detail
(2) To understand the method of discovery and proof in the natural sciences
(3) To appreciate various scientific discoveries in physics, chemistry, and biology

Readings for this chapter

– Wallace, *The Modeling of Nature*
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter V

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

– What does it mean to "model" nature?
– What is the logical structure of the demonstrative regress?
– What are examples of the demonstrative regress in the history of the natural sciences?

The Chapter Questions are collected for review in Appendix I, see p. 79.

8.2 The Inorganic World

> We really know nothing. Truth is in the depth.
>
> – Democritus, DK 117

This section corresponds to the reading of Wallace, *Modeling of Nature*, 1.7–1.9 and ch. 2.

Reading questions

Before you read, consider the following: ***Based upon our readings thus far, how would you characterize matter?***

As you read, consider the following questions:

- How does Wallace incorporate all of the four causes into one "causal model"?
- How is the causal model used to characterize an individual natural body? What does the model include or leave out?
- In Chapter 2, focus on the various *examples* of natural bodies or substances that Wallace discusses.
- What is an element? What is a compound?
- What is an inorganic form?
- How are action and passion found among inorganic substances?
- According to Wallace, what is "the ultimate substrate"? How is it related to particles, atoms, and molecules?
- How is the causal model used to characterize natural generation?
- How is the causal model used to characterize states of matter and inorganic substances?
- Can the causal model be used at large scales (e.g., the Earth or the universe)?

Post-reading questions

Think about the various examples of inorganic substances discussed by Wallace in Chapter 2. How were these discovered? What methods were used? Were tools or instruments or other technical apparatus needed?

Also: Do such methods and techniques for discovering nature's workings in the very small or the very large prove that Democritus in DK 117 is right or wrong?

8.3 The Philosophy of Science

This section corresponds to the reading of Wallace, *Modeling of Nature*, selections from chs. 6–7. Read 6.1–8 and 7.1–7.3, and 7.7; the remainder of these chapters is optional.

Reading questions

Before you read, consider the following: ***Recall our discussions of the Pre-Socratics. How did they investigate nature? What was a reasonable and sufficient guess? Also, what was the difference between general conceptions and specific conceptions of things?***

As you read, consider the following questions:

- Note that *Modeling*, 6.0–4 provide historical background for the development of the natural sciences. It is helpful reading, but student need not stress about all the details.
- In *Modeling*, 6.5, what are the main contentions about science proposed by Kuhn, Lakatos, and Popper? Whatis the core disagreement among them?
- In *Modeling*, 6.6, how did Thomists in the 20th century react to debates about the nature of the sciences? How was natural philosophy involved?
- In *Modeling*, 6.7–8, how does Wallace relate the philosophy of nature and the sciences? How does he define the philosophy of science?
- In *Modeling*, 7.1, what is measurement? What are the main types of measurement and metric concepts?
- In *Modeling*, 7.2, what is a theory? a hypothesis? What are the types of theoretic concepts?
- In *Modeling*, 7.3, what is the logical structure of hypothetico-deductive reasoning?
- In *Modeling*, 7.7, what is the logical distinction between knowledge, opinion, and belief?

Post-reading questions

Based upon our study of Aristotle's *Physics*, what do you think Aristotle would say about Wallace's ideas about the philosophy of nature and science in *Modeling*?

8.4 The Demonstrative Regress

This section corresponds to the reading of Wallace, *Modeling of Nature*, ch. 8.

Reading questions

Before you read, consider the following: ***When reading a mystery novel—such as a good Sherlock Holmes story—what is the "discovery" of the culprit like? Does the plot tell about the effects or the causes first? Why?***

As you read, consider the following questions:

- In *Modeling*, 8.1, how are causal connections captured in using the HD (hypothetico-deductive) methodology? How do demonstrative syllogisms represent causal connections? What are some key differences?
- In *Modeling*, 8.2, what is the role of definition in science? Pay attention to Wallace's examples.
- In *Modeling*, 8.3, what is a demonstration? What are the types of demonstration?
- In *Modeling*, 8.4, what are the roles of foreknowledge and supposition in demonstration? What foreknowledge or suppositions are required scientific demonstration?
- In *Modeling*, 8.5, what is the "demonstrative regress"? What is its basic logical structure, whether presented by Zabarella or by Galileo? Pay attention to the example using the phases of the moon.
- In *Modeling*, 8.6, what is a model? What are the main types of models? What is the role of modelsin scientific reasoning?
- In *Modeling*, 8.7–8, think about the "ontology" underlying different approaches to understanding what the antural sciences are talking about.

Post-reading questions

Think about the various scientific discoveries mentioned in Wallace, *Modeling*, ch. 2. Do you think that the demonstrative regress could be used to make such discoveries? How? (Make some reasonable guesses.)

8.5 Rediscovering the Moon and Planets

This section corresponds to the reading of Wallace, *Modeling of Nature*, chs. 9–10. We will study these chapters in several parts, focusing on various themes. First, we will focus on 9.2–3 and 10.2–3.

Reading questions

Before you read, consider the following: ***People often say things like "We know now that there are more than four elements," or "We know that viruses cause illness." What is the "we" doing in such claims about scientific discoveries?***

As you read, consider the following questions:

- In *Modeling*, 9.2, using the logical methods discussed in 8.3 and 8.5, arrange the following into both *quia* and *propter quid* demonstrations: Galileo's discover of mountains on the moon, Galileo's discovery of the moons of Jupiter, Galileo's discovery of the orbit of Venus.
- In *Modeling*, 9.3, using the logical methods discussed in 8.3 and 8.5, arrange the following into both *quia* and *propter quid* demonstrations: Galileo's discovery of the rate of fall of heavy objects, Galileo's discovery of the law of the rate of fall (acceleration).
- In *Modeling*, 10.2, what were the main difficulties with accepting Galileo's astronomical discoveries, in terms of the Aristotelian logic of discovery and proof?
- In *Modeling*, 10.3, what were the main difficulties with accepting Galileo's law of free fall, in terms of the Aristotelian logic of discovery and proof? Were these proofs enough to prove the motion of the Earth?

Post-reading questions

Recall the distinction between knowledge, opinion, and belief (see *Modeling*, 7.7). Which of the three do you personally possess with respect to the various discoveries and proofs discussed in the readings?

8.6 Discovering the System of the World

> And mind set in order all things that were to be, and all things that were but now are not, and whatever is now and whatever things will be, and this revolution in which the stars and the sun and the moon and the air and the aether go round, having been separated off. This revolution has caused them to be separated.
>
> – Anaxagoras, DK 12

This section corresponds to the reading of Wallace, *Modeling of Nature*, chs. 9–10. We will study these chapters in several parts, focusing on various themes. In this part, we will focus on 9.6 and 10.6.

Reading questions

Before you read, consider the following: ***Have you ever been told that the moon is falling towards the earth? What does this mean? Compare it with an apple falling to the ground.***

As you read, consider the following questions:

- In *Modeling*, 9.6, what is the role of the "Rules of Philosophizing"? Are they foreknowledge or suppositions?
- What is the effect that Newton studied to learn more about gravity?
- For the resolution or first progression of the demonstrative regress (the *quia* demonstration), what are the varous phenomena that Newton had to be familiar with? (Hint: You may have to look up some terms.)
- For the composition or second progression of the demonstrative regress (the *propter quid* demonstration), what becomes known about gravity as a cause?
- In *Modeling*, 10.6, what difficulties were there in understanding or accepting Newton's discovery of universal gravitation?
- What suppositions from natural philosophy are required to understanding Newton's discovery of the law of gravity?

Post-reading questions

Did Newton discover the nature of gravity as a power or natural force? Why does Wallace mention Einstein (see p. 409)? Consider the following comments by Einstein.

> Thus the new theory of gravitation diverges widely from that of Newton with respect to its basal principle. But in practical application the two agree so closely that it has been difficult to find cases in which the actual differences could be subjected to observation. . . . No one must think that Newton's great creation can be overthrown in any real sense by this or by any other theory. His clear and wide ideas will for ever retain their significance as the foundation on which our modern conceptions of physics have been built.

Albert Einstein, "Time, Space, and Gravitation," *Science*, 51, no. 1305 (2 Jan 1920); originally published in *London Times*, 28 Nov 1919 (from Wikisource).

A key difference between Newton's theory of gravity and Einstein's is that Newton did not assume that the force of gravity takes time to propagate through space. Consider his formula for gravity:

$$F_G = G\frac{m_1 m_2}{r^2}$$

In this equation, there are no terms that represent the passage of time. There are only terms for force due to gravity between to objects measured in Newtons (F_G), the mass of two gravitating objects measured in kilograms (M_1, m_2), and the distance between them measured in meters (r^2). (The term G is the gravitational constant.) The equation implies that once one of the objects moves, the force of gravity between them changes *instantaneously*. Newton himself thought that this was a flaw in his theory; it was akin to "action at a distance." (Can you think of a natural philosophical argument that action at a distance is implausible or impossible?)

Einstein's modification of gravity, in simplified terms, takes the fraction in the equation above and transforms it into a new equation, the Einstein equation (no, not $e = mc^2$, a more difficult one that I will not print here). The equation essentially says that "space acts on matter, telling it how to move. In turn, matter reacts back on space, telling it how to curve." This action and reaction, in Einstein's theory of gravity, takes time (gravity propagates at the speed of light).

Misner, Thorne, and Wheeler, *Gravitation*, p. 5.

8.7 Discovering the Microscopic World

This section corresponds to the reading of Wallace, *Modeling of Nature*, chs. 9–10. We will study these chapters in several parts, focusing on various themes. In this last part, we will focus on 9.7–8 and 10.7–9.

Reading questions

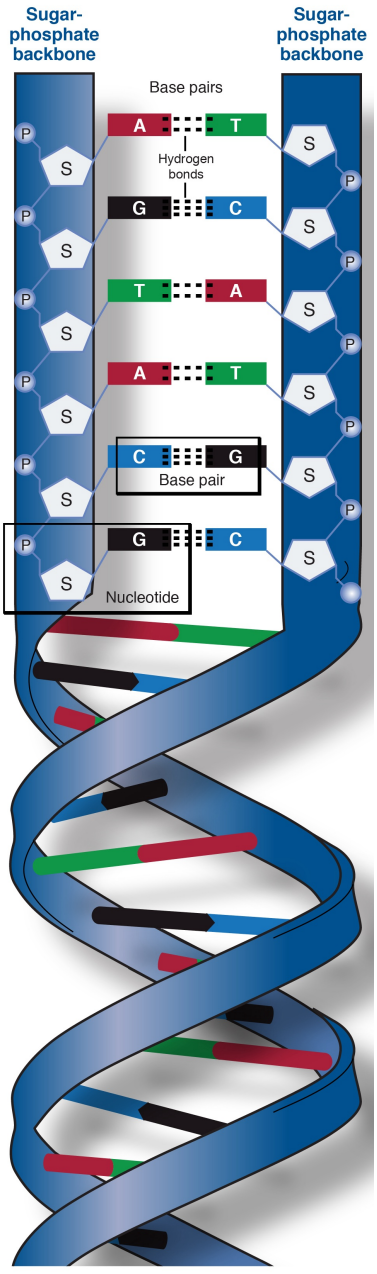
Before you read, consider the following: ***Would Democritus expect that you could see his atoms with a microcope? Can you see atoms with a microscope?***

As you read, consider the following questions:

- In *Modeling*, 9.7, write out in your own words the *quia* and the *propter quid* demonstrations about the discovery of atoms and electrons.
- In *Modeling*, 9.8, write out in your own words the *quia* and the *propter quid* demonstrations about the discovery of the structure of DNA.
- In *Modeling*, 10.7, how do the natural sciences help us to understand sensible qualities? What are limitations of this approach?
- In *Modeling*, 10.8, what key things have we learned about the modeling of nature in light of the demonstrative regress and the history of the natural sciences?
- In *Modeling*, 10.9, what is Wallace's argument that the philosophy of nature and science, even today, ought to be an Aristotelian one?

Post-reading questions

Wallace includes no diagram of a DNA molecule. For reference while reading *Modeling*, 9.8, see the diagram at right.



Schematic representation of a DNA molecule (NIH graphic, public domain).

8.8 Conclusion

The "demonstrative regress," the method of scientific discovery and proof originally set down by Aristotle, is alive and well in the modern natural sciences. As we have seen, it also involves various suppositions and background knowledge from the philosophy of nature. Its twofold "broken circle" in reasoning from effects to cause and back again went by different names, but its logic was the same. Here is Einstein expressing his understanding of this logic:

> There are several kinds of theory in physics. Most of them are constructive. These attempt to build a picture of complex phenomena out of some relatively simple proposition. The kinetic theory of gases, for instance, attempts to refer to molecular movement the mechanical thermal, and diffusional properties of gases. When we say that we understand a group of natural phenomena, we mean that we have found a constructive theory which embraces them.
>
> But in addition to this most weighty group of theories, there is another group consisting of what I call theories of principle. These employ the analytic, not the synthetic method. Their starting-point and foundation are not hypothetical constituents, but empirically observed general properties of phenomena, principles from which mathematical formula are deduced of such a kind that they apply to every case which presents itself. Thermodynamics, for instance, starting from the fact that perpetual motion never occurs in ordinary experience, attempts to deduce from this, by analytic processes, a theory which will apply in every case. The merit of constructive theories is their comprehensiveness, adaptability, and clarity, that of the theories of principle, their logical perfection, and the security of their foundation.

Einstein, "Time, Space, and Gravitation." Source quoted above.

What we should consider, in light of this perennial logic of discovering the details about nature, is whether or not the philosophy of nature and the sciences are really one project of knowledge. Note that the "the philosophy of nature" bases itself on general conceptions known to us at first (leading to a "general theory" in the sense of conceptually broad), while the natural sciences base themselves upon specified conceptions that we only discover later (leading to a "general theory" about the world in the sense of what is causally broad).* Must they be totally different projects?

* For more details, see Brungardt, *Natural Philosophy*, Chapter VI.

The Order of the Cosmos 9

The hidden harmony is better than the apparent.

– Heraclitus, DK 54

9.1 Introduction

In this chapter, we continue our detailed examination of the cosmos. Building upon the methods of scientific discovery and proof, we consider details about physics, chemistry, and biology with a special focus on living things in the cosmos. This includes ourselves, of course, a theme that we complete in the next and final chapter.

Goals for this chapter

(1) To examine the contributions of physics, chemistry, and biology to the study of living things
(2) To consider philosophically living physical substances (their form, activity, and origins)
(3) To understand more about the cosmos as a unity of order and its causes

Readings for this chapter

– Augros & Stanciu, *The New Biology*
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter VI

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

The Chapter Questions are collected for review in Appendix I, see p. 79.

– How do we know that living things are more than machines (beyond physics's paradigm)?
– How can natural philosophy help us to understand the difference between living kids, their cooperation, the harmony in the natural world, as well as the purpose and hierarchy found in living things?
– What causes explain the diversity of living species and their origins in the natural history of the cosmos?

9.2 The World Beyond Physics

This section corresponds to the reading of Augros & Stanciu, *New Biology*, the Introduction and ch. 1.

Reading questions

Before you read, consider the following: ***From our study of Wallace, what did we learn about "paradigms" and the way that Newtonian physics explains the world?***

As you read, consider the following questions:

- In the Introduction to *New Biology*, what is the authors's stated goal for the book? If they succeed, how could this benefit our study of natural philosophy?
- In *New Biology*, ch. 1, why is biology considered by some to be an "extension" of physics? Where did this philosophical view originate and what is it called? Does this philosophy have any currency now?
- What are the two competing schema for the sciences that the authors describe? Which do they defend, and why?
- What is the reason for the "incongruity between contemporary physics and the life sciences"?
- What, according to contemporary physics, best characterizes matter? (I count about seven key characteristics.)
- Towards the end of the chapter, our authors make an analogy involving the rules of grammar and the words of Shakespeare or Milton. What is the analogy and what is it supposed to teach us?

Post-reading questions

Recall Aristotle's definition of nature from *Physics*, II.1. How could we use this definition to help us understand the "new schema" for the sciences proposed by Augros & Stanciu?

9.3 The Distinctiveness of Life

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 2. Consider also some points from Wallace, *Modeling of Nature*, ch. 3, especially 3.4–6.

Reading questions

Before you read, consider the following: ***Recall Aristotle's definition of nature. If living things are not machines, then to what part or parts of the definition or any implied ideas could you appeal for explanation?***

As you read, pay close attention to all of Augros & Stanciu's excellent examples. Write down the ones that you find most convincing. If you can't picture what they are talking about, look it up online. Also, consider the following questions:

This goes for the entire book!

- In *New Biology*, ch. 2, what is the "bizzare state" in which contemporary biology finds itself?
- What is "the machine model" of living things? What are its historical points of origin?
- Our authors argue at length that living things are not machines. These arguments involve growth, repair, development, unity and fuction, food, the use of chemical processes, the notion of the artificial, integrity, and incessant activity.
- What are the important differences between a cell and a factory?
- What is the definition of life that our authors propose? (Also, why are mechanism and vitalism both wrong?)
- How is the new understanding of matter in modern physics compatible with Aristotle's idea about matter?
- What is form like at the chemical level? What is form like at the subatomic level?
- What is the difference between reductionism and emergentism?
- In what ways is a living organism "best understood if seen as the culmination of a long hierarchy of natural forms"?
- Is a virus alive?
- Why do our authors think that "the unique unity, organization, and activity of the organism arises from its unique *form*"? How does this make all living things—even plants—"[masters] of the material world"?

Post-reading questions

Recall why Aristotle thinks that nature is both form and matter, but more form than matter. Do Augros & Stanciu help us understand Aristotle's thesis in a more profound way?

9.4 What Makes Us Any Different?

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 3. Consider also some points from Wallace, *Modeling of Nature*, ch. 4, especially 4.1–5.

Reading questions

Before you read, consider the following: ***Recall Aristotle's definition of nature. If human beings have different natures than other animals, to what part or parts of the definition or any implied ideas could you appeal for explanation?***

As you read, consider the following questions:

- Why do some biologists and psychologists treat animals as "unthinking robots"?
- What is behaviorism? How is it related to materialism?
- What does the study of the brain "not dissolve the mystery of sensation but deepens it"?
- Is "neuronal machinery" necessary or sufficient for conscious experience? What arguments do the authors offer against emergence when it comes to plants and animals?
- In the section "Animal Behavior," our authors begin with an array of arguments that animals are not machines and that they have conscious awareness. (I count about eight arguments.)
- How does an animal perceive or understand its environment? What are its limitations?
- How are an animals senses "closely aligned with its way of life"?
- How do physics and chemistry shed light on how animals are able to act and behave as they do?
- How do animals act instinctively versus consciously? Can animals act on signs or information?
- In the section "Are Animals Intelligent?" our authors develop three arguments at length. What are these arguments? What examples support each of them?
- Pay close attention to how the authors compare and contrast the use of signs or symbols by various primates as well as young human children. What does this investigation tell us?
- What is the "new model" for biological inquiry that the authors propose? (Note the objection that they raise against this new model. What is the objection, and how do they answer it?)

Post-reading questions

How could we use Aristotle's four causes to shed further light on this chapter?

9.5 Competition or Cooperation in Nature?

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 4.

Reading questions

Before you read, consider the following: ***In ordinary English usage, what is the difference between competition and cooperation? What sorts of causes are involved in both cases?***

As you read, consider the following questions:

- What was the paradigmatic relationship among living species in nature proposed by Darwin? How is it defined?
- What are some of the ways that nature avoids competition?
    - Consider the numerous examples under the following headings: geography, niches, food specialization, spatial division, temporal separation, migration, habits, and guilds.
- How do the authors address objections that predation or parasitism undermine the idea that nature is primarily cooperative?
- What are some of the ways that species cooperate?
    - Consider the numerous examples under the following headings: place, obtaining food, transport, partnerships, protection, cleaning, ecological succession, and chemical cycles or dependencies.
- What are some of the ways that there is cooperation within a species?
    - Consider the numerous examples under the following headings: dispersal, territoriality, dominance hierarchies, behavioral differences, and social organization.
- What was Darwin's reasoning when proposing competition as paradigmatic?
- The authors list at least four problems with Darwin's reasoning. What are they?

Post-reading questions

How could we use Aristotle's various "modes" of causality to shed further light on this chapter?

9.6 The Harmony of Organism and Environment

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 5.

Reading questions

Before you read, consider the following: ***What is the difference between these: environment, habitat, ecosystem, biome? (Hint: Look these up.)***

As you read, consider the following questions:

- Why might one think that animals struggle against their environment?
- Aside: Why do the authors "take up questions of origin" in a later chapter?
- What are the ways in which struggle is avoided an harmony between organism and environment found in very cold climates? (There are at least four classes of examples.)
- What are the ways in which struggle is avoided an harmony between organism and environment found in very hot climates? (There are at least three classes of examples.)
- In what ways do organisms not fight the environment but "work with it or around it"?
- What is the "rule of least material" and what are examples?
- How does nature invent new materials? How is it efficient with energy and operation? How are organisms finely tuned?
- Why are nature's economy and efficiency principles of discovery for the biologist? What are some examples?
- Why is nature both "a superb engineer" as well as a "master artist"?

Post-reading questions

How could we use Aristotle's principles of chance as well as his types of necessity to shed further light on this chapter?

9.7 Discovering the Origins of Species

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 6.

Reading questions

Before you read, consider the following: ***Recall the logical structure of the demonstrative regress. What are its key parts? What makes it different than the hypothetico-deductive method?***

As you read, consider the following questions:

- What are three key principles of Darwin's model of the evolutionary origin of species by natural selection?
- How do the authors critique the soundness of the three Darwinian principles?
- What is the "second line of defense"? Why is it inadequate? What are the two alternatives facing Darwinian theory?
- What is "the fossil record"? How was its existence discovered?
- The authors note three crucial features of the fossil record. What are they? What are examples of each?
- What is the "new model" of evolution that the authors propose for plants and animals?
- What are the benefits of the new model? (I count about six.)
- Does the new model address the "evolutionary hypothesis" of Empedocles?
- In the section "The Fact of Evolution," the authors seem to propose a six-part *quia* demonstration for the existence of evolution. What is it?
- Evolution does not explain the origin of life. How do the authors explain it? What are the key terms in their argument?

Post-reading questions

Can you construct a demonstrative regress for (1) the fact of evolution and (2) evolution according to the new model proposed by Augros and Stanciu ("evolution through systematic differentiation," as they call it in the next chapter, p. 193)?

9.8 Nature's Purposes and Modern Science

This section corresponds to the reading of Augros & Stanciu, *New Biology*, ch. 7.

Reading questions

Before you read, consider the following: ***Recall our study of the principle that nature acts for an end. What were the principal arguments for this thesis?***

As you read, consider the following questions:

- In the old Darwinian theory, what is "adaptation"? Why is adaptation to the environment insufficient as an explanation? How do the authors answer objections based upon niches and extinction?
- What are the arguments the authors propose against adaptationism as an evolutionary mechanism? How do they account for variation in population?
- What reasons are there for and against purpose in biology?
- Do the authors argue that purpose exists in natural things, even those without knowledge? Is purpose a human projection into nature?
- Consider the extensive examples of purpose in nature under the following headings:
    - How purpose helps explain things in biology
    - How purpose is related to shape, function, and even life cycle timing
    - How art (technology) imitates nature's purposes
    - How purposes is compatible with other causes
    - Purpose and animal behavior
    - Purpose and animal organs
    - Purpose and nature's efficiency and ingenuity
    - Multipurpose organs
    - Purpose and perfection in activity and size
- Is it rash to deny purpose in nature when one doesn't find it?
- Why is it not surprising that "purpose is a principle of prediction and discovery in biology"?

Post-reading questions

In what ways can you identify the following principles of natural philosophy in this chapter: nature, the four causes and their modes, chance, and both hypothetical and material necessity?

9.9 The Hierarchy in the Cosmos

> The form of the universe consists in the distinction and order of its parts.
>
> – St. Thomas, *ScG*, II.39, n. 7

This section corresponds to the reading of Augros & Stanciu, *New Biology*, chs. 8–9. Students should also look ahead to *CG*, 10.2, about fine-tuning in cosmology, when reading these two chapters.

Reading questions

Before you read, consider the following: ***What does "hierarchy" mean? Which of Aristotle's four causes are required to explain the existence of a hierarchy?***

As you read, consider the following questions:

- In *New Biology*, ch. 8, what reasons are there that modern biology tends to deny the existence of hierarchy in nature? How do the authors argue against these reasons?
- What arguments establish the existence of hierarchy in nature? (I count about six arguments.)
- Can the human intellect be a product of evolution?
- According to our authors, how does the human species, at the end of evolution, complete the cosmos?
- In the last chapter, what are the benefits that the authors of "the new biology" that they have sketched out?

Post-reading questions

The authors note two extremes that their book avoids. What are the extremes, and what is the middle ground?

9.10 Conclusion

Metaphysics, IV.3, 1005b1–2.

Aristotle says that "the philosophy of nature is a sort of wisdom, but it is not the first." There is, evidently, a higher form of wisdom about truth. As wonderful as that is, in what ways do Augros & Stanciu illustrate how the philosophy of nature is itself a sort of wisdom?

Consider how the Thomistic philosopher Jacques Maritain describes the philosophy of nature as wisdom:

Jacques Maritain, *Philosophy of Nature*, 122–23.

> Without a philosophy of nature which is surordinate to the natural sciences and subordinate to metaphysics and which preserves the contact between philosophical thought and the universe of the sciences, metaphysics has no contact with things and can only fall futilely back upon the knowing or willing mind itself. In the order of material and dispositive causality, the wisdom *secundum quid* of the philosophy of nature, taken in its first positions at least, is a condition for speculative wisdom pure and simple, a condition for metaphysics.
>
> And, conversely, without a philosophy of nature to as it were transmit rulings from above to the world of the natural sciences, metaphysics can no longer exercise over the latter its function of *scientia rectrix*. I mean that it remains ineffective either to orient toward a knowledge of wisdom, everything in the sciences of phenomena which aspires without attainment to an intelligible grasp of the real as such, or to judge and delimit the meaning and scope of whatever is subject in these natural sciences to the final regulation of mathematical entities. The immense and powerful mass of scientific activities, the human mind's marvelous endeavor to conquer nature experimentally and mathematically, is left without any direction or light higher than that of empirical and quantitative law, and is wholly cut off from the order of wisdom. It advances historically and it captivates men, but it no longer knows aught of speculative and practical wisdom.

Man's Place in the Cosmos | 10

> Man is a little cosmos [*microcosmos*].
>
> – Democritus, DK 34

10.1 Introduction

In this final part of the course, we will consider the place of the human person in the cosmos. Does mankind complete the universe? Is the cosmos designed for human existence? What can the philosophy of nature tell us about how we could to relate to the natural order?

Goals for this chapter

(1) To consider the order and harmony of the cosmos through the model of cosmogony in the Big Bang theory
(2) To appreciate, using philosophical reasoning, how humankind is a steward of the cosmos

Readings for this chapter

– Reading on fine-tuning in cosmology
– Kearns, "On the Place and Purpose of Humankind in the Cosmos"
– *Supplemental reading:* Brungardt, *Natural Philosophy*, Chapter VI and Conclusion

Chapter Questions

When completing the reading and study materials in this chapter, you should have the following general questions in mind, which are also of use when reviewing the course:

– What is "fine-tuning" in the context of contemporary cosmology? Is it evidence that the cosmos has a First Cause?
– What is the nature of stewardship? Why ought we to think that humankind has stewardship over nature?

The Chapter Questions are collected for review in Appendix I, see p. 79.

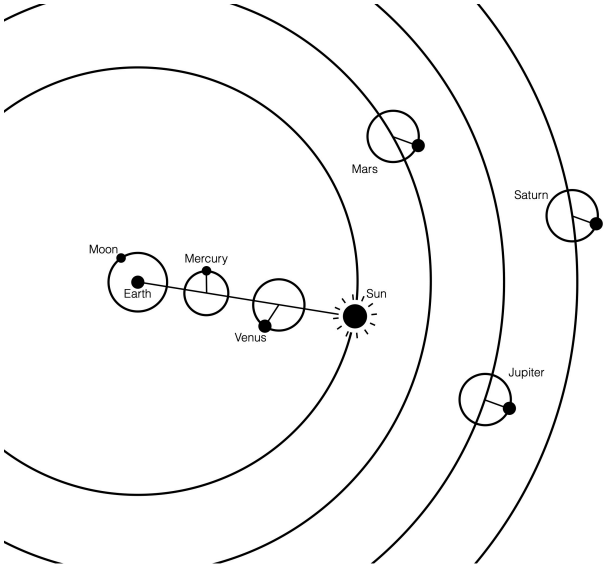
10.2 Fine-Tuning in Cosmology

What is "fine-tuning" in a physical theory? Consider this explanation by the theoretical astrophysicist Luke Barnes:

> When a physicist says that a theory is fine-tuned, they mean that it must make a suspiciously precise assumption in order to explain a certain observation. This is evidence that the theory is deficient or incomplete. As a simple example, consider a geocentric model of the Solar System. Naively, at any particular time, the Sun and planets could be anywhere in their orbits around the Earth. However, in our night sky, Mercury is never observed to be more than 28° from the Sun, and Venus is never seen more than 47° from the Sun. Can a geocentric model explain this observation? Yes, but only by adding a postulate. In Ptolemy's geocentric model, Mercury and Venus travel on epicycles, and those epicycles are centred on a line joining the Earth to the Sun. This explains the data, so the model does not fail. However, in the context of the model, this assumption is unmotivated and suspiciously precise. Given only that the planets and Sun orbit the Earth, there is no reason to expect such an arrangement. This fine-tuning of the geocentric model doesn't necessarily mean that it is wrong,but it should make us wary. We should search for a model in which the data is explainedmore naturally: Mercury and Venus are never seen too far from the Sun because the planets orbit the Sun, not the Earth.

Luke A. Barnes, "The Fine-Tuning of the Universe for Life," in *The Routledge Companion to Philosophy of Physics*, ed. Eleanor Knox and Alastair Wilson (Routledge, 2021), 719.

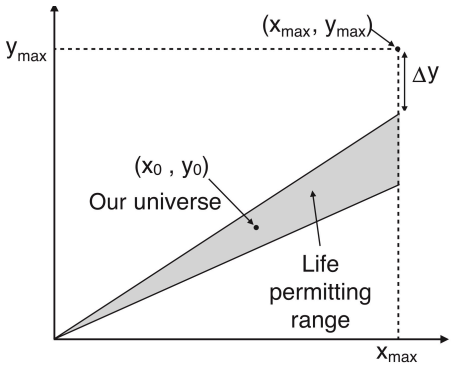
This is only *one* version of Ptolemy's model. See the diagram below.



One version of Ptolemy's model (from Barnes, "Fine-Tuning," 720.).

As Barnes notes, in modern mathematical representations, this is

usually accomplished using graphs. Two (or more) parameters or constants of a model are compared to each other, and the area of the graph that results can be used to represent where "life-permitting" possible universes are located (as it were).



The "wedge" area in the above generic graph is a "fine-tuned" area; from Luke A. Barnes, "The Fine-Tuning of the Universe for Intelligent Life," *PASA* 29, no. 4 (2012): 536. He notes: "When parameter space is explored in the scientific literature, it rarely (if ever) looks like the wedge. We instead see many intersecting wedges."

At the same time, "fine-tuning" has a broader meaning when thinking about art and nature: The violinist carefully puts the strings of her instrument into proper harmony for the sake of playing music well. Object, form, paradigm, and finality are all present. A philosopher might trope this to propose a general definition, saying that an object is fine-tuned for a certain result given a set of conditions, and "we need to know all three variables," namely the object, the result, and the conditions, "to even understand a fine-tuning claim." Due to the contingency of the relationship between the parts or conditions of some whole contributing to the result, fine-tuning frequently raises questions of the presence of intelligence. Yet a designer is not a necessary part of the above definition (however, this does not prevent us from arguing to a "Fine-Tuner").

Jason Waller, *Cosmological Fine-Tuning Arguments* (Routledge, 2021), 79.

What are some examples of "fine-tuning" in cosmology? Consider the following summary, collected by the cosmologist and astrophysicist Martin Rees.

> N, the ratio of the electromagnetic force to the gravitational force between a pair of protons, is approximately 10^{36}. According to Rees, if it were significantly smaller, only a small and short-lived universe could exist. If it were large enough, they would repel them so violently that larger atoms would never be generated.
>
> Epsilon (ϵ), a measure of the nuclear efficiency of fusion from hydrogen to helium, is 0.007: when four nucleons fuse into helium, 0.007 (0.7
>
> Omega (Ω), commonly known as the density parameter, is the relative importance of gravity and expansion energy in the universe. It is the ratio of the mass density of the universe to the "critical density" and is approximately 1. If gravity were too strong compared with

Summary of Rees, *Just Six Numbers*, p. 4; from Wikipedia, "Fine-tuned universe."

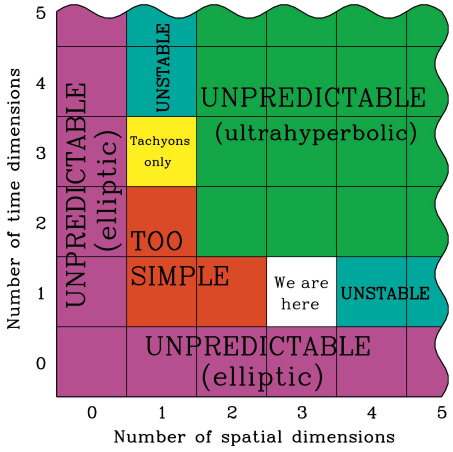
dark energy and the initial cosmic expansion rate, the universe would have collapsed before life could have evolved. If gravity were too weak, no stars would have formed.

Lambda (Λ), commonly known as the cosmological constant, describes the ratio of the density of dark energy to the critical energy density of the universe, given certain reasonable assumptions such as that dark energy density is a constant. In terms of Planck units, and as a natural dimensionless value, Λ is on the order of 10^{-122}. This is so small that it has no significant effect on cosmic structures that are smaller than a billion light-years across. A slightly larger value of the cosmological constant would have caused space to expand rapidly enough that stars and other astronomical structures would not be able to form.

Q, the ratio of the gravitational energy required to pull a large galaxy apart to the energy equivalent of its mass, is around 10^{-5}. If it is too small, no stars can form. If it is too large, no stars can survive because the universe is too violent, according to Rees.

D, the number of spatial dimensions in spacetime, is 3. Rees claims that life could not exist if there were 2 or 4 spatial dimensions.

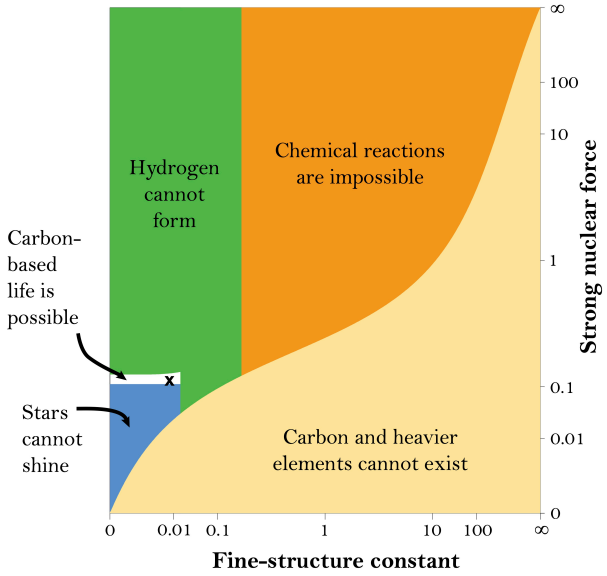
In regard to the last number, D, "Max Tegmark argued that if there is more than one time dimension, then physical systems' behavior could not be predicted reliably from knowledge of the relevant partial differential equations. In such a universe, intelligent life capable of manipulating technology could not emerge. Moreover, protons and electrons would be unstable and could decay into particles having greater mass than themselves. This is not a problem if the particles have a sufficiently low temperature" (Wikipedia, "Fine-tuned universe"). See below.



The anthropic constraints on the dimensions of space and time, from Barnes, "The Fine-Tuning of the Universe for Intelligent Life," 557.

Another interesting example is the relationship between the mea-

sure of the strong nuclear force (the force that holds atoms together, against the postive-negative repulsion of protons and electrons) and the fine-structure constant (the value of the strength of that-electromagnetic force between subatomic particles). See below.



Relationship between the strong force and the fine-structure constant and resulting effects in different possible universes; from Luke A. Barnes, "The Fine-Tuning of Nature's Laws," *The New Atlantis* (Fall, 2015), 91. Our universe is marked with an 'x' on the graph.

One thing to think about is in what sense the "alternative" universes that are represented in such graphs are *possible*. Are they really possible? Or are they only conceptually possible in the mathematics we are using in these models?

Some scientists postulate the existence of other universes (the multiverse) in order to explain fine-tuning. That is, they hypothesize that some universe-generating process selects various values by chance for nature's parameters and constant, and we (of course) end up in the universe capable of supporting life. Others propose that there is no multiverse; rather, the finely adjusted harmony of the cosmos is evidence of its being designed by an Ultimate Intelligence, a Universe Designer. A third option seems possible. Even if there is a multiverse, physical processes that generate the many universes in the multiverse according to various laws of nature would *themselves* have to be finely tuned. In other words, even a multiverse could have been designed and created by God.

10.3 Humankind as Cosmic Steward

This section corresponds to the reading of Kearns, "Humankind in the Cosmos," in Appendix II, pp. 182ff.

Reading questions

Before you read, consider the following: ***What is "stewardship"? Is it only an ethical or a religious idea, or could it be applied to the relationship between man and nature?***

As you read, consider the following questions:

- What is Kearns's purpose in this essay? What is his thesis?
- If humankind has no place or purpose in the cosmos, what follows? What does this thought experiment show us?
- What does Kearns argue we should learn from ancient cultures about the man–cosmos relationship, even when thinking about contemporary cosmology? What follows if we take "the traditional and nearly universal view" of this relationship seriously?
- Are there any indications of stewardship-like activities among non-human things? What does this indicate about human nature?
- How does Kearns argue that it is possible to conceive of humankind as steward of the cosmos?

Post-reading questions

Read Genesis 1:26–28, and reread the passage from Descartes about the mastery of nature (above, p. 11). Which philosophy better supports what the text from Genesis teaches? Why?

10.4 Conclusion

This completes our course in the philosophy of nature.* We would do well to reflect upon the fact that the philosophy of nature leads us to contemplate the universe as a whole, but does not itself *end* or *finish* such contemplation. However, even based upon natural philosophy, we can more fully appreciate what St. Thomas says about the universe in the passage below:

> The good of the order in the universe is more noble than any part of the universe, because each part is directed to the good of the order in the whole as to its end, as the Philosopher states in *Metaphysics* [Book XII].

St. Thomas, *ScG*, I.70, n. 4.

As a concluding thought, consider the following passage from St. Augustine, reflecting upon how it describes nature, order, and finality in the cosmos:

> Our rest is our place. Love lifts us up there, and Your good Spirit lifts our lowliness from the gates of death. In Your good pleasure lies our peace. The body by its own weight gravitates towards its own place. Weight goes not downward only, but to its own place. Fire tends upwards, a stone downwards. They are propelled by their own weights, they seek their own places. Oil poured under the water is raised above the water; water poured upon oil sinks under the oil. They are propelled by their own weights, they seek their own places. Out of order, they are restless; restored to order, they are at rest. My weight is my love [*Pondus meum amor meus*]; by it am I borne wherever I am borne.

St. Augustine, *Confessions*, XIII.9,10, trans. by J. G. Pilkington, from Nicene and Post-Nicene Fathers, First Series, vol. 1, ed. by Philip Schaff (Christian Literature Pub. Co., 1887); text from New Advent.

In this passage, "weight" is no mere heaviness. Rather, it is the very inclination of a creature towards its end, an inclination arising from its nature, a nature instilled in it by the Creator.

See St. Thomas, *ST*, Ia, q. 5, a. 5.

* For some theological implications of the philosophy of nature, see Brungardt, *Natural Philosophy*, Conclusion.

Appendix I: Chapter Questions

The various Chapter Questions are all repeated below, so as to assist students in reviewing for the final examination.

- Chapter 1 (The Intelligibility of Nature)
  (1) What desires shape the beginnings of the study of natural philosophy?
  (2) What is instrumentalism and to what is it opposed?
  (3) What is mechanism and what are some examples in early modern natural philosophy?
- Chapter 2 (Natures and Monsters)
  (1) What is a "monster"? How is the idea of a monster related to nature and the natural?
  (2) What can *Frankenstein* (the novel) teach us about natural philosophy?
- Chapter 3 (The Pre-Socratics and Nature)
  (1) What are reasonable guesses? What are sufficient guesses?
  (2) How do the Pre-Socratics provide guesses about matter and motion in the natural world?
  (3) How do the Pre-Socratics provide guesses about order and necessity in the natural world?
- Chapter 4 (Plato and Cosmology)
  (1) What is the nature of a "likely story" about the cosmos in the *Timaeus*?
  (2) What are the main features of the cosmos founded by intellect and its principles?
  (3) Why is the cosmos in the *Timaeus* also founded by necessity? (Bonus: How does the human being fit into such a cosmos?)
  (4) What shortcomings does the theory of the cosmos in the *Timaeus* have? What are its strong points?
- Chapter 5 (How Is Change Possible?)
  (1) What is the natural path in human thought?
  (2) What is the problem about change? Why must natural philosophy address this problem?
  (3) What are the principles of change? How are they distinct from each other in order to explain change?
- Chapter 6 (What Are Nature's Causes?)
  (1) What is the Aristotelian definition of "nature"?
  (2) What are the four causes? How can the causes be described in different ways?

(3) What is the definition of chance?
(4) What evidence is there that nature acts for an end? Are natural ends (teleology) compatible with chance and necessity in nature?
(5) What are the kinds of necessity that we find in nature?

– Chapter 7 (What Is Motion?)

(1) What is motion? Why is Aristotle's definition of motion unique?
(2) What is the difference between action and passion? What is place? What is time?
(3) What are Zeno's paradoxes? Why must motion be continuous?

– Chapter 8 (Scientific Discovery and Modeling Nature)

(1) What does it mean to "model" nature?
(2) What is the logical structure of the demonstrative regress?
(3) What are examples of the demonstrative regress in the history of the natural sciences?

– Chapter 9 (The Order of the Cosmos)

(1) How do we know that living things are more than machines (beyond physics's paradigm)?
(2) How can natural philosophy help us to understand the difference between living kids, their cooperation, the harmony in the natural world, as well as the purpose and hierarchy found in living things?
(3) What causes explain the diversity of living species and their origins in the natural history of the cosmos?

– Chapter 10 (Man's Place in the Cosmos)

(1) What is "fine-tuning" in the context of contemporary cosmology? Is it evidence that the cosmos has a First Cause?
(2) What is the nature of stewardship? Why ought we to think that humankind has stewardship over nature?

Appendix II: Readings

The following readings are included for the philosophy of nature course.

(1) Simplicius, "On the Interest of Physics," from Rémi Brague, "Is Physics Interesting? Some Responses from Late Antiquity and the Middle Ages," in *The Legend of the Middle Ages: Philosophical Explorations of Medieval Christianity, Judaism, and Islam*, translated by Lydia G. Cochrane. University of Chicago Press, 2009.
(2) Dear, Peter. *The Intelligibility of Nature: How Science Makes Sense of the World*. Reprint edition. University Of Chicago Press, 2008. Chapters 1–2.
(3) Various selections from the fragments of the Pre-Socratic philosophers, translated by Duane H. Berquist.
(4) Augros, Robert M. "Nature Acts for an End." *The Thomist: A Speculative Quarterly Review* 66, no. 4 (2002): 535–75.
(5) Berquist, Marcus R. "A Summary of Different Views about Motion and How It Is to Be Defined." In Learning and Discipleship: The Collected Papers of Marcus R. Berquist. Thomas Aquinas College, 2019.
(6) Augros, Michael. "A 'Bigger' Physics." Lecture. MIT / Institute for the Study of Nature, January 8, 2008.
(7) Kearns, Timothy. "On the Place and Purpose of Humankind in the Cosmos." *Logos: A Journal of Catholic Thought and Culture* 27, no. 2 (2024): 70–87.

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