

University of Cincinnati

Philosophy 1032: How Science Works

Course Description

Like a car, an airplane, or any other tool, science works in a particular way, for a particular purpose. So we can ask: what makes it go? What are its parts, and how do they fit together? What are they for? We will explore these questions by looking at real-life scientific and technological innovations that shed light on the methods, procedures, and concepts of science. Specific topics include: how to define science, types of experimental procedures, the role of statistics, and the values and starting assumptions that influence scientific theories. This course will prepare students for more focused work in particular sciences, will help education students grapple with the nature of science and scientific reasoning, and help non-science majors become more sophisticated consumers of scientific information.

Course Materials

Recipes for Science: An Introduction to Scientific Methods and Reasoning, by Potochnik, Colombo, and Wright, Routledge (2018).

Course Goals

Ability to describe the distinctive features of science and the nature of its success: Science plays a tremendous role in our current society, but there are also a lot of misunderstandings and disagreements about how science works and what it accomplishes. Students will emerge from this course with an understanding of what makes science distinctive and successful, as well as why science is more difficult to define and analyze than one might think.

Ability to critically assess specific scientific findings and popular reports of those findings: Armed with a clear and nuanced view of the nature of science and scientific reasoning, students will be able to identify the key elements of a report of scientific research and assess both the strengths and weaknesses of that research and how it has been reported.

Appreciation for the variety of scientific research: Our investigations will involve careful examination of past and present scientific research, from a variety of fields of natural science and social science. This will enable students to develop a sense of what the range of diverse scientific projects looks like.

Development of the general skills of critical thinking, discussing, and writing: Students will hone their ability to think critically and to express those thoughts in both oral and written form. Philosophy has very high standards for the clarity and rigor of written argument: if you can convince a philosopher of your view, then you can probably convince anyone! Verbal discussions give students the opportunity to figure out their own views, try out arguments before committing to them, and learn from one another.

Steps to Achieving the Course Goals

Participation and Classwork: This is a discussion-based course. Students are expected to attend all class meetings and participate actively in discussion. There will also be regular classwork activities designed to deepen our discussions. Please contact me if you would like suggestions for how to increase your level of participation in class discussions.

Readings: Each reading assignment should be completed before the class meeting when it is scheduled to be discussed. This is important for your ability to participate in class, as well as for your understanding of the ideas we encounter. Successful completion of classwork, homework, and exams will require careful reading.

Homework: Each reading assignment is accompanied by assigned homework. Homework should be typewritten and submitted as a batch at the beginning of the first class meeting following the end of each chapter. Many of the homework

problems will give you the opportunity to work on your skills of reflection and clear writing. Accordingly, you should reflect on and carefully revise all answers before submitting a homework set.

Exams: There will also be two midterm exams and a final exam. The two midterms will each focus on two units of the course; the final exam will be cumulative. The topics and format of the exams will be discussed in advance.

Grading

<u>250 points total</u>	<u>Estimated grade breakdown</u>	
30 points — Participation and Classwork	0-149 points: F	200-207 points: B-
100 points — Homework	150-174 points: D	208-215 points: B
60 points — Midterms (25 points/35 points)	175-182 points: C-	216-223 points: B+
60 points — Final Exam	183-191 points: C	224-231 points: A-
	192-199 points: C+	232-250 points: A

Course Policies

Late Work and Missed Exams: Unless an extension is granted in advance, homework will be penalized 5% for each day late. (If something comes up, it is *always* better to ask me for an extension than to just plan on losing points from a late penalty.) Missed exams can only be made up when there are extenuating circumstances. Any makeup exam must be scheduled beforehand if possible, and if not, then as soon as possible after the exam.

Absences: If you miss a class meeting, you are responsible for finding out about what you missed, including any announcements. If you must miss more than one class meeting in a row, please get in touch with me as soon as possible to make plans for keeping up with the class. Missing more than one class meeting will lower your participation and classwork grade. I will provide opportunities for makeup classwork upon (timely) request.

Collaboration: You are encouraged to discuss any and all material with your classmates, including the project assignments and studying for exams. The only limitations are:

- All written work must be completed on your own and must contain your own ideas.
- Students may not give or receive any help from other students during exams.

Avoiding Plagiarism: You may not use others' words except when directly quoting a legitimate source. To make a direct quote, you must use quotation marks and cite the source. You must also cite the sources for all ideas you discuss that are not your own. Failing to do these things will result in *plagiarism*, which is a serious violation of academic integrity. If you aren't sure whether something counts as plagiarism, you can always ask me.

Any violations of academic integrity will be addressed according to the University's policy on academic misconduct.

<u>Schedule</u>	<u>Topic</u>	<u>Reading Assignments and Assigned Exercises</u>
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NB: this syllabus is written for a course that meets twice weekly for 80 minutes each meeting, for a total of 15 weeks.

I SCIENCE: WHAT AND WHY

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| Meeting 1 | What's science good for?
(Planned classwork: in pairs, agree on (1) a scientific finding that your everyday life depends on and (2) a scientific finding that you don't understand or know whether to believe) | |
| Meeting 2 | Climate science; importance of science
(Planned classwork: Ex. 1.1 in pairs) | <i>Recipes</i> 1.1, Exercises 1.5, 1.7 |
| Meeting 3 | What counts as science?
(Planned classwork: Ex. 1.13 individually, then discuss with a partner; later 1.12) | <i>Recipes</i> 1.2, Exercise 1.15 |
| Meeting 4 | The nature of science
(Planned classwork: Ex. 1.20, work divided across groups of four) | <i>Recipes</i> 1.3, Exercises 1.23, 1.26 |

II EXPERIMENTS AND MODELS

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| Meeting 5 | Why do experiments?
(Planned classwork based on Ex. 2.11, 2.12) | <i>Recipes</i> 2.1, Exercises 2.6, 2.7 |
| Meeting 6 | The perfect experiment
(Planned classwork: 2.14 in groups of 3-4; then whole class compares and assesses experiments) | <i>Recipes</i> 2.2, Exercises 2.13, 2.17 |
| Meeting 7 | Variety of experiments
(Planned classwork: working in small groups, each half of the class evaluates one of two popular reports of scientific findings, agrees on experimental design, strengths, and weaknesses) | <i>Recipes</i> 2.3, Exercises 2.25, 2.26 |
| Meeting 8 | What are scientific models?
(Planned classwork: 3.2 in pairs) | <i>Recipes</i> 3.1, Exercises 3.1, 3.5 |
| Meeting 9 | Different kinds of models
(Planned classwork: in groups of five, first answer 3.11, then complete 3.14, each person focusing on one of the five types of models) | <i>Recipes</i> 3.2, Exercise 3.16 |
| Meeting 10 | How models are used in science
(Planned classwork: 3.20, 3.24) | <i>Recipes</i> 3.3, Exercises 3.19, 3.21 |
| Meeting 11 | Overflow/review | |
| Meeting 12 | Midterm 1 | |

III PATTERNS OF SCIENTIFIC REASONING

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| Meeting 13 | Scientific arguments
(Planned classwork: in pairs, complete 4.2 and (later) 4.12) | <i>Recipes</i> 4.1, Exercise 4.5, 4.8 |
| Meeting 14 | Deductive reasoning
(Planned classwork: 4.16 in small groups, discuss and complete 4.17 as a class) | <i>Recipes</i> 4.2, Exercises 4.13, 4.15 |

- Meeting 15 Inductive reasoning *Recipes 4.3, Exercises 4.20, 4.24*
(Planned classwork: start class with 4.21 in pairs, then later 4.27 as a class)
- Meeting 16 Abductive reasoning Exercise 4.30
(Planned classwork: class discussion of 4.30, then 4.31 and 4.32 in small groups)

III STATISTICAL AND CAUSAL REASONING

- Meeting 17 Statistics and probability in science *Recipes 5.1, Exercise 5.5*
(Planned classwork: class discussion based on 5.5, then 5.2 in small groups)
- Meeting 18 Reasoning with probabilities *Recipes 5.2, Exercise 5.6*
(Planned classwork: 5.9 and 5.12 in pairs)
- Meeting 19 Descriptive statistics *Recipes 5.3, Exercise 5.15*
(Planned classwork: pop-quiz style 5.17, then 5.22 and 5.23 in small groups)
- Meeting 20 Inferential statistics *Recipes 6.1, Exercise 6.6*
(Planned classwork: 6.2 and 6.4 in groups of four, then 6.8 and 6.9 in pairs)
- Meeting 21 Statistical hypothesis-testing *Recipes 6.2, Exercises 6.12, 6.19*
(Planned classwork: 6.15 and 6.16 in pairs, consulting with other pairs as needed)
- Meeting 22 Bayesian hypothesis-testing *Recipes 6.3, Exercises 6.21, 6.22*
(Planned classwork: 6.24 in pairs)
- Meeting 23 Causal reasoning *Recipes 7.1, Exercises 7.6, 7.10*
(Planned classwork: 7.1 and 7.5 as a class)
- Meeting 24 Testing causal hypotheses *Recipes 7.2, Exercises 7.15, 7.16*
(Planned classwork: 7.13 and 7.14 in pairs)
- Meeting 25 Overflow/review
- Meeting 26 **Midterm 2**

IV SCIENTIFIC THEORIES AND SOCIETY

- Meeting 27 How science helps us understand *Recipes 8.1, Exercises 8.9, 8.10*
(Planned classwork: 8.1 as a warmup, later 8.7 in groups of three, each focusing on conception of explanation)
- Meeting 28 Theories and new theories *Recipes 8.2, Exercises 8.11, 8.12*
(Planned classwork: 8.17 in pairs, then discussion)
- Meeting 29 Science's role in society *Recipes 8.3, Exercises 8.20*
(Planned classwork: 8.22 in pairs)
- Meeting 30 Science's future Exercise 8.27
(Planned classwork: 8.25 in small groups)
- Exam block **Final Exam**