BIG IDEAS

- The demarcation of science (i.e., distinguishing what is science and what is non-science), often assumed to be a rather straightforward application of scientific method, is sometimes more difficult or problematic in practice. (SE pp. 364-371)
- Seen from a sociological viewpoint, science is also a political enterprise, influencing whose theories or research projects are supported and funded. Scientific progress involves a dynamic interplay of both conservative and revolutionary forces. (SE pp. 374-383)
- Feminist theories have not produced a distinctly 'feminine' approach or gender-based theory of science, but have, on the other hand, offered diverse and innovative perspectives from women who previously were barred from the sciences. (SE pp. 380-383)

Chapter 15: Connecting to the Philosophy of Science

Background

Historically, the philosophy of science has been linked to epistemology, often as a branch of that subject. Although the Ministry expectations and this text do not go far into the problems of the philosophy of mathematics, they are also clearly related to the sciences and may be of interest to some students. The opening investigation of frontier science, such as in cosmology, will also build upon the discussion of scientific realism and constructivism in Chapter 14, especially as students go into the fascinating aspects of cosmic string theory (e.g., with its suggestion of an eleven-dimensional universe). Related to these topics is the question of whether knowledge is rational or empirical (see question 2, SE p. 373), as explored in Chapter 10 (SE pp. 251-256). In Chapter 15, the interplay of rationalism and empiricism is exemplified through mathematical models and experimental apparatus.

About Chapter 15

Refresh the questions raised in the Unit Opener (SE pp. 314-315) about astrology—whether it is a science or pseudo-science—to help lead students to explore claims about alternative medicine: whether it should be respected as a traditional cultural practice (as folk wisdom), or exposed as "junk science" (folklore). This exploration forms the basis of students' arguments for the culminating activity debate on alternative health care, applying the theories explored in Chapters 13 and 14. For example, they may want to review the section on Kuhn in Chapter 13 (SE pp. 332-333), as well as the concept of Aboriginal knowledge in Chapter 12 (explored in part in the "Making Connections" feature on SE pp. 298-299). Students also embark on a political inquiry into science, which may find support from Unit 6: Social and Political Philosophy (e.g., SE p. 394 on Conservatism and Liberalism, and the dialectics of revolutionary, critical awakening on SE p. 459). Also in this chapter, students again encounter the question of whether there is a distinctly female way of knowing in the sciences.

Features

In this chapter, the following features are included to help students make personal connections and/or deepen their understanding of the philosophy of science. You may use all or some of these features as explained in the table that follows.

Feature	Student Textbook Page(s)	Opportunity for Assessment	Strategies for Classroom Use
Philosophy in Everyday Life	372	Questions 1 and 2, SE p. 372. Have students find their own cases of commentators' debunking of "junk science" and write a critique of whether the critics' arguments are convincing.	Look up the word *libertarian* as used on SE pp. 179 and 425, and consider how the political viewpoint could influence commentary on either climate change or the science of cancer.
Youth Voices	381	Survey of classmates or school.	Realizing we cannot generalize from the testimony of one student (a single case), devise a survey to provide quantitative data and interview questions to gather qualitative data on the topic of whether science is typically a male activity (in its participants and orientation).

continued

Feature	Student Textbook Page(s)	Opportunity for Assessment	Strategies for Classroom Use
Making Connections	382-383	Questions 1 and 2, SE p. 382.	Aristotle claimed that the egg, being the passive earth element, did not play a role in conception: only the active fire element in sperm. It was Italian scientist Gabriele Falloppio who revised this thinking in the sixteenth century, with the more empirical revolution of the Renaissance. How does this illustrate Kuhn's concept of paradigm shifts?
Philosophical Reasoning in Context	378	Questions a) and b), SE p. 378. Also see Chapter Review questions 7 and 8, SE pp. 384-385.	Consider examples of false or spurious correlation (proximity to window and test scores), compared to cases of genuine correlation (arm length in proportion to height). Why do statisticians say, as a rule, that "correlation does not prove causation"? How can this be used in the upcoming culminating activity debates, with regard to regimes of alternative medicine or cases of successful public regulation of scientific research?

Teaching Plan 1 (SE pp. 362-373)

Learning Goal

Students will critically re-examine the boundaries between science and non-science, applying the question of demarcation to alternative-medicine healing practices.

Activity Description

In preparation for the culminating activity debates, students will re-examine the definition of science as they interrogate different cases, such as cosmic string theory in physics and alternative-medicine practices.

Assessment Opportunities for Chapter Questions

The table below summarizes assessment opportunities for selected chapter questions, including questions in the Chapter Review, which are relevant to this teaching plan.

Assessment Type	Assessment Tool	Feature Questions	Section Questions	Chapter Review Questions
Assessment for Learning	Self-directed reflection and research	1-2, SE p. 372		12, SE p. 385
Assessment as Learning	Self-directed reflection and research		1-4, SE p. 373	
Assessment for Learning	Comparison chart/graphic organizer			1 and 11, SE pp. 384-385
Assessment as Learning	Written or spoken commentary			6, SE p. 384

Resources Needed

Make copies of these Blackline Masters:

- BLM 15.1 Apply Toulmin's Argument Model
- BLM C Comparison Chart
- BLM D Argument Builder
- BLM G Debate Assessment Rubric

Possible Assessment of Learning Task

Run the culminating activity debate on alternative healing practices. See the culminating activity instructions and rubric on BLM 13.1, or use BLM G to assess students' debate participation.

Timing

225 minutes
(three 75-minute classes)

Learning Skills Focus

- Responsibility
- Collaboration
- Independent work
- Organization
- Self-regulation
- Initiative

Students could also be given the opportunity to write a pseudo-science primer—using magazine, public-service announcement, and comic book techniques—explaining to a younger audience how they can detect and protect against purveyors of pseudo-science.

Assessment (For/As Learning)

As teachers move through each chapter, opportunities will be highlighted to provide assessment for/as learning in preparation for assessment of learning at the end of each chapter.

Task/Project	Achievement Chart Category	Type of Assessment	Assessment Tool	Peer/Self/ Teacher Assessment	Learning Skill	Student Textbook Page(s)	Blackline Master
Neutrino story	Knowledge; Application	For	Critical application of demarcation criteria and Kuhn's cycle of science	Self; teacher	Independent work	364-365	
Mini-debate	Knowledge; Communication	As	Debate on cosmic string theory	Self; peer	Collaboration; initiative	366	BLM G
Assessment of alternative medical practices	Thinking; Application	For	Using Toulmin's argument model to critique practices	Peer; teacher	Collaboration	368-371; 373, question 4	BLM 15.1
Junk science	Thinking	As	Further research and creative reporting	Self; teacher	Independent work	372; 385, question 12	

Prior Learning Needed

Students may need some background on different alternative medical practices in order to examine specific cases and engage in the culminating activity debates.

Teaching/Learning Strategies

1. The chapter jumps right into big questions about whether topics in physics and cosmology fit the description of natural science, as defined by Popper's demarcation theory, or whether they are better described as natural philosophy (like the thoughts of pre-Socratic philosophers). The topics offer an opportunity to both engage students in the frontiers of science, and to lose them there.

   Acc If the topics in this section of the chapter seem either too complex or not of interest to students in your class, you could make this an optional extension activity for those who are able and interested in pursuing them. Look up the following video titles (available on YouTube). These two documentaries may be easier for students to comprehend, but still open inquiry into metaphysical questions related to life and science:

   Cosmic Journeys: When Will Time End?

   Cosmic Journeys: How Large is the Universe?

   a) Using Einstein's theory of relativity (SE pp. 365-366) as a familiar yet perplexing starting point, consider how he used mathematics (rationalism) to arrive at what seemed like far-fetched conclusions (e.g., the passage of time is not constant throughout the universe, but relative to one's velocity and proximity to large masses), long before there was empirical evidence (direct observations and

experiments) that corroborated his theory (e.g., Hubble's observation through his telescope that galaxies were receding from us—and faster the farther away they are). Additional evidence that corroborated Einstein's initial prediction that the universe was expanding (the smoking gun for the Big Bang) was the cosmic background radiation, discovered by Penzias and Wilson at the Bell Laboratories in the 1960s. These researchers had been trying to identify the uniform source of static coming to us from the edge of the universe (or the beginning of time). This is a classic case of rationalism and empiricism combining to give us greater confidence in the rigours of a theory, making it now (in Kuhn's terms) the *normal science* paradigm in physics instead of a crazy idea. Recent experiments at the Hadron Supercollider in Switzerland suggest we could be on the cusp of another revolution, if researchers can corroborate that muon neutrinos created in the collider arrived at a detector in Italy faster than the speed of light—something Einstein thought was impossible.

Look up the following video titles on the Internet (available on YouTube) for background on these theories and discoveries:

The Elegant Universe - Einstein's Relativity

Albert Einstein: How I See the World (Part 1 of 6)

NOVA scienceNOW | What If | Black Hole

The University of Waterloo's Perimeter Institute for Theoretical Physics is also the source of many inspiring lectures on astrophysics. Go to:

perimeterinstitute.ca

b) The story of neutrinos (not in the student textbook) is another classic example of rationalism and empiricism (theoretical scientists and observational scientists) combining to make discoveries in science: in this case helping to explain nagging anomalies in the observational data relating to neutrinos. As Kuhn describes in his model of scientific revolutions—the cycle of science—these irregularities are first disregarded as errors in the equipment or attributed to faulty empirical methods instead of a fundamental flaw in the standard model of nuclear fusion: a theory that explains the production of light at the core of our Sun. Ultimately, scientists wanted to understand how many neutrinos the Sun produces and how many reach Earth.

This fascinating story also takes us to an abandoned mineshaft in Sudbury, Ontario, home to the world's most sophisticated neutrino detector (also a radiation-free environment), once visited by Stephen Hawking. (The *NOVA* documentary listed above visits this neutrino detector. This documentary is not available for viewing on the Internet, but it is interesting and may be worth seeking out at a public library or a video rental store.)

Ask students to read the story about hunting neutrinos found at this *NOVA* Web link:

http://www.pbs.org/wgbh/nova/physics/solar-neutrinos.html

Next, ask students to visit the following Web link:

http://www.pbs.org/wgbh/nova/neutrino/missing.html

At that Web page, students will find a chronology of "the missing neutrinos." Ask students to apply Kuhn's five-stage model of the cycle of science (SE pp. 332-333) to the steps in the chronology. Ask students to identify where each of Kuhn's stages can be found in this dramatic story of scientific discovery.

c) The last example is the most bizarre (SE p. 366), and it is useful in that it does not as yet have a clear resolution. Cosmic string theory attempts to explain how the

four forces of nature (electromagnetism, gravitation, and the strong and weak nuclear force) are united into one. It does this by positing tiny vibrating strings as the basic building blocks of everything, but so small they are below the level of the quarks and, therefore, not something we can produce or observe as of yet in particle accelerators (atom smashers). Alternatively, theorists posit that these strings can sometimes be stretched into membranes, even comprising universes such as our own. If they cannot be discovered empirically, there is no test with which to falsify the elegant mathematics that suggest they ought to exist. It is a different case from the neutrinos (which can be measured empirically), leading empirical scientists to say that cosmic string theory is natural philosophy instead of science. Brian Greene's documentary (based on his book) wonderfully explains cosmic string theory, including how we may live in a world of 11 (not three or four) dimensions, and how there may be parallel universes—the collisions between them giving the appearance of the Big Bang explosion. Look up the following video title on the Internet (in several parts, available on YouTube):

The Elegant Universe 2

DI Consider having students illustrate or dramatize cosmic string theory, as in a comic-strip explanation for younger audiences. Or, hold a brief debate on whether university physics students should be encouraged to go into cosmic string theory, as 80 percent are now doing. Is this a sound scientific pursuit and wise expenditure of public funding?

Look up the following video titles (available on YouTube) for help in approaching the topic of cosmology:

Great Minds: Stephen Hawking - The Grand Design Of The Universe

Stephen Hawking on Science in the 21st Century - Part 7 (1998)

TIME 10 Questions: 10 Questions for Stephen Hawking

Great Minds: Richard Feynman - The Uncertainty Of Knowledge

2. Turning away from the horizons of space and time, we next explore more down-to-earth questions: the efficacy of different healing practices (e.g., acupuncture, homeopathy, or Chinese herbal medicine). Encourage students to do their own research, perhaps booking a computer lab to give them access to the Internet. Have them critically question the reliability of various Web sites, and what criteria they use to determine authority in sources. Look up these video titles (available on YouTube) for more background on alternative medicine:

Ben Goldacre on Homeopathy

The placebo effect

To open inquiry and increase cultural sensitivity on Aboriginal healing practices, which may even include the spiritual use of tobacco, look up the following video titles (available on YouTube):

Our Land is our Medicine: The Burt Lake Band of Ottawa & Chippewa Indians

Our Forest, Our Cultures: Scientific and Traditional Native American perspectives

Use the activity outlined in section question 2 on SE p. 379 and BLM 15.1 to help students prepare for the culminating activity debate on alternative medicine. Working in pairs, students will apply Toulmin's argument model to one alternative medical treatment and graphically display their thinking about a conclusion that they understand to be true. See also question 4 on SE p. 373, which asks students to make personal reflections as to whether they would consider using alternative medicine.

3. For the feature on "junk science" (SE p. 372), encourage students to pick up on the political dimension of who is sponsoring some of these critics who label research "junk science." Look up the following video title to explore ideas of "bad science":

   Ben Goldacre - Bad Science - Interview 19/10/10

   (This topic forms a bridge into the next chapter section, which begins on SE p. 374, on the politics of science.)

   DI Have students write their own magazine article or create a radio or TV news story debunking something they consider to be "junk science," or busting the "junk science" debunkers (by way of investigative journalism into their sources of funding, for example). See Chapter Review question 12, SE p. 385.

4. The section on Larry Laudan (SE pp. 371 and 373) addresses Popper's demarcation problem, but does so by revisiting the question of intelligent design, taken up in Chapter 14 (SE pp. 349-351). This can be used to reinvigorate the discussion from that earlier chapter, as well as bring in the constructivist thinking in science in opposition to Popper followers who tend to be scientific realists (see SE p. 353).

5. Progress check on culminating activity preparations. Ask students to use BLMs C and D to organize notes and develop coherent arguments for the debates.

6. Run the alternative health-care debate, using BLM 13.1 to set up the proceedings and to evaluate students.

   Acc Some students may find it difficult to speak up in a debate, even though they are prepared. Consider asking these students to show their notes, and to write up their position so they can be evaluated more fairly than on the basis of their spoken contributions.

Text Answers

Page 372: Philosophy in Everyday Life

1. "Junk science" is a derogatory term that applies to practices that purport to be scientific, like global-warming research, but are supposedly debunked by the media-hyped myth-busters. There is overlap with pseudo-science when it comes to healing practices, or with topics such as parapsychology (déjà vu, out-of-body experiences, prognostication, etc.).

2. Society may face dangers if scientific data that shows health and economic risks from climate change or smoking are swept under the rug by corporate-sponsored critics, like the so-called Friends of Science (funded by the oil companies) who denounce the idea that humans contribute significantly to global warming by burning fossil fuels. Conversely, people who expose pseudo-science may be seen to be doing a public service, saving taxpayers from funding charlatans.

Page 373: Section questions

1. *Knowing* in science is often more empirical, as outlined through the scientific method, but it is also supplemented by math. It is hard to imagine a scientist claiming no use for math, even though it is more deductive (rule as opposed to evidence governed). Scientific truths are different from the truths of history, though history also involves the close examination of evidence from primary documents. Excluding art history, artistic truth involves something that may be either subjective or intersubjective (shared), as when an audience member or entire audience feels deeply the poignancy of an exhibit, passage, or play. In discussing literature, there is a demand for evidence to substantiate claims, but we also recognize that the reader

co-creates meaning in texts (reader-response theory). It could be argued, with the constructivists, that this happens also in science, and that it masks this human tendency by appealing to a facade of objectivity and rationality.

2. See the Brian Greene reference earlier (*The Elegant Universe* video) to get students started on this writing activity on cosmic string theory. If trying to conserve time, you could show a two-minute clip on cosmic string theory to stimulate thought and interest (look up the following video title, available on YouTube):

   Who lives in the eleventh dimension? - Parallel Universes - BBC science

   Use class discussion to stimulate students' writing. This also makes a good test question, if left open-ended, but look for students to use terms such as *empiricism* and *rationalism,* weighing whether it's natural philosophy or science.

3. Bloggers who misinterpret Laudan's article as defending creationism somehow miss that he was blasting the attackers of creationism for misusing the philosophy of science. The question invites students to explore Laudan's constructivist or anti-realist stance with respect to the philosophy of science, where he is questioning whether Popper's demarcation criteria can be applied to much of what we do consider mainstream science. Students can find Laudan's article at this Web link:

   http://faculty.washington.edu/lynnhank/Laudan.pdf

4. This question makes a good follow-up to the culminating activity debate on alternative medicine.

Learning Goal

Students will explore the political dimensions of scientific progress and apply their insights to the questions of public-regulation science funding.

Teaching Plan 2 (SE pp. 374-385)

Activity Description

Students explore the political dimensions of science, bringing in concepts from Unit 6 and applying them toward their debate on science funding. Essential to this discussion is the question of whether science, unchecked by the public, can be dangerous.

Assessment Opportunities for Chapter Questions

The table below summarizes assessment opportunities for selected chapter questions, including questions in the Chapter Review, which are relevant to this teaching plan.

Assessment Type	Assessment Tool	Feature Questions	Section Questions	Chapter Review Questions
Assessment as Learning	Group work		1-4, SE p. 379	
Assessment as Learning	Self-reflection, research, and writing	1-2, SE p. 382		
Assessment as Learning	Group discussion		1-3, SE p. 383	
Assessment for Learning	Record answers in notes for take-up in class			2, 7, 8, SE pp. 384-385
Assessment as Learning	Group discussion and individual writing			3, 4, 5, 9, 12 SE pp. 384-385
Assessment for Learning	Debate preparation			10, SE p. 385

Resources Needed

Make copies of these Blackline Masters:

- BLM 13.1 Unit 5 Culminating Activity: Philosophy of Science Debates
- BLM C Comparison Chart
- BLM D Argument Builder
- BLM G Debate Assessment Rubric

Timing

225 minutes
(three 75-minute classes)

Learning Skills Focus

- Collaboration
- Independent work
- Organization

Possible Assessment of Learning Task

Run the culminating activity debate on public interest and control of funds. Use instructions and rubric on BLM 13.1. You may also use BLM G for assessment purposes.

Assessment (For/As Learning)

As teachers move through each chapter, opportunities will be highlighted to provide assessment for/as learning in preparation for assessment of learning at the end of each chapter.

Task/Project	Achievement Chart Category	Type of Assessment	Assessment Tool	Peer/Self/ Teacher Assessment	Learning Skill	Student Textbook Page(s)	Blackline Master
Comparing philosophers' political positions	Knowledge	For	Reading for comprehension and note taking	Self	Independent work	379, section question 2; 384, Chapter Review question 1	BLM C
Fallacies	Knowledge; Application	For	Investigation and application of informal logic to debates	Self; peer	Initiative	45-61	
Critique of feminist philosophy of science	Thinking; Communication	As	Group discussion and response to section questions 1-3, SE p. 383; Chapter Review question 9, SE p. 385	Self; peer	Independent work; collaboration	380-383	

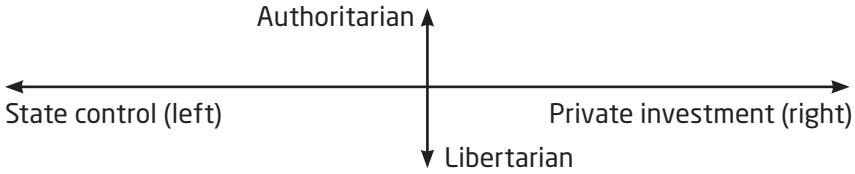
Prior Learning Needed

Ask students to research how the National Research Council Canada awards funds for scientific projects. How are other research grants dispensed at universities, such as endowments or appointments of research chairs, institutes, etc.? Look at student organizations on various campuses in Ontario that promote science education.

Teaching/Learning Strategies

1. To engage students in thought on the politics of science, pitch them the margin question on SE p. 376, and consider starting with Feyerabend's more dramatic and engaging position on the need to defend the public from the misusage of science. The controversy created by his quotes on SE p. 376 may then invite interest in the more historical build-up through Popper, Kuhn, and Toulmin (SE pp. 374-376). Use the explanation of conservatism, liberalism, and anarchism in Unit 6 (SE pp. 394-396) to open this topic, and consider putting the thinkers on a spectrum (such as in the visual that follows). Forms of economic organization are

on the horizontal scale, from state control on the left to private investors making economic decisions on the right. Forms of civil liberty or social control are on the vertical scale, from dictatorship at the top to individual freedom at the bottom.



Examples: Mao and Stalin (totalitarian communism, upper left); Gandhi (independence and pro-democracy, multicultural tolerance movement, lower left); Hitler (fascist national socialism, upper centre-right).

Acc Connect familiar political parties in Ontario to positions on the political spectrum, which is something students should be accustomed to from Grade 10 Civics courses. Students in Grade 12 World Issues or Politics can help identify where other countries' leaders are located (e.g., Russia and China today) or minority parties in Canada such as the Bloc Québécois and Green Party.

2. False causality and other logical fallacies (SE p. 378): The opening section of this feature is part of the mandatory curriculum set out in the Ministry expectations, but teachers can work it in wherever they see fit. Here is one of those moments, leading into debates, where students can see the benefits of learning informal logic. Encourage students to brush up on their familiarity with logical fallacies (SE pp. 45-61) so that they will watch for (or use) these in the debates. It can be presented to them as "defence against the dark arts," where they get to use Latin phrases like Hermione Granger in the Harry Potter series (e.g., *ad misericordiam* or *post hoc ergo propter hoc* can be used like charms). Students can also employ constructive uses of fallacies, like red herring (SE p. 464) or contradiction (SE pp. 24 and 32): "Oh Harry, don't you see? If she could have done one thing to make absolutely sure that every single person in this school will read your interview, it was banning it!" (This quote refers to the Minister's imposition of draconian rules at Hogwarts School of Witchcraft and Wizardry.) Conclusion: If you want to ensure that students will read the opening chapters on philosophical reasoning, tell them they are forbidden to use these dark arts in the debate!

3. Debate preparation: Have students answer Chapter Review question 10, SE p. 385, to get them researching and processing their thoughts, and writing down their ideas. Have students peer review these arguments within their group, to foster exchange and control for error (in fact, this is also how scientific communities function). Ask students to use BLMs C and D to organize their notes and develop coherent arguments.

Check out the following Web sites for the National Research Council Canada, including:

About National Research Council (including audit and evaluation of institutes)

http://www.nrc-cnrc.gc.ca/eng/about/index.html

2011 Success Stories (benefits of regulation demonstrated)

http://www.nrc-cnrc.gc.ca/eng/news/success.html

2011 Canadian Science Policy Conference (CSPC) (multi-sector cooperation)

http://www.nrc-cnrc.gc.ca/eng/events/nrc/2011/11/16/cspc.html

Then, prime students on debate protocols. Look up the following video titles (available on YouTube) and consider using them as exemplars:

Karl Popper Demo Debate: USA was right in rejecting the Kyoto Protocol part1

British Parliamentary Demo Debate

4. Run the culminating activity debate on public funding of science. Use BLM 13.1 to set up the proceedings and to evaluate students.

Acc Some students may find it difficult to speak up in a debate, even though they are prepared. Consider asking these students to show their notes, and to write up their position so they can be evaluated more fairly than on the basis of their spoken contributions.

Students will need to craft an arguable motion on the topic: Who should control science funding—expert scientists or the general public (laypeople)? Students can then form position statements for the opening round.

5. This chapter promotes discussion about feminism in the philosophy of science. Use the "Youth Voices" feature on SE p. 381 to make connections to science education. Encourage students to consider who is winning and losing if young women are deterred from pursuing careers in the sciences. Is this still the case, or are women now making up the majority of students in fields such as pre-med at universities? Has the gender gap been remedied in fields such as engineering, or information technology (once bastions of male dominance)?

Keller's story (see the "Profile" feature on SE p. 381) offers a dramatic example of the barriers women have faced in the sciences, but also the triumph that can come with pursuing a science career. Look up the following video title (available on YouTube):

Evelyn Fox Keller, Society and Health, Tue 7 July

Keller's perspective is different from that of Patricia Hill Collins in Chapter 12 (SE pp. 298-299), which drew on Nancy Hartsock's early *standpoint theory*: a materialist approach that grounds knowledge in the kind of subject (race, age, gender, etc.) who perceives and comes to know. On the contrary, Harding and Keller (SE pp. 380-381) try to avoid *essentializing* women—the suggestion that women, in general, have a different view or method of science—while pointing to their possibly unique contributions. Does this involve a contradiction, or is it more a matter of saying that had these women not been given a chance, their unique contributions would not have surfaced? Is there a vicious circle involved in taking up gender, or do they escape this problem? Does Hekman offer help on this score (see SE pp. 281-282)—avoiding an essence of core identity behind women, without losing the ability to mobilize for social change in the name of the collective women's movement?

DI Design a science magazine or TV show for teenage girls. Consider the arguments of neuroscientists like Louann Brizendine, author of *The Female Brain* and *The Male Brain* (see her chapters on the Teen Girl Brain and Teen Boy Brain). See also the October 2011 issue of *National Geographic* magazine on teenage brains.

Feminist philosophers might ask: In trying to redress the problem of males reading less, is science intentionally or inadvertently gendered as a predominantly "male" activity? Writer Jill Davis explains in her article "Teen Magazines for Boys" (see SE p. 381 for an abridged version):

> "Boys interested in the latest in science and technology will enjoy Popular Science Magazine. It calls itself the 'what's new' magazine, giving the reader all the latest information in the fields of automotive, energy, aeronautics, electronics, communications, tools, science, computer products and space. Stories range from archeology to medical breakthroughs and space exploration to new insights about the environment."

Are these topics written in such a way that they appeal more to males? Are females socialized into reading magazines like *Seventeen, People,* or *Cosmopolitan* instead, or do these magazines actually appeal to females' natural inclinations? Who's reading *Scientific American*, *Astronomy,* and *Discover* magazines: males or females?

Connect the "Making Connections" feature on SE p. 382, regarding studies on conception, to the "Philosophy in Everyday Life" feature on Ethics of Genetics and Reproduction, SE p. 216. See the following discussion of related topics in the Text Answers section for the "Making Connections" feature, question 2, SE p. 382.

6. Closing consideration: cognitive science (or neuroscience) is a topic threaded throughout the student textbook (e.g., Metaphysics, SE pp. 122-126; Epistemology, SE pp. 272 and 274). As Foucault notes (in *The Hermeneutics of the Subject*), for the Stoics and early Christian thinkers, life itself was thought of as an enduring test, or an experiment in living toward the goal of either achieving harmony with nature or peace with one's creator and fellow human beings. In what ways is ethics, or the consideration of right living, similar to and different from science? Can we ethically run experiments in ethics to falsify claims, or are these forbidden, leading us instead to use thought experiments (the famous trolley car problem, or refugee ethics; see SE p. 196, question 3 and SE p. 236, question 5)? Is there a science or morality that explains evil through cognitive psychology, or do these fields address a different kind of problem: empirical, as opposed to the normative questions? (See medical and environmental ethics, SE pp. 229-233.) Professor Cheryl Misak of the University of Toronto applied Peirce's pragmatist theory of inquiry (the basis for the *fallibilist* theory of scientific progress, SE p. 331) to ethics in her work, as a way of responding to ethical relativism (see SE p. 206).

Text Answers

Page 378: Philosophical Reasoning in Context

1. a) Yes, this is a fallacy of false causality—also called spurious correlation. Other variables that might be involved would include increased policing or an improved economy (less unemployment), reducing the crime rate.

   b) Yes. The "magic pen" is also likely keeping potential friends away, if you think it really deters elephants. "What experiment could possibly be set up to falsify such a claim?" Popper might ask.

Page 379: Section questions

1. Use Toulmin's argument model in Figure 15-7, SE p. 377, to critique the argument about lab animals on SE p. 379. Note that the parts of the model are labelled in parentheses in the argument about lab animals on SE p. 379. (e.g., warrant, qualifier, etc.).

   For students to formulate their own argument for or against animal testing, ask them to consider philosopher Peter Singer's utilitarian arguments and try to apply Toulmin's argument model for or against the case made by Singer. Alternatively, visit an animal rights advocacy Web site and critique their arguments.

   Peter Singer's articles are available from his Web site:

   http://www.utilitarian.net/singer/

   For example, students could find and read on Singer's Web site his article "Setting Limits on Animal Testing," first published in *The Sunday Times*, December 3, 2006. Students could also look up Singer's article "Animal Experimentation" at this Web link:

   http://philosophy.tamucc.edu/readings/ethics/singer-animal-experimentation

Students could also research the animal rights advocacy organization PETA. Its Web site is:

http://www.peta.org/issues/animals-used-for-experimentation/default.aspx

2. Use this activity with Toulmin's argument model (see BLM 15.1) to help students prepare for the culminating activity debate. See Teaching Strategy 2 in Teaching Plan 1 (in this chapter).

3. The terms *conservatism*, *liberalism,* and *anarchism* can be found in Unit 6, SE pp. 394-396, as well as in the descriptions and quotes of philosophers of science on SE pp. 374-375. The notion that Kuhn was more conservative than Popper may be overstated, as it is when applied to Wittgenstein (on whom Kuhn drew for his theory). Both Popper and Kuhn were trying to describe what they saw, not so much advocate for a position, and in doing so, both pointed to how societies tend to conserve even outdated ideas as bedrock for making truth claims (see Chapter 11, SE p. 282).

   Nancy Cartwright (discussed in Chapter 14) is not a self-professed anarchist, as Feyerabend was, but her view of localized as opposed to universal laws could be seen as paralleling the political view of local as opposed to centralized, state control. It is potentially dangerous, however, to make these kinds of substitutions unless there is evidence that the thinker herself advocates such a political stance. The risk is to commit false analogy, another logical fallacy. Like Kuhn, Cartwright is drawing on Wittgenstein, and so is attacking hasty generalizations in our thinking instead of forms of political organization. (On the difficulty of leveraging political positions: Wittgenstein wanted to emigrate to the Soviet Union to become a street sweeper, but the Russians offered him instead a position at Moscow University, saying they didn't need philosophers who sweep streets. John Maynard Keynes talked him out of the move, and he eventually became Chair of Philosophy at Cambridge.)

4. Lysenko was promoted during the Soviet era because he advocated a Marxist (historical and dialectical materialist) model of genetics. His model led to planting new varieties of wheat hybrids in Siberia, but the earth would not yield and the experiment failed (thus illustrating Popper's concept of falsification). The intrusion of state ideology corrupted the scientific community by intimidating scientists who were critical of the theories and experimental results, thus preventing the investigation of anomalies under Kuhn's model or the advance of science through open inquiry (the pragmatist model of fallibilism). For current examples of a government's involvement with scientific research, consider the United States' banning of stem cell research under President George Bush, jeopardizing the separation of state and religion under the United States Constitution.

Page 382: Making Connections

1. The example of conception demonstrates the influence of historically entrenched cultural values and ideas (*pictures that hold us captive*) in science. For instance, Aristotle claimed that the egg, being the passive earth element, did not play a role in conception: only the active fire element in sperm. It was Italian scientist Gabriele Falloppio who revised this thinking in the sixteenth century, during the more empirical revolution of the Renaissance. This illustrates Kuhn's concept of paradigm shifts, in that as the model changes, so does the way we see the phenomenon under study (how we regard the sperm and egg).

   Although Kuhn is credited with introducing a "social history of science," there are precursors in such writers as philosopher Gaston Bachelard (1884–1962) in France and microbiologist Ludwik Fleck (1896–1961) in Poland. Bachelard came to the conclusion that humans cannot carry out the Enlightenment project of rationally freeing the mind from myths and imagination; instead of objectivity in science, he

increasingly embraced the subjective element in his analysis of fire, water, and the "poetics of space." Fleck's pioneering work on syphilis, *Genesis and Development of a Scientific Fact*, showed that the science of virology grew out of the pre-modern worldview of demons in the bloodstream, made visible by microscopes. (Fleck began developing his ideas for that work while diagnosing diseases, such as typhus, among other prisoners in the concentration camp Buchenwald.) Belief (superstition) in demons guided investigators to look for the agents carrying God's scourge. Fleck likened scientific theories to collective hallucination: everyone in the field agrees on seeing the same mirage, forming thought collectives instead of unveiling the truth—a concept similar to Kuhn's paradigms (models).

2. To say that the newer theory of conception improves on earlier theories or represents an advancement in science is to invite the topic of scientific realism versus constructivism (SE p. 356), but even for constructivists it can make sense to say that a more current theory better accommodates the data or offers more useful predictions. Recall Hacking's concept of robust fit, in Chapter 14 (SE p. 357).

Page 383: Section questions

1. Is it safe to generalize about females showing more care, and males' more rational or detached observation? A similar debate took place between Carol Gilligan and Lawrence Kohlberg over moral reasoning: whether it is a care-based (Gilligan) or a Rawlsian rule- and justice-based (Kohlberg) enterprise when resolving moral dilemmas. (See Rawls, SE pp. 401-403, 428-429.) It might help to set up this parallel debate to open inquiry into the sciences.

2. Re: Ursula Franklin, Professor Emeritus from the University of Toronto, and her perspective on technology for people and the politics of science, see:

   http://www.media-studies.ca/articles/franklin.htm

3. To help students begin developing their views and survey questions, ask them to read the "Youth Voices" feature on SE p. 381.

Pages 384-385: Chapter Review

1. Popper's criteria for distinguishing science from non-science is as follows:

   a) Science turns non-scientific (mythical) explanations of nature into more rigorous, evidence-based, and experimentally corroborated (scientific) theories.

   b) Science offers useful predictions and discoveries that lead to improved technology.

   Rorty agrees that science offers a more coherent and useful description of the world (using similar criteria: see quote on SE p. 367), but in grounding the motivation behind science in our desires, he suggests that religion seeks to satisfy different kinds of desires than science, similar to literature, thus removing some of the antagonism. Rorty, however, is also an ironist and he often seeks to trouble the dogmatic assumptions of fundamentalists, showing an affinity with pragmatists in the pursuit of inquiries that are useful in our liberal, democratic lifestyle. It makes the pursuit of science less distinct from an ethical (normative) path toward the "happy life," and so less a matter of scientific method and objective truth than of shared moral values. (see quote on SE p. 368).

   Laudan calls for the demise of the demarcation problem, as many instances of what we consider sound scientific research would not stand up to the dividing criteria imposed by Popper and his ardent followers. Students may want to look up Laudan's article "The Demise of the Demarcation Problem," which may help them to better interpret his position. (The entire article is available at Google Books).

2. Consider these logical fallacies that may apply to alternative medical treatments: false analogy, composition (attributing parts to the whole or vice versa), false causation, appeal to authority, etc. Metaphysical assumptions would include mind/body dualism or integration, the presence of a soul or spirit, divine intervention in the lives of people, the existence of objectively healthy states (or realist grounds to believe in cures that have merits independent of our cultural values about what is good or bad, sound or unsound), etc.

3. The question calls for students to sum up their own learning about feminist contributions, or to extend it through further research. This might be used as an extension activity for those looking for more evidence of the role feminism plays in every area of philosophy, which would make a larger but interesting study.

4. Stimulate students' thinking and response to Haraway's ideas by looking up the following video title (available on YouTube) or by giving students a longer excerpt from her book.

   Donna Haraway. Cyborgs, Dogs and Companion Species 2000 1/9

5. The precautionary principle calls for not using a chemical, such as chlorine, unless we know fully what harmful side effects it may cause. In effect, we err on the side of caution until more is known, instead of using something for an extended period and then discovering it is harmful. Some parents' groups are calling for the removal of Wi-Fi in schools, believing the radio signals may be harmful to students and teachers exposed to the signals all day. Here you have to weigh the costs and benefits of using Wi-Fi, which is a form of utilitarian consequentialism (seeking the greater good for the greatest number). Have students apply this kind of thinking to the three examples given.

6. Here is an example of the cost-benefit analysis at work: Your dentist is aware that the amalgam in fillings is a potentially dangerous metal, but has likely determined that the risks are not so great (the amounts ingested or absorbed by the body) as to warrant removal of the product—a lower cost option than porcelain fillings. People adhering to the precautionary principle might advocate that we not use the amalgam until more is known about its effects on people. Evidence-based medicine would seek empirical grounds on which to make a recommendation. In the absence of evidence, we may get metaphysical principles disguised as medical knowledge or reliable prescriptions. Ideally, evidence-based medicine would rely on longitudinal studies conducted of amalgam- and porcelain-filling patients, cross referenced against control groups (those without fillings) to rule out a placebo effect (people feeling well or sick due to powers of suggestion).

7. "After this, therefore because of this" can be illustrated simply by saying that just because B follows A, does not mean A is the cause of B. (If you suffer a headache after reading this, this explanation may not be the cause.)

8. Example (a) is an example of the fallacy of false causality, but it is less clear in the case of whether the death penalty acted as a deterrence to murder (b). Another variable involved could be the availability of guns, less police enforcement, economically hard times, gang or ethnic and racial conflict, etc. Population growth itself could account for an increase in homicides, over a longer time span. There is nothing in the data that points to murderers actually taking into account the consequences of their actions; that is inferred from the data, but may not enter into their thinking when acting in the passion of the moment (e.g., the statistics do not reveal how many of these were premeditated murders or manslaughter cases).

9. In addition to Nobel Prize recipients, to enhance the debate, consider researching the ethnic and gender diversity among university students (graduate and undergraduate) in physics, chemistry, physiology, and medicine.

10. Students will construct an opinion piece on who should govern science funding. You can scaffold this task by breaking it down into steps: (1) What knowledge base is required to make informed decisions on whether a particular experiment or project should receive public funding? (2) Are there cases where having insider perspective, or membership in the group (science community) can blind someone to problems? (3) Is there sometimes a need for arm's-length distance, to avoid conflicts of interest (e.g., a group of close colleagues funding their friends or inner circle)? (4) Could too much public control politicize science, putting persons without scientific knowledge but strong agendas or ideology in control of funding? How do governing bodies, such as the College of Physicians and Surgeons or the College of Teachers, balance insider and outsider perspectives to ideally protect the public interest while maintaining professionalism?

11. This activity calls for the creation of a graphic organizer to show how the philosophy of science (metaphysical, epistemological, ethical, or political) can be applied to physics, chemistry, and biology. Students could do this (along with their teacher) by creating a dialogue about philosophical aspects of these fields, and then turning it into a newsletter-style article to share the results.

12. See Teaching Plan 1, Teaching Strategy 3 (in this chapter) for a possible time to introduce the journalistic piece (for print, radio, television, or the Internet) that explores how the media cover environmental, health, or science issues. Consider how form and content may be at variance, as students explore rhetoric and logic in the stories or arguments they read (e.g., in researching for the debates) and create in this exercise. Aesthetic criteria such as symmetry and proportion, or elegance ($E=mc^2$) do enter into our consideration of the sciences (e.g., string theory is mathematically elegant, as physicist Steven Weinberg puts it, leading us to believe it must be valid). Here, students might reconsider Putnam's argument about the collapse of the fact-value dichotomy (SE p. 303).