June 21, 2017 version

University of Washington
Daniel J. Evans School of Public Policy and Governance

Science, Technology, and Public Policy

PUBPOL 583
Summer, 2017 (June 21 to August 16)
Wednesday 5:50 to 8:20
Parrington 308
(Check for room changes on exceptionally warm days.)

From the spaceship to the computer chip, public officials work hard to promote innovation through science and technology. In turn, advances in science and technology invite governmental response. This course examines important public policy issues associated with science and technology. The issues include the debate over how much government support is necessary to spur research and innovation, the role of government as a regulator of technology, the manner in which technology alters the way in which scientific initiatives are organized, the clash between scientific findings and political ideology, and the governance challenges arising from 21st century technologies. Students also examine impending technologies, the relationship between culture and technology, and specific policy issues of interest to students in the class.

LEARNING OBJECTIVES

Understanding the manner in which government policies affect science and technology is an essential skill for persons leading twenty-first century institutions. This course examines the major facets of the relationship between innovation, public policy, science and technology. By the end of the course, students should have improved their knowledge and skills in the following areas.

Understand how government support for basic and applied research can be used to spur economic growth, promote political stability, and increase tax revenues.

Be aware of impending developments in science and technology and the public policies that will deal with them.

Understand the relationship between culture, imagination, and public policy.

Comprehend the relationship between science and ideology and the reasons why public officials often attempt to repeal various laws of nature.

Understand how science and technology policies appear on the policy agenda, how they are "sold," and the tools available to public officials for shaping scientific innovation.

Appreciate the debate over the relative effectiveness of private versus public avenues to research and innovation.

Be aware of the governmental response to the most serious ethical concerns about emerging technologies.

Be aware of the ways in which scientific innovation reshapes governmental activities – especially the debate between practitioners of Big Science and systems with "nobody in charge."

Improve your skill at giving advice to public officials on science policy issues.

The instructor relies upon readings, lectures, in-class exercises, and student presentations to achieve these objectives. The course begins with an examination of innovation challenges, moves through a review of impending technologies with disruptive effects, proceeds through the treatment of these technologies in science fiction and popular culture, and concludes with an examination of the policy issues arising from them. As a result of completing the course, students should improve their ability to complete full-scale analytic studies of various science and technology issues.

If you bring a computer to class, you will be able to follow the lessons and exercises by connecting to the class catalyst site.

The instructor, Dr. Howard E. McCurdy, is an expert on space policy. He has published seven books on the U.S. space program including the award-winning *Space and the American Imagination* and *Robots in Space*, coauthored with Roger Launius. A book on innovation in the U.S. space program, *Seeds of Discovery*, is forthcoming. Dr. McCurdy received his bachelor's and master's degree from the University of Washington and his doctorate from Cornell University. He divides his time between American University in Washington, D.C., where he is a professor of public affairs, and the University of Washington, where he is a frequent visitor to the Evans School of Public Policy and Governance.

Professor McCurdy can be reached most easily at mccurdy@american.edu.

Books and Readings:

Much has been written on science and technology. The course seeks to acquaint students with the essential works, especially those with implications for public policy. Most of the readings can be found on the class Catalyst site. No books have been assigned through the campus store.

A good introduction to science policies for non-scientists can be found in Richard A. Muller, *Physics for Future Presidents* (New York: Norton, 2008). For students who want a basic textbook, a good selection is Neal, Smith, and McCormick, *Beyond Sputnik* (University of Michigan Press, 2008). Students who enjoy *Physics for Future Presidents* might also want to consult Muller's more recent *Energy for Future Presidents* (New York: Norton, 2013). Additional readings are listed on the course syllabus.

Assignments:

The class is typically run like a seminar, with students as well as the instructor making contributions to the learning process. Students should read as much as they can and complete the following four assignments.

1. Master one of the essential readings for the course. Explain it to the other students in the class at the session for which that topic is scheduled. The summary may take the form of a verbal presentation, a short written summary or a PowerPoint presentation. Each student should master one essential reading.

2. Watch a film that portrays an impending technology. (You might also examine the novel on which the film is based, if one exists.) Summarize the manner in which the film treats the technology in popular culture. Prepare a written summary, a verbal presentation or a PowerPoint presentation. Class presentations should contain a section of the film between four and ten minutes in length.

3. Describe how some impending technology works. The syllabus contains a number of appropriate topics. This is a good assignment for students with a STEM background. The summary may take the form of a demonstration, a short written summary or a PowerPoint presentation.

4. Prepare a policy brief. This may take the form of a written summary and/or a PowerPoint presentation. It should summarize the arguments for and against a particular policy issue and make a recommendation, with a rationale.

Students may complete the assignments individually or in small groups of two or three people. Students are encouraged to work in small groups to complete in-class exercises and those groups may carry over to the four assignments. The number of presentations will depend upon the size of the class and the length of the term. Depending upon the size of the class, groups may need to complete more than one presentation. Check with the instructor for the number of presentations required for each class.

Exceptional reports or presentations should be brief, specific (without being overwhelming), interesting, technically correct, flawlessly worded, (if presented to the class) extemporaneously delivered, and contain fresh insights.

Class presentations should be about twelve to fifteen minutes long, with additional time for questions and comments for a total of about twenty minutes.

In fashioning reports and presentations, students typically rely upon existing sources of information. Take care to distinguish between your words and the writings of others. The latter require proper attribution.

Student may be asked to assist with the presentation of audio-visual material in the classroom and otherwise assist the instructor with maintaining the schedule of presentations and other administrative matters.

As a seminar, the class depends upon the ability of students and the instructor to share insights from areas in which they possess expertise. The amount of knowledge contained in the class invariably exceeds the amount possessed by any one participant. Students are encouraged to act as instructors in their policy areas, informing other class members (including the instructor) of current issues and developments.

Grading and other course requirements:

Grading in a seminar-style class is less formal than grading in a more conventional class. Grades are based on the major policy assignment (30 percent), the technology assignment (20 percent), the film and culture assignment (15 percent), the reading summary (15 percent) and class participation with regular attendance (20 percent).

Please pay special attention to the requirements regarding attendance. Students need to attend class sessions in order to receive credit for the course. The course operates as a seminar and relies upon student presentations and participation for learning. Ideally, you should attend all of the class session. This said, we do not want you to come to class if you are ill. In order to balance these conflicting necessities, you can receive credit for any class that you may miss by following the instructions described below. Students who miss an excessive number of classes should contact an academic adviser to arrange for an alternative solution as they are in jeopardy of receiving a deficient grade or no credit for the course.

If you miss a class, you can receive credit for that session by completing the following tasks. Watch any PowerPoint presentations associated with that session. Prepare brief written summaries of the recommended readings for that session. Review any lessons contained in materials available on the Catalyst site. Complete any exercises given that week and inspect the associated answer key. Identify the class session you missed, notify the instructor that you have completed this work, and submit the reading summaries with your notification. A guide to these materials can be found on the class program.

Class sessions and reading assignments:

Session 1. Introduction: why is innovation so important to public officials in a technological society?

(Session 1) Introduction to the course. Distribution of syllabus; course objectives, assignments and readings. Overview of material covered in the course. Suggested subjects for policy briefs and other assignments. Students should identify themselves and their interests. Form preliminary groups and sign up for essential readings and assignments.

- Form small teams or work individually, as you wish. Students may use a mix of joint and individual work as their preferences allow.
- Pick a reading to summarize and – by implication – the date on which the summary is due.
- Pick a technology to summarize. Due on session 3 although some reports could be presented as early as session 2.
- Pick a film to summarize and possibly show. Select a date from the sign-up sheet.
- Select a date to present your policy issue. You can settle the particular issue later.

If you can, read the following selection before the first class.

- Howard McCurdy, "Governance Challenges of 21st Century Technologies," (2016). Available at publicpolicyinnovation.com. From the home page, go to the section called essays under research.

Part 2: Technology and culture.

(Session 2) How do producers of literature, film and art portray technology as it passes through popular culture? Culture as a filter for technological beliefs. Culture shifts, analogies and reality gaps.

- Essential reading: Ray Kurzweil, *The Singularity is Near* (2005), long version. Section B.
- Richard P. Feynman, "Plenty of Room at the Bottom," (1959). Section B.
- Howard McCurdy, "Conclusion: Imagination and Culture," from Space and the American Imagination (2011). Section E.

Part 3. Technology: the furtherance of innovation in a technological society.

(Session 3) The innovation process: how does innovation occur?

- Essential reading: Matt Ridley, *The Evolution of Everything* (2015). A good summary can be found in the essay by the same title (2016). The summary is available in section A. Ridley makes the case for spontaneous innovation.
- Craig Lambert, "Disruptive Genius," *Harvard Magazine* (July-August 2014). Available on line. Based on the work of Clayton Christensen, noted for his work on disruptive innovation and his book *The Innovator's Dilemma* (1997).

(Session 4) Government spending on research and development: what is the proper role of government in funding basic and applied research? This section covers the current debate over the relative balance between public, private and philanthropic spending. (For help with these readings, look at the guidance titled "Understanding the Kealey-Ridley-Mazzucato debate," attached to the course syllabus.)

- Essential reading: Mariana Mazzucato, *The Entrepreneurial State* (2013), selections on class site. Mazzucato presents the progressive position on government innovation. Read the first two pages of the preface by Carlota Perez and the first section of chapter 1 (to the top of page 17). (Section A)
- Essential reading: Terence Kealey, *The Economic Laws of Scientific Research* (1996) (selections). Kealey presents the conservative position on government funding for scientific research. Begin with the book review by Richard Nelson. Both available on section A.
- Alternatively, you might look at the following book. It is easier to understand than Kealey's 1996 treatise. Terence Kealey, *Sex, Science and Profits: How People Evolved to Money* (2008). Kealy adopted the misleading title to sell books; the study really deals with the history of science and is a more readable version of his 1996 thesis.

Part 4. Policies

(Session 5) How do science and technology issues get on the public agenda? "Sputnik moments" and the force of precipitating events. The players in science policy.

- *Beyond Sputnik*, chapter 3 (The Players in Science Policy) On the class site. Section C. A good introduction to actors and institutions for science majors.
- Essential reading: Baumgartner and Jones, *Agendas and Instability in American Politics* (1993). The famous theory of punctuated equilibrium.
- Langdon Winner, "Do Artifacts Have Politics?" (1980) (Section D).

(Session 6) Should society acting through the regulatory mechanisms of government outlaw certain types of technology? Governments set the rules by which the innovation game is played – so what needs to be regulated? Americans commonly resolve ethical issues involving science and technology through collective action rather than the marketplace. What science makes possible may violate collective norms arising from culture, as in "that's not the way we do things here." Carrying that argument further, should government regulators prohibit certain technologies because they are too disruptive to the marketplace? What can public officials do to mitigate the labor market

dislocations that occur from the accelerating pace of technological change and capital accumulation? Regime values and other standards as sources for rule-making.

- Essential reading: Bill Joy, "Why the Future Doesn't Need Us," *Wired Magazine* (August 4, 2000) Class site section E or the Internet.
- Ray Kurzweil, "Promise and Peril" (2003). A rejoinder to Joy's worrisome article. Available on line.
- McCurdy, On Frankenstein, from "Vision and Leadership," pp. 259-64. Class site section E.
- Innovating through Regulation: the Case of Airborne Wind Shear Detection and Alert Systems (case study on class site).

(Session 7) Why do politicians periodically attempt to repeal the laws of nature? Politics, ideology and voodoo science policy.

- Essential reading: Aaron Wildavsky, *The Rise of Radical Egalitarianism* (1991). Attitudes toward hierarchy and equality shape beliefs about science and technology. Available on section E. A study of Wildavsky's insights should also cover the following work by Douglas and Wildavsky.
- Essential reading (incorporated with above) Douglas and Wildavsky, *Risk and Culture* (1982). A seminal work on the relationship between ideology and beliefs about the world. Selections on class site section E.
- Charles Krauthammer, "The New Socialism" *Washington Post* (11 December 2009) and "The Myth of Settled Science" *Washington Post* (21 February 2014). The conservative position on science and ideology. The first item is available on the class site section E; both items are available on the Internet.
- Carl Sagan, *The Demon-Haunted World* (1996), excerpts. Available on section F. Sagan blames bad science on public misconceptions and ignorance.
- Michael Crichton, *State of Fear* (2004). In this highly controversial treatment of global climate change, Crichton blames bad science on ambition and greed. Available on section D.

(Session 8) How do governments organize themselves to conduct science policy? Disruptive technologies not only change the products people use, they change the way in which governments organize themselves to deliver public policies. Prizes, partnerships and self-regulating "smart" systems are examined here.

- Before class, read and contemplate the exercise Organizing for the Future.
- *Beyond Sputnik*, chapter 12 (Big Science) (class site section G)
- Essential reading: Harlan Cleveland, *Nobody in Charge* (2002). Excerpts on class site section G).
- Charles Perrow, *Normal Accidents* (1984). Excerpts available on section G.
- W. Henry Lambright, *Managing "Big Science": A Case Study of the Human Genome Project* (March 2002). Lambright calls it Big Science, but recognizes that the approach departed significantly from earlier Big Science undertakings like Project Apollo. Available on the Internet.

- Howard McCurdy, From Sailing Ships to Space Ships (2017). A review of public-private partnerships for space exploration. Will be placed on section G.

Part 5. Technology and the Future

(Session 9) Ultimately, what is the purpose of science and technology? Reasons we explore space. The ultimate purpose of discovery.

- Optional essential reading: Leo Marx, "Does Improved Technology Mean Progress?" *Technology Review* (January 1987). The shifting purpose of scientific inquiry over the past 200 years. Class site section E.
- Seth Shostak, "In Touch at Last," (1999). Section B. Shostak reveals the ultimate purpose of technology.
- Steven Dick, "They Aren't Who You Think," (2003). The future is stranger than we can imagine. Section B.

Supplementary Readings

Introduction

- Nelson D. Schwartz, "Gap Widening as Top Workers Reap the Raises," *New York Times* (July 24, 2105).
- "U.S. Science Policy before and after Sputnik," in Neal and Smith, *Beyond Sputnik: U.S. Science Policy in the Twenty-First Century* (2008).

Innovation and the future

- Alex Davies, "Elon Musk's Grand Plan to Power the World with Batteries," *Wired* (May 1, 2015).
- Mortimer Zuckerman, "The President Daydreams on Iran," *Wall Street Journal* (April 25-26, 2015).
- Dan Froomkin, "The Computers Are Listening: How the NSA Converts Spoken Words into Searchable Text," The Intercept (on line), May 5, 2015.
- Devlin Barrett, "U.S. Will Change Program to Track Phones," *Wall Street Journal* (May 4, 2015).
- David Kay, "Genetically Engineered Bioweapons." (Class site)
- Andy Myers, "'Bionic Eye' Brings Sight to the Blind," *Insight* (Johns Hopkins Medical Center publication) (Spring, 2015).
- Todd C. Frankel, "Sedation device could replace doctors," *Washington Post* (May 12, 2015).
- PBS News Hour, "How Smart is Today's Artificial Intelligence?" (May 8, 2015).
- Martin Ford, *Rise of the Robots* (2015).
- Nick Bostrom, Superintelligence (2014).
- J. Craig Venter, *Life at the Speed of Light* (2013). See especially chapters 11 and 12 on biological teleportation.
- "The Medium is the Message," to be found in Marshall McLuhan, *Understanding Media* (1964).
- Patrick Porter, "It's Time to Abandon the Global Village Myth," warontherocks.com (2014).
- Seth Shostak, "In Touch at Last" (*Science*, December 3, 1999) (Class site)[1]
- Rich Karlgaard, "The Future Is More Than Facebook," *Wall Street Journal* (May 17, 2012).
- *Beyond Sputnik*, chapter 1 (Science Policy Defined)
- Harvey Brooks, "The Evolution of U.S. Science Policy," in Smith & Barfield, eds., *Technology, R&D, and the Economy* (1996).

[1] In early 1999, editors at *Scienc*e magazine (the journal of the American Association for the Advancement of Science) asked readers to imagine the world in 2050. Shostak's enticing vision appeared in December within the first of four groups of articles.

- Mark Mills and Julio Ottino, "The Coming Tech-led Boom," *Wall Street Journal* (January 30, 2012) (Available on the class site with the reading by Karlgaard)
- Craig Lambert, "Disruptive Genius," *Harvard Magazine* (July-August 2014).
- Robert Ehrlich, *Nine Crazy Ideas in Science: A Few Might Even Be True* (Blackboard)
- Robert J. Gordon, *The Rise and Fall of American Growth* (2016). According to Gordon, the era of innovation is ending.
- Larry Downes, "Europe's innovation deficit isn't disappearing any time soon" *Washington Post* (June 8, 2015).

Technology, culture, and ideology

- Ray Kurzweil "Promise and Peril," from Alan Lightman et. al., *Living with the Genie* (2003).
- Paul Offit, "Junk Science Isn't a Victimless Crime" (class site)
- Carl Sagan, *The Demon-Haunted World* (selections on class site)
- Meadows et al, *The Limits to Growth* (class site) [2]
- Charles Perrow, "The Habit of Courting Disaster," *Nation* (October 11, 1986).
- Stanley Kubrick, *Dr. Strangelove or: How I Stopped Worrying and Learned to Love the Bomb* (1964).
- Stanley Kubrick and Arthur C. Clarke, *2001: A Space Odyssey* (1968).
- John McDermott, "Technology: the Opiate of the Intellectuals," *New York Review of Books* (July 31, 1969).
- Muller, "Evidence" (on global warming), chapter 22 in *Physics for Future Presidents* (2008). Be sure to read the accompanying "The Conversion of a Climate-Change Skeptic," *The New York Times* (July 28, 2012).
- Robert Pool, *Beyond Engineering: How Society Shapes Technology* (1997).
- Albert Teich, *Technology and the Future* (2013).
- McCurdy, *Space and the American Imagination*, conclusion (2011). (Class site)
- Steven Dick, "They Aren't Who You Think" (Blackboard)
- William Collins et. al., "The Physical Science Behind Climate Change," *Scientific American* (August 2007).
- Richard Lindzen, "The Climate Science Isn't Settled," *Wall Street Journal* (November 30, 2009).
- William Happer, "Global Warming Models Are Wrong Again," *Wall Street Journal* (March 27, 2012)
- Climategate (Google)[3]
- *Contact* [film or novel written by Carl Sagan]
- James Cameron, *Avatar*
- Michael Crichton, *Prey*

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[2] For additional background, see the Wikipedia article "The Limits to Growth."

[3] See, for example, Patrick J. Michaels, "How to Manufacture a Climate Consensus," *Wall Street Journal* (12/18/09); Michael Gerson, "Whose war on science?" *Washington Post* (12/11/09)

- Michael Crichton, *Micro*
- Joel Silver, *The Matrix*
- Christopher Nolan and Emma Thomas, *Inception*
- Stephen Hawking, *The Grand Design*
- Brian Greene, *The Fabric of the Cosmos* (PBS), *The Elegant Universe* (book)
- 2001: A Space Odyssey (moon colonies and more)
- Contact (wormholes, search for extraterrestrial intelligence)
- Esyllium (O'Neill space colonies)
- Moon (lunar mining, robotics)
- Blade Runner (aka Do Androids Dream of Electric Sheep)
- Avatar (avatars)
- Ender's Game (computer games)
- Jurassic Park (genetics)
- Elizabeth Suhay and James Druckman, "The Politics of Science," (on science denial) *Annals of the American Academy of Political and Social Science* (March 2015).
- Joel Achenbach, "Why science is so hard to believe," *Washington Post* (February 12, 2015).

Science and Technology Policy issues

The players in science policy

- McCurdy, *The Space Station Decision* (1990)

The politics of science policy

- *Beyond Sputnik*, chapter 2 (U.S. Science Policy before and after *Sputnik*)
- Richard Paul, "Rocketing Ahead" (www.prx.org) Listen to segments A and B.
- Charles Lindbloom, "The Science of Muddling Through" (Blackboard)
- Michael Crichton, *State of Fear* (selections on Blackboard)
- Baumgartner and Jones, *Agendas and Instability* (selections on Blackboard)
- Ted Lowi, *The End of Liberalism* (selections on Blackboard)
- *Beyond Sputnik*, chapters 6, 7, 8, and/or 9 (Universities; Federal Laboratories; Industry; The States).
- *Beyond Sputnik*, chapter 4, pp. 52-67 (The Process for Making Science Policy)
- McCurdy, "Strategic Planning Study" (class site)
- Roger D. Launius, *Historical Analogs for the Stimulation of Space Commerce*, NASA monographs in aerospace history no. 54 (2014).

The science of science policy

- Terence Kealey and Arm Rudenski, "Endogenous Growth Theory for natural scientists," *Nature Medicine* 4 (September 1998) 995-999.
- Terence Kealey, *Sex, Science, & Profits* (2009).

- Julia Lane, "Assessing the Impact of Science Funding," *Science* (5 June 2009: 1273-1275 (Blackboard)
- Kellogg Foundation, Logic Model Development Guide.
- Julia Lane, "Let's Make Science Metrics More Scientific," *Nature* (25 March 2010) 488-489 (Blackboard)
- Block and Keller, eds., *State of Innovation: The U.S. Government's Role in Technological Innovation* (2011).
- Joseph Lerner, *The Architecture of Innovation* (2012).
- Joseph Stiglitz, *Economics of the Public Sector* (2000).
- John Logsdon, *After Apollo* (2014).
- Mariana Mazzucato, *The Entrepreneurial State* (2013).
- Richard R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy* (1959).
- *Beyond Sputnik*, chapter 5 (Federal Funding for Research) and chapter 4, pp. 67-69 (How Policy Is Evaluated)
- Matt Ridley, *The Rational Optimist: How Prosperity Evolves* (2011).
- Michael Polanyi, "The Republic of Science" (1962). This ten page paper argues that science works best as an economic market, providing the conceptual foundation for conservative attempts to reduce the government presence in science.

Organizing for science policy

- Perrow, *Normal Accidents*, (selections on class site)
- W. Henry Lambright, "Apollo: Critical Factors in Success and Implications for Climate Change" (class site)
- McCurdy, "Inside NASA at 50" (class site)
- Cook-Deegan, "Origins of the Human Genome Project" (class site)
- Malcolm Gladwell, "The Engineer's Lament," *The New Yorker* (May 4, 2015).

Regulation

- Michele Boldrin and David K. Levine, "The Case Against Patents" (September 2012).
- Terence Kealey, "Let's Abolish Patents," in *Sex, Science, and Profits* (2009).
- Science, Smoking, and Politics (case study in Blackboard)
- Lee Fritschler and Catherine Rudder, *Smoking and Politics* (2006)
- Cornelius Kerwin, *Rulemaking* (1998)
- Norman Jewison, *Other People's Money* (1991)

Governance challenges

- Kurzweil, *The Singularity is Near*, selection from chapter 9 (Response to Critics) on the likelihood of governmental regulation, pp. 470-73

- *Beyond Sputnik*, chapter 19, pp. 337-43 (Grand Challenges for Science and Society)
- Albert Teich, "Government and Technology," in *Science, Technology and Society: An Encyclopedia* (2005)
- *Beyond Sputnik*, examine some of the following: chapter 20 (Science, Science Policy, and the Nation's Future); chapter 13 (Scientific Infrastructure); chapter 15 (Science, Technology, Engineering and Mathematics Education); chapter 16 (The Science and Engineering Workforce); chapter 17 (Globalization and Science Policy)

Understanding the Kealey-Ridley-Mazzucato debate

The Kealey-Ridley-Mazzucato debate sits at the apex of the current controversy over how much money governments should spend on science and technology. The debate originated in Great Britain, where all three authors reside, and spread to the United States through organizations like the Cato Institute.

Ridley argues that inventions arise spontaneously, much like species emerging from the biota of the world. He criticizes liberals who disassociate themselves from the creationist doctrine of evolution for adopting a creationist view of technology – the idea that governments can create innovation.

Kealey makes two arguments. Government spending on science and technology, he insists, is a far less efficient instrument for societal innovation than investments made through the private marketplace. Mazzucato points to the various innovations initiated through government support. Kealey does not deny these results, but he does not think that they undercut his efficiency argument. His second argument is more complex. Governments, he says, cannot purchase technological innovation in the same ways they buy education or crime reduction. This argument rests on what he characterizes as the non-linear nature of discovery, which leads back to Ridley's argument.

To grasp the concept of non-linear policy, read the following materials in the order listed.

- If you have not seen it before, look at the Kellog "logic model," which is based on a linear model.[4] Consider how a model applied to policy issues like crime prevention (through strategies such as the "broken window" approach to aggressive policing) might be applied to science challenges like pandemics.
- Read the essay summary by Matt Ridley, "The Evolution of Everything," available on the class catalyst site section A.
- For an example of spontaneous innovation, if you wish, retrieve and read Janet Patton, "How Owensboro tobacco grew a possible miracle drug to treat Ebola," *Lexington Herald-Leader* (August 10, 2014). As you might suspect, this is an example of a non-linear policy.
- To introduce yourself to Terence Kealey, read JR Minkel, "The Economics of Science: Interview with Terence Kealey," *Scientific American* (March 3, 2003) and the book review by Richard Nelson. The book review is available in Catalyst A.
- Follow that with the rebuttal contained in Mazzucato's *The Entrepreneurial State* (first two pages of the preface and the first chapter up to page 17, also in Catalyst A.

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[4] W. K. Kellogg Foundation, *Logic Model Development Guide: Using Logic Models to Bring Together Planning, Evaluation, and Action*. [Examine chapter 1, pages 1-14. Download from http://www.wkkf.org/Pubs/Tools/Evaluation/Pub3669.pdt or google Kellogg Logic Model Development Guide.

From there, you may be ready for the full works:

Matt Ridley, *The Evolution of Everything* (2015).
Terence Kealey, *Sex, Science and Profits* (2008).
Terence Kealey, *The Economic Laws of Scientific Research* (1996).
Mariana Mazzucato, *The Entrepreneurial State* (2013).

For guidance with *The Economic Laws of Scientific Research*, look at the difference between linear and non-linear models of innovation, starting with the introduction and basic model on pages 203-04, then moving through pages 216-19. Next, examine the basic efficiency model on pages 205-207, 219-20, and 224-25. Finally, you might enjoy perusing the examples, such as the section on civil aircraft starting on page 212. The rest is pretty advanced and—as you might guess—highly controversial. As an example, look at the discussion of the spillover effect beginning on page 225. (Much of this is available on Catalyst A.) Kealey calls it "second-mover" research; it basically means that the people who make the most money from new technologies are often in the second or third wave of entrepreneurs who take advantage of basic discoveries that spill over from the people who first make them. Keeley argues the contrary – access costs to early scientific research are very high, he asserts. This contradicts the conventional belief that second movers can "reverse engineer" first mover discoveries without knowing much about the science behind the item being copied. Kealey offered these arguments in a more understandable form in *Sex, Science and Profits: How People Evolved to Make Money* (2009). The book deals with the emergence of the concept of progress, not what the title suggests.

Finally, reexamine the Mazzucato book, at least from pages 18-23 in Catalyst A. Which argument do you find more persuasive?

Interesting Readings on Particular Policy Issues

- Janet Patton, "How Owensboro tobacco grew a possible miracle drug to treat Ebola," *Lexington Herald-Leader* (August 10, 2014).
- Rob Stein, "Vaccine system remains antiquated," *Washington Post* (November 24, 2009).
- David Willman, "$40-Billion Missile Defense System Proves Unreliable," *Los Angeles Times*, June 15, 2014. Also Seattle Times, June 17, 2014.
- Alan Levin, "Will Boeing's automation be blamed for pilot errors in Asiana crash?" Bloomberg News.
- Matthew M. Aid, *Intel Wars* (2012).
- The Task Force on U.S. Drone Policy (Gen. John P. Abizaid & Rosa Brooks, Co-Chairs) *Recommendations and Report* (2014): executive summary.
- American Civil Liberties Union, *Protecting Privacy From Aerial Surveillance* (December 2011).
- Elise Hu, "Feds Can't Enforce Net Neutrality," NPR, 14 January 2014.
- NPR, "When It Comes to High Speed Internet, US Is Falling Way Behind," February 6, 2014.
- Susan Crawford, *Captive Audience* (2013). Alternatively, look at NPR, "When It Comes to High Speed Internet, US Is Falling Way Behind," February 6, 2014.
- Dawn Nunziato, *Virtual Freedom* (2009).
- Charles E. Schumer, "A Strategy for Combatting Patent Trolls," *Wall Street Journal*, June 12, 2013.
- Joseph Rago, "Tom Fanning: The Natural Gas Skeptic," *Wall Street Journal* (June 8, 2013). (Class site)
- Brian Palmer, "The nuke next door," *Washington Post* (September 14, 2010).
- Raj Patel, "Can the World Feed 10 Billion People?" *Foreign Policy* (May 4, 2011).
- National Geographic Freshwater website.
- National Academy of Sciences, Committee on Human Spaceflight, *Pathways to Exploration*, 2014, selections. On line.
- NASA, NASA News, "Near Miss: the Solar Superstorm of July 2012," July 23, 2014.
- Daniel Baker et. al., "A Major Solar Eruptive Event in July 2012," *Space Weather* 11 (October 2013) 585-591.
- Mortimer Zuckerman, "The President's Daydreams on Iran," *Wall Street Journal* (April 25-26, 2015).
- Bill McKibben, "Power to the People: Why the rise of green energy makes utility companies nervous," *New Yorker* (June 29, 2015).
- Craig Timberg, "A disaster foretold – and ignored," (on the vulnerability of the Internet) *Washington Post* (June 23, 2015).
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[5] See also Laurie Goodstein, "Judge Rejects Teaching Intelligent Design," *New York Times* (21 December 2005) and NOVA, "Judgment Day: Intelligent Design on Trial," Public Broadcasting System, November 2007.

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RECOMMENDED FILMS FOR TECHNOLOGY AND CULTURE ASSIGNMENT

Here is a list of influential science fiction films that explain new technologies, describe the process of innovation, and illustrate themes emphasized in the course. Exceptional films commonly fit multiple categories. A few television programs and novels are included as well.

Space exploration

2001: A Space Odyssey (also artificial intelligence and transhumanism)
Destination Moon (1950)
Apollo 13 (also innovation process)
Contact
Close Encounters of the Third Kind
The Martian
Elysium (2013)
Hidden Figures
October Sky

Robotics

Blade Runner
Bicentennial Man
Star Trek: The Measure of a Man (television program)
Star Wars: A New Hope
Day the Earth Stood Still (original 1951 release; see the ending message)
Robocop
Terminator (1984 release)

Genetics and transhumanism

Moon (also innovation process)
Jurassic Park (also innovation process)
Arrival
Cocoon
Star Trek: First Contact (Cyborgs)
Ex Machina
Children of Men

Nanotechnology

Incredible Voyage

Prey (novel)
Micro (novel)
Eye in the Sky
Terminator 2: Judgement Day

Artificial Intelligence

The Matrix
Social Network
War Games
Transcendence (also nanotechnology)
Her

Energy and Nuclear Weapons

Dr. Strangelove
The Day After (1983)
The China Syndrome (1978)

Innovation Process

Alien
Avatar (also transhumanism)
October Sky

HOW THINGS WORK – EXPLAINING IMPENDING TECHNOLOGIES
SUGGESTED TOPICS

Ideally, for this assignment, students will select the technology displayed in the film they presented.

Space exploration

- Alternative methods of space travel: options include VASIMR engines, UW's fusion drive, anti-matter engines, space elevators and wormholes
- Geoengineering (on Mars it is known as terraforming)
- Teletransportation (also known as teleportation)
- Orbiting O'Neill space colonies

Robotics

- Self-driving cars
- Nanodrones

Genetics and transhumanism

- Cloning
- CRISPR (genome modification technology)
- Molecular assembler

Nanotechnology

- Nanocomputers
- Nanobots
- Grey goo (self-replicating nanoorganisms)
- Somatic cell engineering

Artificial Intelligence

- How does a small computer chip contain all that information? Generally offered as a prelude to quantum computing.
- Quantum computing and the concept of multiple realities (Schrodinger's cat)
- Quantum entanglement
- Speech recognition
- Neural nets (computers modeled on the human brain)
- PRISM (the technology Edward Snowdon revealed)
- Mesh networks and other alternatives to the Internet

Energy and Nuclear Weapons

- Nuclear electric power generating plants, including fusion reactors (Helium-3) and nuclear waste
- Dyson spheres
- GPS and missile guidance systems
- Missile defense systems
- Production of weapons grade material and the disposal of nuclear waste byproducts
- Accidental detonation of a nuclear weapon – how close have we come?
- Cavorite (could a soldier shoot down an airplane with a cavorite gun?) and invisibility cloaks

Innovation Process

- Space commerce (See *Alien*, *Silent Running*, *Moon* or *Avatar*)
- Communication with extraterrestrial civilizations (see *Arrival*)

SUGGESTED TOPICS FOR POLICY BRIEF

Should NASA send astronauts on a 900-day journey to Mars? Really?

It is okay to let private corporations send toilet paper and fresh clothing to people on the International Space Station – but human beings? Do we really want to give the private sector that responsibility?

What does the state of Washington need to do to get ready for self-driving cars?

Should the Seattle City Council allow pizza delivery and the transport of Amazon book orders by drones?

Should the U.S. Congress allow the Department of Defense to deploy fully autonomous drones – robotic devices with facial recognition software that are authorized to kill? (View *Eye in the Sky* and *Prey* to imagine how small these devices could be.)

Should the courts allow law enforcement officials operating without a search warrant to introduce evidence obtained by drones? (View *Eye in the Sky*.)

Should the courts treat sentient robots as "persons" in the legal sense of the term? (See "Measure of a Man.")

Should we ban human cloning? Just in the United States or everywhere?

How about the practice of using human stem cells to harvest human organs?

Should the government outlaw genetic modifications for the purpose of creating super (trans) humans – essentially a new species?

Should the governments of the world ban the production of self-replicating nanorganisms (or any other nanoorganism for which the toxicity effects are unknown)?

Who pays for highly effective gene therapies that cost $1 million or more per patient? (Be sure to view *Elysium* before attempting to answer this question.)

Should the government ban strong artificial intelligence until we better understand its implications?

Should the U.S. government (through the Federal Communications Commission) insist upon net neutrality?

When it comes to energy innovation, in the words of Larry Summers, is the federal government a "crappy venture capitalist?" In other words, should the federal government be prohibited from investing in energy technologies?

Now that Harry Reid no longer represents Nevada, what are we going to do with all that nuclear waste sitting in eastern Washington and elsewhere?

If North Korea presses ahead with efforts to fit nuclear warheads on missiles that can reach the Pacific Northwest, what should the United States do? Would a missile defense intercept system work?

Can we solve global climate change the same way we resolved the dangers of smoking – by allowing victims to sue the producers of greenhouse gases?

Should the U.S. government be allowed to engage in geoengineering as a means of counteracting climate change on the Earth? (Consult Thomas Ackerman at the U.W.)

Beyond just talking about the importance of science literacy, what can the federal or state government do to strengthen STEM education?