Honors Biology 350: Biology and Society

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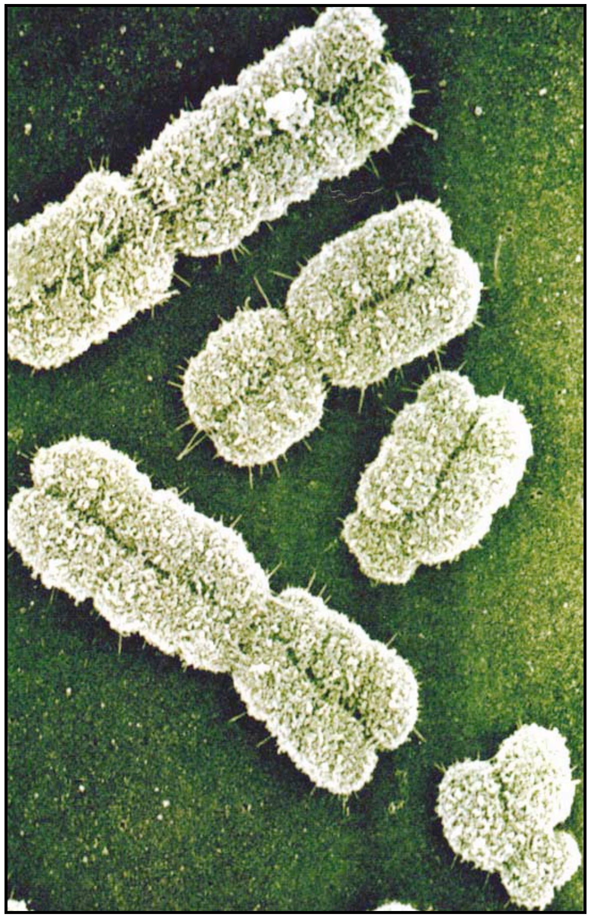

Electron Micrograph of Human Chromosomes

“We are called to be the architects of the future, not its victims.”

Buckminster Fuller

Introduction

Biology and Society, if strictly defined, is the interaction and relationships between the science of biology and society at large. Put this way it is clear that medical research is not of necessity a part of biology as a science. Much of what is characterized as medical research is technological research. It is applying what biology as a science has discovered to create new medical techniques. Stem cell research is one example of the application of scientific knowledge to create new medical tools. It is applied technological research.

An example of biological scientific research of humans is the Human Genome Project, the sequencing of human DNA. It has produced dramatic new knowledge of human genetics, but by itself, provides no direct applications to human medicine. This is a crucially important distinction and one that must be kept in mind when discussing the relationship between science and society.

A list of topics relating specifically to the relationship between biology as a science and society at large might include the following.

- **Biology as a science and the relationship to Society's Support of Research**

    Society's Support of Fundamental Research versus

    Society's Support of Applied Medical Technology

        Research on Aging

        Stem Cell Research

        Genetic Screening

- **Biology as a science and the relationship to Religion**

    Biology and Religious Objections to Teaching Evolution in Public Schools

    Biology and Religious Beliefs in the Special Creation of Human Beings

    Biology and Religious Beliefs about when "life becomes sacred"

    Biology and Religious "Moral Panic" about human sexual behavior

- **Biology as a science and the relationship to Racism**

    The Human Genome Project and Racism

    The Genetic Study of Populations and Racism

- **Biology as a science and the relationship to Environmental Change**

    Human Population Growth and Biodiversity

    Climate Change and Biodiversity

The goals of the course are:

1. To introduce and reinforce an understanding of the nature of science

2. To introduce and analyze the relationship between professional science and the general public in America

Dramatic changes have occurred in the relationship between professional science and the American public since World War II. What have these changes produced? What is the relationship today between science and society in America?

3. To introduce the major secular ethical systems of thought

It is necessary that we cover the traditional secular systems of ethical philosophy at the beginning of a course of this type. Consequentialism and utilitarianism are the traditional ethical systems available for a public discussion of ethics. However, mediational or provisional ethics may provide the best compromise of values for a public and secular system of ethics in our world today.

4. To introduce and discuss some of the major social, ethical issues that exist between science and society in America today

The Course Structure

The framework for the course consists of the following elements.

A) The introduction which consists of three parts:

Unit One: The Nature of Science
- Defining Science
- The Epistemic Values of Science
- Science as a Profession

Unit Two: The Relationship between Science and Society
- What does the general public think about science?
- Why does our society support science?

Unit Three: Ethical Philosophies
- The Relationships between science and philosophy
- The Divisions of Ethics
- Traditional Ethical Theories
- Public Ethics in a Pluralistic Society

B) The remainder of the course consists of topics relevant to the relationship between science and society today. Their order of presentation has been organized using Peter Singer's concept of an expanding circle of ethical responsibility. The first topics presented relate to the individual and the family. The following topics then expand the ethical relationships to the community, the state, and, finally, the world.

Major Topics of the Course

Unit Four: Genetics and Medicine

- A Primer on Human Genetics
- Genetic Screening
- The Human Genome Project

Unit Five: Human Reproduction

- Embryogenesis and Development
- Prenatal Care
- Conception control, and Birth control
- Assisted Reproductive Technologies (ART)
- Gender Selection
- Stem Cell Research
- Cloning Humans
- Genetic Engineering of the Human Gemline

Unit Six: Human Longevity

- Maximum Life Span
- Life Expectancy
- Health Expectancy
- Research on Aging

Unit Seven: The Human Impact on the World

- History of Human Population Growth
- How many people can the Earth support?
- Biodiversity

Unit Eight: Ethics and Equity in the 21st Century

C) Each of these topics is divided into two parts.

1. What is the scientific knowledge needed to address the topic?

2. What are the central ethical issues involved in the topic?

Unit One: The Nature of Science

Topic One: Defining Science

1) As a set of rules for how to look at the world

The Epistemic Values of Science

2) As a very human activity with all of the attendant failings

Science as a Profession

3) As the product of the activity of science

Scientific Knowledge

Science and Epistemic Values

"Against the background presumption that our aim is to understand the world of experience, a world of unbroken regularity, these values are tools or standards that we cherish, since 'they are presumed to promote the truth-like character of science, its character as the most secure knowledge available to us of the world we seek to understand' Hence, an 'epistemic value is one we have reason to believe will, if pursued, help toward the attainment of such knowledge'" (McMullin 1983; Ruse 1996)

Terms and Definitions to Know

Epistemology—the systematic investigation of the origin, nature, methods, and limits of human knowledge. It attempts to answer the question, "how does the human mind perceive and know what is outside itself?" (Bronowski 1960)

Descriptive—that about a phenomena that can be proven or verified by experience or experiment; descriptive statements are empirical observations subject to scientific verification.

Descriptive Epistemology—empirical observations on how we actually view the world.

Prescriptive—that which gives direction or rules; prescriptive statements are statements of what we should do to achieve specific goals.

Prescriptive Epistemology—rules for how we should view the world that are based upon more fundamental epistemological assumptions.

Epistemic Values—are prescriptive epistemological values that serve in achieving a specific goal. In science that goal is to produce reliable knowledge of the natural, physical world.

The Epistemic Values of Science

1) Only those claims to knowledge where the underlying physical causes of a phenomenon have been shown can be accepted by science. This requirement that the cause and effect mechanism that produces a phenomenon must be demonstrated is called **skepticism**. Methodological skepticism requires that all underlying assumptions of a claim to knowledge be identified and their validity questioned. The philosopher David Hume in his *Treatise on Human Nature* (1740), is credited with being the first to show the importance of skepticism in epistemology.

2) Only knowledge claims based upon **physical evidence** can be a part of science. The corollary of this is that all knowledge claims based upon authority alone must be rejected. Personal beliefs do not support claims to knowledge in science. This reliance on physical evidence is closely tied to the rejection of the "scholastic tradition" of accepting the word of authority as absolute truth which began in the Renaissance and continued on through the Reformation with the rejection of the authority of the Catholic Church.

3) **Prediction** by itself is insufficient to support knowledge claims. Correlation by itself fails to link cause to effect. What is needed is an understanding of the mechanism by which a given phenomenon is produced. This is reflected in science by the value placed on skepticism. But if prediction is combined with a **coherence** to the sum of our reliable knowledge of the physical world, successful prediction in science does support knowledge claims.

4) **Coherence** is the logical connections between the elements of a set of concepts and facts; the degree of coherence that a set of concepts and facts has is a measure of its internal, logical consistency. In science all concepts and scientific facts must cohere to all other scientific facts and concepts; they must be both internally and externally, logically consistent.

5) **Consilience**, as a property of scientific theories, increases the reliability of scientific claims to knowledge. The degree that a scientific theory has consilience is a measure of its ability to explain and unify many separate and seemingly unrelated areas of scientific study. Consilience presupposes the unity of knowledge that follows from the assumptions of realism. That is, if there is only one real world, then all true knowledge will be coherent and contribute to understanding that world. The term consilience was first used by William Whewell in 1840.

David Hume (1711-1776)

Hume was an eighteenth century Scottish philosopher and historian. He is consider, today, to be the greatest philosopher to have written in the English language. His *Treatise on Human Nature* (1740), is considered his most important work.

Epistemic Values and the Origin of Modern Science

The origin of modern science can be established by locating when the shift toward the epistemological values of modern science began. This shift in values has been defined most clearly by the late Jacob Bronowski.

> "I hold that the scientific revolution from 1500 onward was an essential part of the Renaissance..."
>
> "Since that time we have been in the unique position of trying to form a single picture of the whole of nature including man. That is a new enterprise; it differs from the preceding enterprises in that it's not magical, by which I mean that it does not suppose the existence of two logics, a natural logic and a supernatural logic."
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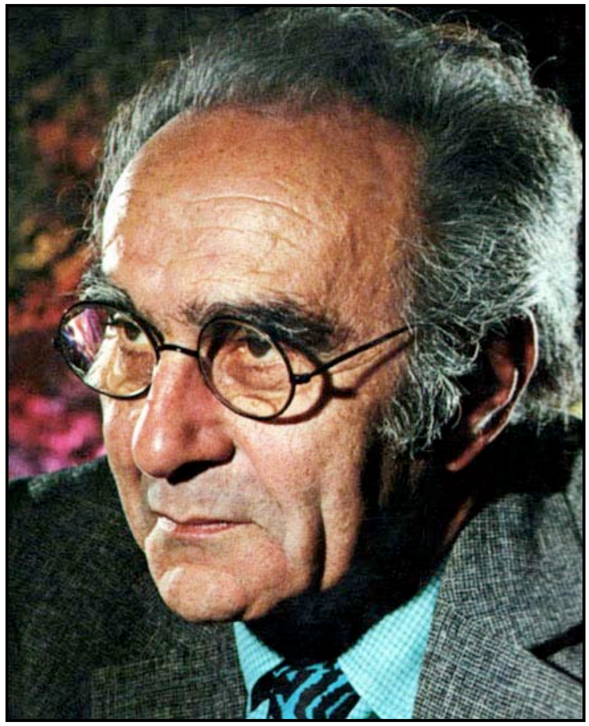
> "If one had to put a date to this, [the origin of modern science] one would say that roughly speaking between 1500 and the publication of Porta's book in 1558, which was called *Natural Magic* the turning point took place." (Bronowski 1978)

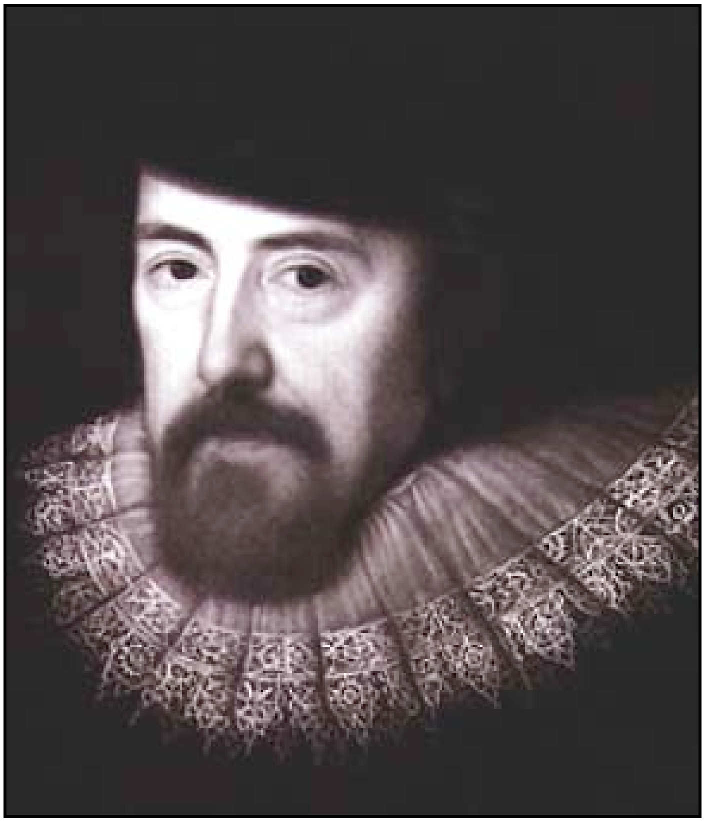


Jacob Bronowski (1908-1974)

Bronowski, Polish-born, British mathematician and man of letters, eloquently presented the case for the humanistic aspects of science. His best known book, *Science and Human Values* (1956), still provides one of the best portraits of the common ground between science and the humanities. His last major project was the authorship and narration of the BBC television series *The Ascent of Man* (1973), a brilliant account of science, art, and philosophy in human history. From 1964 until his death Bronowski was a resident fellow of the Salk Institute of Biological Sciences, San Diego, California.

Giambattista della Porta (1535-1615)

Giambattista della Porta was a polymath who dabbled in nearly everything. *Magiae Naturalis*, his first book, is also his best known work and the basis of his reputation. The first edition, which consisted of four books, appeared in 1558; an expanded edition of twenty books was first published in 1589. It is an extraordinary hodge-podge of material representing that unique combination of curiosity and credulity common in the late Renaissance. But combined with the author's insatiable desire for the marvelous and apparently miraculous is a serious attempt to define and describe natural magic and some refined application of both mathematical and experimental techniques in science. The book was published in English as *Natural Magick* in 1658.



Francis Bacon (1561-1626)

"Finally came the concept of natural law itself. And that was represented, in a most spectacular way, for the first time in the writing of Francis Bacon between 1600 and 1620. It was Francis Bacon who was the first person to say 'knowledge is power.' It was Bacon who said in the *Novum Organum* 'we cannot command nature except by obeying her.'" (Bronowski 1978)

For more on the history of science go to:
http://fire.biol.wwu.edu/trent/alles/Gallery.pdf

Time Line for the Epistemic Values of Science

1558—Porta's book *Magiae Naturalis* (*Natural Magic*) is published

1620—Francis Bacon "we cannot command nature except by obeying her"

1662—the founding of the Royal Society in England with their motto [roughly translated from Latin] "Take nobody's word for it; see for yourself"

1740—David Hume on skepticism in *Treatise on Human Nature*

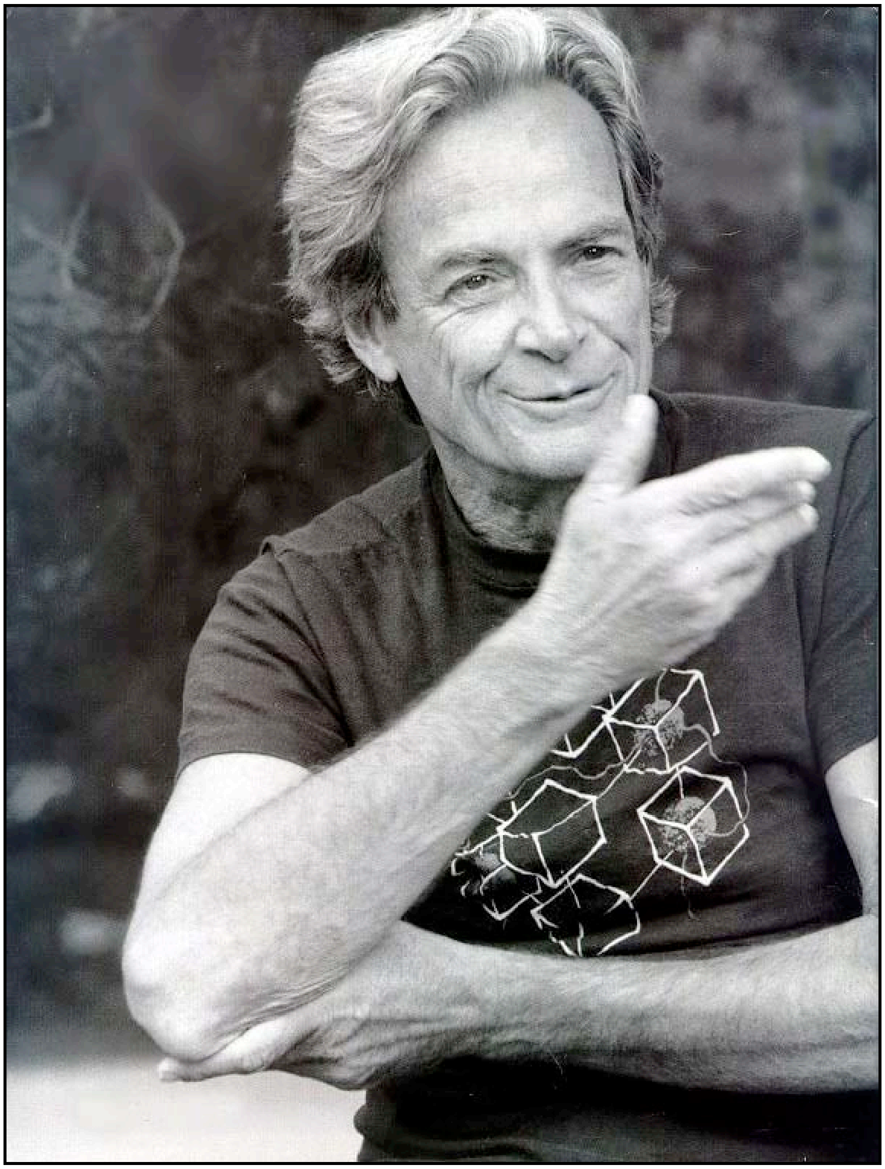
1840—the work of William Whewell on the *Consilience of Inductive Sciences*

Topic Two: Science as a Profession

How is science as a profession organized today?

How does it operate to produce reliable knowledge?

How long has science been a profession?



"Science is a long history of learning how not to fool ourselves."

Richard Feynman (1918-1988)

The Organization of Modern Science

The University Connection

Institutes—The NIH, Salk, Max Planck

Societies—AAAS, NAS

Journals—*Nature, Science*

The Reward System

(research / publish—peer reviewed journals / grants / promotions / prizes)

Science as a Self-Correcting System

(You are rewarded for finding mistakes as much
as you are for making new discoveries.)

The Corporate Connection

The Rise of Biotechnology

Fundamental as opposed to Directed or Applied Research

The "Motive" of Research

How can we define who is a professional academic scientist?

"By statured scientists I mean those who collect and analyze the data, build the theoretical models, interpret the results, and publish articles vetted [peer reviewed] for professional journals by other experts, often including their rivals."

E. O. Wilson in *Consilience: The Unity of Knowledge* (1998)

Professional Science can be divided as follows:

Academic and Institutional Science—consists of those scientists working in public and private institutions such as universities and institutes where the major funding for research is public monies. Publishing results in peer reviewed journals is a central goal of this research.

Corporate or Industrial Science—consists of those scientists working for private companies or corporations where funding is provided by private investment. Publishing results is not a goal of this research.

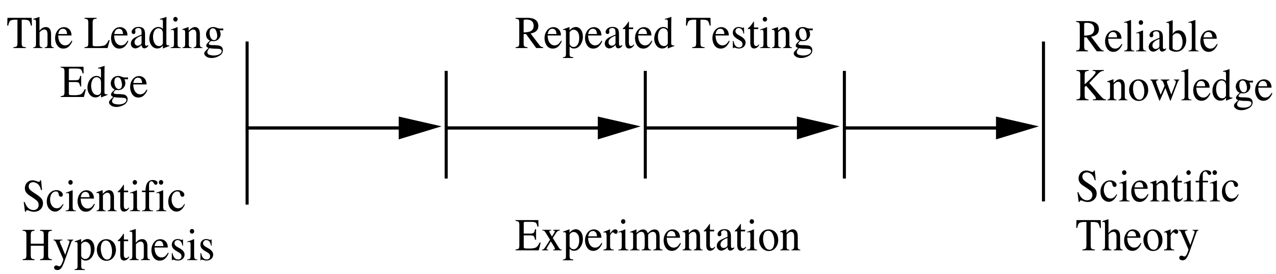
Both Academic and Corporate Science can then be divided into:

Fundamental or Pure Research is driven by the goal of discovering new knowledge without regard to the direction the research might take.

Directed Fundamental Research has a predetermined goal that only can be achieve by the discovery of new knowledge. The cure of specific diseases such as cancer is an example of such research.

Applied Research takes existing scientific knowledge and applies it to develop new technological applications. The development of computer software produces no new scientific knowledge and yet is central to developing new applications of our existing scientific knowledge of electronic computing. Applied research is done by both professional scientists and engineers.

How does science produce reliable knowledge?



How old is professional science?

The creation of a profession from 1662 to 1869

Time Line for Science as a Profession

Mid 1600s—founding of the Royal Society in England and the Academie des Sciences in Paris

1665—first issue of the scientific journal the *Philosophical Transactions* of the Royal Society

Early 1800s—“France despite and because of the Revolution, was the first and most vigorous country in offering opportunities for professional scientists, in any sense that we know them today.” (Ruse 1996)

1833—William Whewell in England coins the term “scientist”

1869—founding of the scientific journal *Nature* by T.H. Huxley and friends

T. H. Huxley (1825-1895)

Huxley was the first to forge the connection between professional scientists and public education, i.e. with the training of science teachers and the link to training doctors. Huxley was also an example of the new breed of scientists who relied solely on their income earned as a professional scientist. Darwin, in contrast, was independently wealthy and did all of his research without having a professional position.

Unit Two: The Relationship between Science and Society Today

Topic One: What does the general public think about science?

All indicators point to widespread support for government funding of basic research. The 2002, NSF survey of American adults found that **72%** believe that the benefits of scientific research outweigh the harmful effects. And **81%** of survey respondents agreed with the following statement: "Even if it brings no immediate benefits, scientific research that advances the frontiers of knowledge is necessary and should be supported by the Federal Government." In Europe, 75% of those surveyed agreed with the statement.

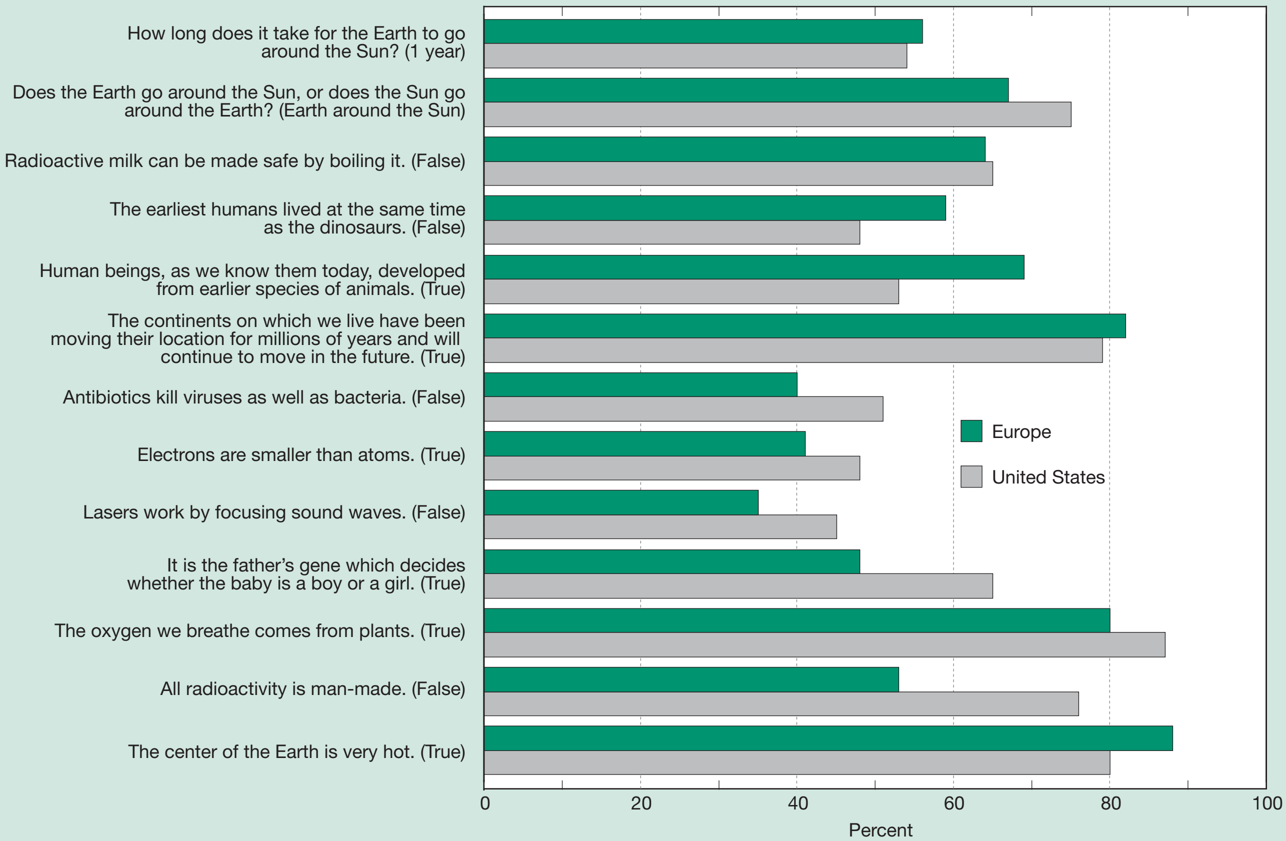
In contrast, only **33%** of Americans understand the nature of scientific inquiry well enough to make informed judgments about the scientific basis of results reported in the media. (NSF 2002)

Web References

http://www.nsf.gov/statistics/seind02/

http://www.nsf.gov/statistics/seind04/c7/c7h.htm

Figure 7-6
Public understanding of scientific terms and concepts: 2001



SOURCES: National Science Foundation, Division of Science Resources Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology, 2001; and European Commission, Eurobarometer 55.2 survey and standard report, *Europeans, Science and Technology*, December 2001.

Science & Engineering Indicators – 2004

about this problem.[26] However, the message still has not reached a large segment of the population, in both the United States and Europe.

Americans apparently are also becoming more familiar with the terminology of genetics. In a 2001 NSF survey, 45 percent of respondents were able to define DNA. The percentage of correct responses to this survey question increased in the late 1990s, a trend that probably reflected the heavy media coverage of DNA use in forensics and medical research. More recently, a 2003 Harris poll found that 60 percent of adults in the United States selected the correct answer when asked “what is DNA?” (the genetic code for living cells), and two-thirds chose the right answer when asked “what does DNA stand for?” (deoxyribonucleic acid) (KSERO Corporation 2003).

Surveys also indicate that the American public lacks an appreciation of basic statistical concepts and terminology. If statistics were confined to academic journals and textbooks, this finding would be of limited interest. But daily newspapers and even television newscasts rely on tables and charts to illustrate all kinds of trends. (See sidebar, “Understanding Statistics.”)

Understanding the Scientific Process

NSF surveys have asked respondents to explain in their own words what it means to study something scientifically. Based on their answers, it is possible to conclude that most Americans (two-thirds in 2001) do not have a firm grasp of what is meant by the scientific process.[27] This lack of understanding may explain why a substantial portion of the population believes in various forms of pseudoscience. (See discussion of “Belief in Pseudoscience” in this chapter.)

In 2001, both the NSF survey and the Eurobarometer asked respondents questions designed to test their knowledge of how an experiment is conducted and their understanding

[26] A recent study found that the number of prescriptions for antibiotics for children in the United States declined significantly between 1996 and 2000 (Finkelstein et al. 2003) and that parents who demand antibiotics for their children's ear infections can be swayed by doctors to change their minds (Siegel 2003).

[27] Correct explanations of scientific study include responses describing it as theory testing, experimentation, or rigorous, systematic comparison.

Topic Two: Why does our society support science?

Estimated R&D expenditures by source, for the years 1940 and 1998

Expenditures (in millions)	Total	Industry	Federal	Universities and colleges	Other*
1940 (in 1998 dollars)............	3,617	2,453	702	325	136
Percent of total	100	67.8	19.4	9.0	3.8
1998 (in 1998 dollars)............	227,173	149,653	66,930	4,979	5,611
Percent of total	100	65.9	29.5	2.2	2.5

*Includes state governments and nonprofit institutions.

(modified from *Science & Engineering Indicators – 2000*, Page 9, Text table 1-3)

What do we get by doing science?

Survival Value & Control

For science to exist we must want to know; we must really want to know. We must be willing to give up all our preconceived notions and beliefs and let nature be the final arbitrator of truth.

The tradeoff is that there is tremendous survival value in having reliable knowledge about our world. With it comes control over nature and for the first time in human history we are no longer at the mercy of an indifferent universe.

Freedom of Action & Control

Moral responsibility can arise only when there is freedom of action and the ability to control the outcome of relevant events. Thus, there are two aspects in assessing moral obligation. The first is that we must be free to act upon our ethical considerations. The second is that our actions must be able to change the course of physical events. We must be able to control the outcome of events to have moral responsibility, for no moral entity can logically be held responsible for anything that is beyond their control. Thus, *control*, itself, is the logical first principle for determining moral responsibility.

The most significant change in our world in the last four hundred years is that science and technology have immensely extended our control over natural events. This extension of control has extended our moral obligations in directions undreamed of by our ancestors. It is, therefore, the fundamental task of our age to analyze and come to understand how this extension of control over the natural world has changed our moral obligations.

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