Science 201 – UNIT I – Lecture 1

Science as a Way of Knowing – A Candle in the Dark

I. "THE DEMON-HAUNTED WORLD" – Carl Sagan

A. The "dark unknown"; think back in time 500 years before science; demon/spirit possession/ghosts/spells/curses/evil-eye/malevolent air/sin/wrath of a god—superstitious/religious (supernatural) explanations for disease; sacrificial offerings; not until the 18th century was mental illness no longer generally ascribed to supernatural causes; pre-modern versus modern scientific theories of disease; eclipses versus astronomy; Inquisition—*Thou shalt not suffer a witch to live* (Exodus 22:18)—witch-burnings (Sagan quote); modern versions (faith healing, people letting their children die rather than have medical treatment or blood transfusions, origin of AIDS—Christian fundamentalists; in Africa—cause: a man who has sexual intercourse with a widow before her ceremony of purification, at the end of a year of mourning; cure: sex with a virgin)

B. "Science as a candle in the dark"—gradual removal of supernatural explanations for the phenomena in the ***physical world*** around us

II. SCIENCE WORKS, It Gets Results

The scientific method has proven to be the most reliable and successful method of thinking in human history…. —Steven D. Schafersman

A. How does science differ from superstition/religion?
"It delivers the goods" – Carl Sagan; it has external validity

B. Tremendous improvement in human condition —1500 vs. now—e.g., medicine
Life expectancy: Europe—20-30 years in Medieval times; 50 in 1915; 60 in 1930; today approaching 80

C. Incredible progress in all areas where science has been applied—e.g., Physics (Copernican Revolution; astronomy, practical applications—e.g., space travel, computers, cell phones), Geology (Plate Tectonics), Biology (medicine, genetics & evolution)

III. SCIENCE AND THE SCIENTIFIC METHOD

A. Origin of science – ancient Greeks—rational examination; cause & effect; e.g., Pythagoras, Euclid; Islamic world—science during the Dark Ages, BUT

B. Real beginning of science as a way of knowing—**Scientific Revolution**—most important "event" in Western history—Westfall quote – 1500s and 1600s in Europe; 1543 may be taken as the beginning of the scientific revolution—publication of Copernicus' *The Revolution of the Heavenly Bodies* (understanding that Earth is not at center of universe—heliocentric solar system—bitterly opposed by Catholic Church; Galileo—house arrest; Giordano Bruno—declared a heretic and burned at stake)

C. Science (word derived from *scientia*, Latin for knowledge) is not merely a collection of facts, concepts, and useful ideas about nature, or even the systematic investigation of nature, although both are common definitions of science.
Science is a method of investigating nature—<u>a way of knowing</u> about nature—that discovers reliable knowledge about it. *– a method; a process*

D. Reliable knowledge – knowledge with a high probability of being true because its veracity has been justified by a reliable method. Scientists have great confidence in their findings, BUT never 100% proven; this is how science works; always questioning, uncertainty, learning more (philosophical and political problem).

E. Scientific Method is *the methodology or set of procedures used by scientists to obtain reliable knowledge about nature, using observation (the gathering of empirical evidence), hypothesizing (developing possible explanations), and testing (of the hypothesis or its predictions—i.e. experimentation) and which is based on logical reasoning and a skeptical, continually questioning attitude.* ***observe-hypothesize-test***

F. The reliance on **evidence** is a critical distinction for the scientific method (versus intuition, believing what others tell you, listing to authority figures, what you read, divine revelation, faith, magic, superstition, pure logic, the reading of chicken entrails, channeling, etc.); *the evidence is available to anyone*; Schafersman quote

G. The scientific method is practiced within a context of scientific/critical thinking, which is based on three things: 1) *Empiricism: The Use of Empirical Evidence*
(empirical = based on observation or experiment)
2) *Rationalism: The Practice of Logical Reasoning*
3) *Skepticism: Possessing a Skeptical Attitude*

H. Science is often counter-intuitive (there are invisible beings that cause disease—how is this different from a vengeful god or possession by evil spirits? **Evidence**!)

I. Scientific "Baloney detector" or "BS detector"—tools for skeptical thinking: Evidence, independent confirmation of facts, encourage debate, authority means little, logic, is the hypothesis falsifiable?

IV. PHILOSPHICAL BASIS OF SCIENCE

A. Mechanistic/Naturalistic Viewpoint – the basis of modern science
—that all events of the universe can be described or explained by natural laws

B. Vitalistic Viewpoint (the doctrine of the supernatural)
—that the universe is controlled by supernatural powers called spirits, gods, or vital forces. e.g., **religion—may be extremely meaningful, giving meaning and value to life**, BUT not useful for a description of the physical world

C. Some people resort to the supernatural for whatever is not understood at a given point in time—"**God of the Gaps**" (gaps in scientific knowledge) Not a good strategy for religion since we are constantly learning more (e.g., Intelligent Design)
"Ignorance more frequently begets confidence than does knowledge: it is those who know little, and not those who know much, who so positively assert that this or that problem will never be solved by science." – Charles Darwin

V. HOW WILL HUMANS USE SCIENCE?

A. Tremendous potential for good or ….; Westfall quote; *the wonder of science*
B. Misuse of Science: **Pseudoscience** (purport to use the methods and findings of science, but do not: e.g., Astrology, Creation "Science," faith-healers, ESP
C. Misuse of Science: Politicization of Science: e.g., Environmental Brownlash
D. Antiscience attitude (misunderstanding, fear); the above often blend together
E. Critical need for science education—in a world increasingly based on science, we'd better understand it (note rise in pseudoscience and superstition—UFO abductions, Bermuda triangle, crop circles, pyramidology, crystal power, etc.)—*need to understand the method, as a way to think, not just facts*; Sagan quote

"The Scientific Revolution was the most important "event" in Western history…. For good and for ill, science stands at the center of every dimension of modern life. It has shaped most of the categories in terms of which we think, and in the process has frequently subverted humanistic concepts that furnished the sinews of our civilization. Through its influence on technology, it has helped to lift the burden of poverty from much of the Western world, but in doing so has accelerated our exploitation of the world's finite resources until already, not so long after the birth of modern science, we fear with good cause their exhaustion. Through its transformation of medicine, science has removed the constant presence of illness and pain, but it has also produced toxic materials that poison the environment and weapons that threaten us with extinction. It should be obvious that I consider some of the items on that list desirable and some highly undesirable.

– Richard Westfall http://web.clas.ufl.edu/users/rhatch/pages/03-Sci-Rev/SCI-REV-Home/05-RSW-Sci-Rev.htm

These scientific theories—such as the theories of relativity, quantum mechanics, thermodynamics, evolution, genetics, plate tectonics, and big bang cosmology—are the most reliable, most rigorous, and most comprehensive form of knowledge that humans possess. Thus, it is important for every educated person to understand where scientific knowledge comes from, and how to emulate this method of gaining knowledge. Scientific knowledge comes from the practice of scientific thinking—using the scientific method—and this mode of discovering and validating knowledge can be duplicated and achieved by anyone who practices critical thinking.

– Steven D. Schafersman http://pbisotopes.ess.sunysb.edu/esp/files/scientific-method.html

"If we teach only the findings and products of science—no matter how useful and even inspiring they may be—without communicating its critical method, how can the average person possibly distinguish science from pseudoscience?"

– Carl Sagan (*The Demon-Haunted World*)

Quotes to accompany Science as a Way of Knowing —A Candle in the Dark

"Science is not the affirmation of a set of beliefs but a process of inquiry aimed at building a testable body of knowledge constantly open to rejection or confirmation. In science, knowledge is fluid and certainty fleeting. That is at the heart of its limitations. It is also its greatest strength."

– Michael Shermer

"There are many hypotheses in science which are wrong. That's perfectly all right; they're the aperture to finding out what's right. Science is a self-correcting process. To be accepted, new ideas must survive the most rigorous standards of evidence and scrutiny."

– Carl Sagan

"It is in the admission of ignorance and the admission of uncertainty that there is a hope for the continuous motion of human beings in some direction that doesn't get confined, permanently blocked, as it has so many times before in various periods in the history of man."

– Richard P. Feynman

"The ultimate court of appeal is observation and experiment... not authority."

– Carl Sagan

"For me, it is far better to grasp the Universe as it really is than to persist in delusion, however satisfying and reassuring."

– Carl Sagan

"It is sad that while science moves ahead in exciting new areas of research, fine-tuning our knowledge of how life originated and evolved, creationists remain mired in medieval debates about angels on the head of a pin and animals in the belly of an Ark"

– Michael Shermer

"I do not think it is necessary to believe that the same God who has given us our senses, reason, and intelligence wished us to abandon their use, giving us by some other means the information that we could gain through them."

– Galileo Galilei

"doing what little one can to increase the general stock of knowledge is as respectable an object of life, as one can in any likelihood pursue"

– Charles Darwin

Above quotes obtained from http://www.2think.org/quotes.html

"Happy is he who has been able to learn the causes of things."

– Virgil (*Georgics*)

“Science, Ann Druyan notes, is forever whispering in our ears, ‘Remember, you’re very new at this. You might be mistaken. You’ve been wrong before.” Despite all the talk of humility, show me something comparable in religion.”

– Carl Sagan (*The Demon-Haunted World*)

“Science may be hard to understand. It may challenge cherished beliefs. When its products are placed at the disposal of politicians or industrialists, it may lead to weapons of mass destruction and grave threats to the environment. But one thing you have to say about it: It delivers the goods.”

– Carl Sagan (*The Demon-Haunted World*)

“You can go to the witch doctor to lift the spell that causes your pernicious anemia, or you can take vitamin $B_{12.}$ If you want to save your child from polio you can pray or you can inoculate.

– Carl Sagan (*The Demon-Haunted World*)

“Whenever possible, scientists experiment. Which experiments suggest themselves often depends on which theories currently prevail. Scientists are intent on testing those theories to the breaking point. They do not trust what is intuitively obvious. That the Earth is flat was once obvious. That heavy bodies fall faster than light ones was once obvious. That bloodsucking leeches cure most diseases was once obvious. That some people are naturally and by divine decree slaves was once obvious. That there is such a place as the center of the Universe, and that the Earth sits in that exalted spot was once obvious….The truth may be puzzling or counterintuitive. It may contradict deeply held beliefs. Experiment is how we get a handle on it.”

– Carl Sagan (*The Demon-Haunted World*)

“Obsession with demons began to reach a crescendo when, in his famous Bull [decree] of 1484, Pope Innocent VIII declared,

> ‘It has come to Our ears that members of both sexes do not avoid to have intercourse with evil angels, incubi, and succubi, and that by their sorceries, and by their incantations, charms, and conjurations, they suffocate, extinguish, and cause to perish the births of women’

as well as generate numerous other calamities. With this Bull, Innocent initiated the systematic accusation, torture, and execution of countless ‘witches’ all over Europe….Innocent himself died in 1492, following unsuccessful attempts to keep him alive by transfusion (which resulted in the deaths of three boys) and by suckling at the breast of a nursing mother. He was mourned by his mistress and their children….There were strong erotic and misogynistic elements—as might be expected in a sexually repressed, male-dominated society with inquisitors drawn from the class of nominally celibate priests. The trials paid close attention to the quality and quantity of orgasm in the supposed copulations of defendants with demons or the Devil….’Devil’s marks’ were found ‘generally on the breasts or private parts’….As a result pubic hairs was shaved, and the genitalia were carefully inspected by the exclusively male inquisitors. In the immolation of the 20-year-old Joan of Arc, after her dress had caught fire the Hangman of Rouen slaked the flames so onlookers could view ‘all the secrets which can or should be in a woman’….There were 28 public immolations [witch burnings], each with 4 to 6 victims on average, in that small city in a single year. This was a microcosm of what was happening all across Europe. No one knows how many were killed altogether—perhaps hundreds of thousands, perhaps millions.”

– Carl Sagan (*The Demon-Haunted World*)

"I worry that, especially as the Millennium edges near, pseudoscience and superstition will seem year by year more tempting, the siren song of unreason more sonorous and attractive. Where have we heard it before? Whenever our ethnic or national prejudices are aroused, in times of scarcity, during challenges to national self-esteem or nerve, when we agonize about our diminished cosmic place and purpose, or when fanaticism is bubbling up around us - then, habits of thought familiar from ages past reach for the controls. The candle flame gutters. Its little pool of light trembles. Darkness gathers. The demons begin to stir."

– Carl Sagan (*The Demon-Haunted World*)

"If we can't think for ourselves, if we're unwilling to question authority, then we're just putty in the hands of those in power. But if the citizens are educated and form their own opinions, then those in power work for us. In every country, we should be teaching our children the scientific method and the reasons for a Bill of Rights. With it comes a certain decency, humility and community spirit. In the demon-haunted world that we inhabit by virtue of being human, this may be all that stands between us and the enveloping darkness."

– Carl Sagan (*The Demon-Haunted World*)