A Brief Essay on Essays

Your grade in this course will be based on two essays as well as classroom participation. I would like to keep the essay assignment as flexible as possible, but I will insist on the following ground rules.

1. One of your essays should be 'methodological' or 'philosophical' in character. By this I mean that it should deal with the basic question 'How does science work?' or to put it another way, 'What do you mean by Natural Law?' Of course, these questions are much too general to discuss in an essay. You will need to focus on one particular issue. See the examples below and further discussion the syllabus.

   The second of your essays should deal with one recent development in science that affects the way we look at the world. I have listed some sample topics below.

2. The essays should be of some moderate length, say from five to ten pages. They should be written in good English style of the sort one would read in a literate science essay. If you can get a hold of John Barrow's book of essays, *Between InnerSpace and Outer Space*, you will find a charming essay of advice to aspiring science writers (written for high school students),"As well as science what do you know?" There are many other good essays in the book that illustrate the art. Other great contemporary science writers include J. Bronowski (*The Identity of Man, The Origins of Knowledge and Imagination*), A. N. Whitehead (*Science in the Modern World*), Richard Feynman, and of course, Stephen J. Gould.

3. The essays should be based on some good solid library research as well as your own independent thinking. Beware of the lightweight and tendentious articles that one often finds on the web or in the popular press. Some science writers who are not themselves scientists write well, but really don't understand what they are writing about and often fail to distinguish between well established science and current speculation. (Timothy Ferris comes to mind.) Their books can give you a good overview but need to be supplemented with further research.

4. Any of the topics listed below are acceptable "as is." If you would like to choose a different topic please write a proposal stating the specific questions you want to research as well as your basic bibliography. Give it to me so that I can review it.

Topics on the meaning and practice of science.

1. Bronowski suggests that the central task of science is to predict the future. The success of science is judged by its success in this prediction. This would seem to leave out astronomy, cosmology, geology, paleontology, anthropology, oceanography, and perhaps even history (if you regard history as a science). How would you generalize his ideas to include these sciences? To put it another way, construct a philosophy of science in which these disciplines, which don't involve predicting the future, would have a natural place. Be careful to explain how one tests the validity of their propositions.

2. There is a movement in literary theory called variously "postmodernism" or "deconstruction." It is associated with people like Jaques Lacan, Roland Barthes, Michael Foucault, Jacques Derrida, and Ferdinand de Sausssure. In a nutshell, God and the self are dead, the author is absent from his or her work, language is an alien circle that each of us is condemned to repeat, society is irredeemable, and the self is necessarily alienated from the word. (!!) These ideas were enormously influential in academic circles during the 1970's and are still around making trouble. One of the deconstructionists' agendas is to show that science is meaningless because the language that is used to do science is just a social construct reflecting the"dominance hierarchies" of our society. If you have studied these people in your literature or philosophy classes, you might do us a service with a review or introduction especially with regard to postmodernism and science. What little I know about the subject comes from *The Non-Local Universe* by R. Nadeau and M. Kafatos, which was written partly in response to the postmodernists' mindset.

3. There is an old problem in quantum mechanics called the "Schrodinger cat paradox," which seems to show that one can kill a cat by looking at it! (Don't try it. This is a thought experiment only.) This puzzle has been around for 75 years, and we still don't know what to do about it. Write a review of the various solutions that have been proposed. (This is a tough one. Don't choose this unless you are ready for some difficult reading.)

4. Einstein based many of his discoveries on "thought experiments." Since then many other physicists have used arguments of this type. What exactly is a thought experiment? Give some examples. Why does this

technique work? How does it work? What is there about the universe that makes this kind of argument successful? You might start with *The Character of Physical Law* by Richard Feynman.

5. There is an old argument that there must be something miraculous about life in the universe because, "According to the second law of thermodynamics, order can never arise from disorder." If this were true, of course, it could never snow! a) Give a brief historical review of this argument. What is wrong with it? b) Is it possible to talk about the entropy of the universe? c) How does organized complexity arise in the universe? I am sure that no one knows the complete answer to this question, but at least review some of the ideas that have been discussed.

6. In Dreams of a Final Theory (see above) Steve Weinberg argues that we will recognize the "final theory" when we have it because it will be beautiful! This is a remarkable paradox; a theory that reduces all reality to the behavior of elementary particles is to be judged on the basis of its beauty. Was Keats right when he wrote, "Truth is beauty, beauty truth"? (Ode to a Grecian Urn) Is beauty a valid criterion for scientific truth? If you want to take a really theological approach to this read *The Evidential Power of Beauty* by Thomas Dubay.

7. The recent spate of books on science and religion seems to have started with *The Tao of Physics* by Fritjof Capra. The book was a surprise best-seller and made Capra something of a cult hero. I have trouble taking it seriously because of the way it refuses to make a distinction between physics as fact and physics as metaphor. Here is a sample:

   > In the hadron bootstrap, all particles are dynamically composed of one another in a self-consistent way. In Mahayana Buddhism a very similar notion is applied to the whole universe.

   Is it really a very similar notion? Does this sort of analogy explain anything? (Incidentally, the "bootstrap hypothesis" is now more or less discredited. Does that mean that Buddhism doesn't work either?) And yet, words like "wave," "quark," and "strangeness" as used in physics seem like metaphors themselves. When is a metaphor useful and when is it not?

If you tackle this topic you might want to look at Diarmuid OMurchus *Quantum Theology*, which does for (or to) Christianity what Capra did for Buddhism, and *The Dancing Wu Li Masters* by Gary Zukav. The latter is a generally useful book with occasional lapses like, "Einstein was a Wu Li master."

8. The laws of physics are always expressed in terms of mathematics, and often the mathematics is very advanced and subtle. In several cases new mathematics had to be "invented" to formulate the laws. Calculus, for example, was invented by Newton so that he could formulate the laws of mechanics. The puzzle is that mathematics seems to be a human invention. Why is it that these symbols that we put on paper are so remarkably effective in describing the basic laws of the universe? Start with the essay, "Why is the Universe Mathematical?" in *Between Inner Space and Outer Space* by John Barrow. There are several other essays in this delightful book that touch on the same topic.

New developments in science

9. Most books on cosmology claim that the universe has one of two possible futures (depending on the density of matter in the universe), either it will expand forever or it will eventually contract to a point and "start over." Now it seems that the universe has chosen a third option intermediate between these two. The expansion is actually speeding up. Review the evidence for this conclusion. The cosmology section in Barrows book would be a good place to start, but there have been some spectacular finding published subsequently. Most of this stuff is on the web. Ask me for references.

10. Some particle theorists believe that there will one day be a "theory of everything" from which, in principle, all things could be calculated. I have trouble getting my mind around this. Every theory I know about starts with some assumptions and builds on them. What makes them think this is possible? Could there be a theory with no starting assumptions? How would you know when you had the right theory? Is it true that all reality can be reduced to a theory of elementary particles? Be sure to read *Dreams of a Final Theory* by Steven Weinberg (for), *Theories of Everything* by John Barrow (against) and *A Brief History of Time* by Stephen Hawking (maybe). A recent book, *Three Roads to Quantum Gravity* tackles a more modest question, why is the world

3-d? The answer (or partial answer) is fascinating and shows just how difficult such questions are.

11. It has recently become possible to map the human genome. Review the discoveries that have led up to this. The DNA molecule resembles a computer code in which the information is written in an alphabet consisting of four letters customarily called A, G, T, and C (rather than the usual binary code). Some people have concluded from this that we are "computable," *i.e.* all the information required to make us (in some sense) is specified in our DNA. What does this mean? Is it true? There is further speculation that the universe itself must be computable in the same sense. Review the arguments that lead to this conclusion.

12. There is a perennial argument between physics and Christian theology regarding free will and determinism. Barrow quotes Karl Popper, "If the physical laws of this world are autonomous, we are not free; if we are free, then the physical laws are not autonomous." If everything that happens comes about from some initial conditions through the laws of physics (as Laplace and the nineteenth century physicists believed) then, in principle, all our choices could be predicted. On the other hand, the doctrine of free will seems essential to Christianity. (Martin Luther claimed that everything is predetermined *and* we have free will. Don't ask me to explain this.) Recently some have argued chaos theory and/or quantum mechanics provides a way around this impasse. What do you think? John Polkinghorne's *Faith of a Physicist* has some material on this.

13. How did life begin? Anyone who claims to know the answer to this one is probably a few pickles short of a barrel, but there are some interesting speculations that are not completely crazy. What is the evidence? See *The Fifth Miracle* by Paul Davies.

14. There is an argument called the "anthropic principle" that says that the universe in some way "knew that we were coming." (I think I am quoting Freeman Dyson.) There are many versions of this argument. Summarize and evaluate them. Barrow and Tipler have written a huge book on the subject and John Polkinghorne revisits it in several of his books. See *Belief in God in an Age of Science*. (The hard part of this topic is saying something that is not already contained in one of Barrow's books.)

15. J. A. Wheeler claims that we create the ancient universe by observing it! His argument is based on quantum mechanics. Most people do not take it seriously despite Wheeler's huge reputation as a physicist. What do you think? Since we are a product of the ancient universe ourselves, how can we create it? This may sound dumb, but nothing Wheeler says should be dismissed lightly.

16. Chaos theory is hot in physics these days. It has produced three remarkable insights: a) There are problems in physics, most of them actually, that *in principle* can't be solved. b) There are systems that are completely deterministic and yet completely unpredictable. Again, these are not exceptional. Most real systems, even our solar system, fall into this category. c) In such systems, said to be "chaotic," a kind of beautiful order emerges from the chaos. What is going on here? Is the order, symmetry, and beauty we see in nature a product of this effect?

I list these topics mostly to get you started and to show by example what I am looking for in the assigned papers. By all means, write about something that interests you!