Module I: The Limits of Scientific Knowledge

Introduction

In this module we will examine the basic principles of nonlinear system theory (including the phenomenon of chaos), metamathematics, quantum mechanics, relativity and string theory. We will devote special attention to questions that these theories *cannot* answer (even in principle). The realization that such questions exist, and the fact that science paints a complex and highly counterintuitive picture of "reality" will hopefully make it easier to bridge the gap between science and theology. In attempting to do so, we will consider whether the notion of a "cosmic mystery" is acceptable to scientists, and whether religious teachings must satisfy certain rational standards before they can become acceptable to an educated population. If some sort of common ground can be found on these issues, it could be a possible starting point for a constructive dialogue between scientists and theologians.

Project 1: Linear and Nonlinear Dynamic Systems

The purpose of this project is to highlight some of the most important differences between linear and nonlinear dynamic systems. In each problem, you will be asked to do some analytical work as well as some numerical simulation. You will also be required to interpret your results, and draw appropriate conclusions about the system equilibria and their stability properties.

PREREQUISITES

Demo 1: Introduction to Nonlinear Systems and a Brief Scilab Tutorial

Writing Assignment 1 (1-2 pages)

In this assignment you will be asked to reflect on the limitations of scientific explanations, based on what you have learned about quantum mechanics, metamathematics and chaos theory. I would also like you to explain what the term "mystery" means to you personally, and whether you think there is room for this notion in the context of science. If so, would you say that this is a possible "point of contact" between science and religion?

Online Discussion Forum

First Online Discussion

Introduce yourself briefly, and say a few words about what your main interests are (this could be anything that is important to you). I would also like you to describe your current position on the relationship between science and religion. Do you think they are incompatible, or do you think there might be some common ground? Do you see any way in which these two disciplines could potentially become "allies"?

Possible Topics for Subsequent Online Discussions in This Module

- Among the many questions that science cannot answer, which ones did you find the most intriguing? Explain why.

- What do you make of the fact that modern scientific theories describe physical reality in ways that are highly counterintuitive? Do you think, for example, that space is really nine dimensional (as string theory suggests), or is this simply a convenient mathematical model?

- How do you interpret the fact that any sufficiently complex formal system contains statements whose truth cannot be determined (even in principle)? Would you agree that human logic is fundamentally imperfect, and that there are things we will never know?

- What role does humility play in science? As you think about this question, focus on how this virtue relates to the recognition that science cannot resolve certain fundamental questions about the nature of physical reality.

- Given what you have learned about linear and nonlinear dynamic systems, how would define the difference between "linear" and "nonlinear" thinking? Can you cite any examples from your own experience?

Module II: Fundamental Theological Questions

Introduction

In this module you will learn some of the basic concepts and ideas that arise in Christian theology. One of our primary objectives in this context will be to examine the theological method of inquiry, and compare it with the approach used in engineering and science. You will also learn how to look for possible bridges between science and theology using analogical imagination. This will allow you to frame and analyze certain complex theological questions in a way that is more familiar to technically educated individuals.

Project 2: The Four Types of Attractors

The purpose of this project is to introduce the notion of an attractor, which is a fundamental concept in the analysis of dynamic systems. You can think of an attractor as a sort of "magnet', which "gathers" solutions that start from different initial conditions, and draws them toward itself. You will see that nonlinear dynamic systems can have four different types of attractors. The most interesting among them are so-called "strange attractors", which are one of the "trademarks" of chaos. You will find that the geometric form of these objects cannot be properly

described using standard Euclidean terms such as points, lines, surfaces or volumes. In that respect, they resemble coast lines, clouds, plants and the human brain (all of which are *fractals*).

PREREQUISITES
Demo 2: Phase Plots and Attractors

Writing Assignment 2 (1-2 pages)
In this assignment, you will be asked to examine the relationship between faith and reason, based on what you have learned about Christian theology. I would like you to consider whether it makes sense to describe God using attributes such as omnipotence and omniscience, and whether the notion of "existence" applies to God in a meaningful way. I would also like you to elaborate on the differences (and possible similarities) between the scientific and theological methods of inquiry. Do you think that science is in some way "superior" to theology because it relies on measurable data and repeated experiments? Or would you argue that the methods of any given discipline are dictated by the nature of the problems it investigates?

Online Discussion Forum

Possible Topics for Online Discussions in This Module

- Do you think that science allows room for religious faith, or are the two mutually exclusive?

- Do you think that logical consistency is a sufficient requirement for theological claims, or should they satisfy more stringent criteria?

- Do you see theology as a purely theoretical discipline? If not, what kind of evidence do you think theologians ought to look for (given that their subject of inquiry isn't controllable in any way)?

- How can a good and omnipotent God allow for the existence of evil? Is this a logical contradiction?

- How can analogical thinking help us bridge some of the differences between science and theology? Can you give an example that works for you personally?

Module III: Controversial Issues: Miracles, Evolution and Religious Pluralism

Introduction

The principal objective of this module is to evaluate whether a scientifically educated individual can rationally accept certain controversial religious teachings, such as the existence of miracles, the "purposefulness" of evolution and the possibility that some religious traditions might reflect the truth more accurately than others. As we examine these questions, you will learn how order and disorder can coexist in complex systems, and how this unusual mix of predictability and surprise can lead to the emergence of new forms of organization in nature. We will also consider the philosophical and theological implications of chaos theory and nonlinear dynamics, in the context of phenomena such as intermittency and hypersensitivity to initial conditions. A proper understanding of these phenomena will be very helpful in our discussion of miracles, and their relationship to the "laws of nature".

Project 3: Order, Randomness and What Lies In Between

The purpose of this project is to demonstrate that order and randomness needn't be mutually exclusive. We will initially examine this property in the context of chaos theory, and consider how seemingly random dynamic behavior can arise in models that are completely deterministic. We will then look at a somewhat different kind of system, in which randomness is introduced from the "outside". Our objective in this case will be to determine whether or not the solutions of such a system exhibit some sort of "hidden order".

PREREQUISITES
Demo 3: Simulation of Discrete Systems
Demo 4: Discrete Systems with Random Elements

Writing Assignment 3 (1-2 pages)

In this assignment, you will be asked to examine whether a scientifically educated individual can rationally accept certain controversial religious teachings, such as the existence of miracles, the "purposefulness" of evolution and the claim that some religious traditions reflect the truth more accurately than others. Pick one of these three issues, and articulate your own views about it. Do you think the scientific and theological positions on this issue can somehow be reconciled?

Online Discussion Forum

Possible Topics for Online Discussions in This Module

- How would you define a "miracle"? Do you think that miracles must necessarily represent violations of natural laws?

- Does saying that a phenomenon is random count as a valid explanation, or is it simply an implicit recognition of our ignorance?

- In light of what you have learned about chaos theory and quantum mechanics, do you think it is reasonable to assume that every event must have an identifiable “cause”?

- Does the fact that genetic mutations are a random process undermine the theological assumption that evolution has a purpose? How does your answer relate to what you have learned about the interplay between chance and lawful behavior in complex systems?

- Do you think evolution has a “purpose” and/or a “direction”? If so, what might that be?

- What would be the difference between saying that evolution follows a “plan” and saying that it has a “purpose” or “direction”?

- Given that different religious teachings conflict on many fundamental questions, should we necessarily conclude that only one of them can be correct? If not, how can we overcome the apparent discrepancies?

- What are your own views on religious pluralism?

Module IV: The True, the Good and the Beautiful

Introduction

This module is designed to demonstrate that aesthetics and ethics are areas of common interest for science and theology. As such, they provide a natural framework for exploring possible similarities and differences between the scientific and theological worldviews. In the lectures devoted to these topics, you will learn about competing theories regarding the origins of the “aesthetic drive” in humans, and examine how beauty can serve as a guide to discovering scientific truth. You will also see a number of examples that illustrate what mathematicians and physicists consider to be “beautiful”.

In the domain of ethics, we will focus on three important questions: the problem of free will, moral relativism and whether there is such a thing as “scientific ethics” (as distinct from other forms of morality). These questions expose some deep discrepancies between the secular and religious views of morality, and suggest that their positions may be impossible to reconcile. We will argue, however, that this may be an overly pessimistic conclusion, and that the pursuit of an “integrated” approach to ethics is not an unrealistic goal.

Project 4: The “Butterfly Effect” and Intermittency

In this project we will examine the sensitivity of nonlinear dynamic systems to small changes in parameters and initial conditions. Our objective will be to show that in some cases even the most miniscule variations can produce significant effects, while in others there will be no noticeable difference at all. Edward Lorenz (who discovered the phenomenon of chaos) described this hypersensitivity to small changes as the “butterfly effect”, referring to the possibility that something as insignificant as the movement of a butterfly’s wings could ultimately affect global weather patterns.

We will also consider an unusual property known as *intermittency*, where the system exhibits long periods of regular behavior which are interrupted by sudden and unpredictable aperiodic bursts. The existence of such phenomena suggests that the behavior of physical systems can occasionally deviate from empirically established rules and patterns for no apparent “reason”. This brings into question the classical assumption that every observable effect must have an identifiable cause.

Writing Assignment 4 (1-2 pages)

In this assignment, you will be asked to reflect on how beauty and the possibility of doing good have influenced your choice of profession. You will also be asked to discuss how you see the relationship between beauty and truth, and why aesthetic criteria have been such a useful guide for new scientific discoveries. Do you agree with the way theologians interpret this connection? If not, what alternative explanations do you favor?

Online Discussion Forum

Possible Topics for Online Discussions in This Module

- Would you agree that science and theology overlap in the domains of ethics and aesthetics? If so, how?
- What is it that you find most beautiful in nature? What are your tastes in art, music, literature, etc.?
- Do you distinguish between natural beauty and beauty created by humans? If so, how would you describe this distinction?
- Would you say that beauty is completely subjective, and that physical reality is completely objective? If not, how would you rephrase this statement?
- What virtues do you think are most important for a scientist?

- Do you think that scientists are usually in a position to choose their own research projects, or are their choices limited by external pressures? What implications does this have for science?

- Do you think that scientific and technological knowledge should be pursued unconditionally, regardless of its potential consequences for society? If not, where would you draw the line?

- Do scientists have a moral obligation to use their knowledge and talents for the greater good of humanity, or is this just a matter of individual preferences?

- What is your position on moral relativism? Do you believe that there are many competing ethical systems, or are you inclined to say that certain moral truths are absolute and universal?

Final Online Discussion

Has your position regarding science and religion changed since your first online posting? If so, how? What aspects of the course were the most important in initiating this change? If your views on this topic didn't change in any way, explain why this is the case.