THE NEWTONIAN REVOLUTION – Part One

Philosophy 167: Science Before Newton's *Principia*

Class 1

Overview of the Course; Ptolemaic Astronomy

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I. Overview of the Course

A. 1510-1810: The "Scientific Revolution"

1. General agreement that before, say, 1510 there was no high quality empirical science in the sense we use the term today, while by, say, 1810 Newtonian mechanics and gravitation were in place and thermodynamics, modern chemistry, optics, and electromagnetism were in the process of emerging
   a. 1510: ***the*** exemplar of science at its best was Ptolemaic astronomy, though Copernicus was about to produce his initial proposal for replacing it
   b. 1810: ***the*** exemplar of science at its best was Newtonian mechanics and celestial mechanics, and seminal experiments were being done following Volta's invention of the battery in 1800 in electrolysis and electricity, as well as in pneumatics and polarization of light
2. The "scientific revolution": a revolution in which we learned how to achieve extraordinarily high quality knowledge of the empirical world -- or at least appear on the surface to have achieved this
   a. By 1810, a body of extraordinarily high quality empirical knowledge already established, and new knowledge in other areas being produced at an accelerating rate
   b. By 1810, a method of conducting inquiry and marshaling evidence that was beginning to be directed at other areas (including human behavior)
   c. By 1810, a standard by virtue of which empirical science came in the 19th century to have the highest intellectual authority, if it didn't have it before
3. To a predominant extent, this revolution took place during the 17th century, which opens with Gilbert's *De Magnete* and closes with the initial dissemination of Newton's *Principia*
4. This course and its second semester continuation amount to an examination of the scientific revolution over these 300 years, focusing on the 17th century
   a. First 2 classes: pre-1600 developments
   b. Next 12 classes: 17th century developments leading up to Newton's *Principia*
   c. First 11 classes of next semester: Newton's *Principia*
   d. Last 3 classes: its reception and impact during the 18th century

B. The "Newtonian Revolution": the *Principia*

1. Emphasis on Newton's *Principia* because, most agree, it was the pivotal event leading to modern advanced science
   a. Published in 1687, with new editions in 1713 and 1726
   b. Answered questions that had dominated empirical inquiry in the 17th century
   c. Opened the way to new lines of inquiry that dominated the 18th century
2. Prefer to call this two semester course the "Newtonian revolution" because the phrase, "the scientific revolution" has come to cover a good deal of less successful empirical research
   a. The real revolution: science as typified by the *Principia*

b. The real revolution: acknowledging science as exemplified by it

3. But from the day the book was published there was wide disagreement about what exactly the *Principia* achieves and how it achieves it – an exemplar, but of what?
   a. Three hundred years of controversy over the *Principia*, starting with Newton and Leibniz, continuing throughout the 18th century, leading to the emergence of philosophy of science as a discipline in the disputes between Whewell and Mill in the mid-19th century
   b. Disagreement continues unabated to the present day
   c. Agree that it represents science at its best, but disagree about what science at its best is
4. Ironic since Newton consciously wrote the *Principia* to show the world how to do truly successful empirical science, on his view in a way that it had never been done before
   a. Thought he had discovered how to achieve high quality knowledge of the empirical world
   b. Excitement with this discovery part of what drove him to complete the book (with the exception of a couple of papers a decade earlier, his first publication, at age 44)
5. To see why he might have thought this, need to understand just what science amounted to at the time he began writing the *Principia* in late 1684 or early 1685
   a. The main goal of this semester is to do this, putting the *Principia* into context
   b. After next week, focus on 1600-1684, ending with the insights that prompted Newton to write the book

C. A Course in the Philosophy of Science

1. Philosophy of science concerned with the nature and the limits of the "knowledge" achieved in the empirical sciences and with how the methods followed yield this "knowledge"
   a. Especially concerned with the status of generalizations and theories
   b. And with the process of adducing evidence in support of them
2. Philosophy 167 and 168 form a course in the philosophy of science
   a. Looks at one episode in the history of science, but always from the point of view of asking exactly how Newtonian science is epistemically different from what preceded it
   b. ***How did we first come to have high quality evidence in any science?*** -- an historical question, but also a philosophic question (what is it for evidence to be high versus low quality?)
3. The usual approach to studying the philosophy of science is to read various 20th century works by philosophers writing about science -- e.g. Philosophy 116
   a. Different views about the nature and limits of scientific "knowledge"
   b. Laying out unresolved issues and indicating why they remain unresolved
4. My preferred approach is to trace through an episode in the history of science in some detail to see how those issues become important and why there is room for disagreement over them
   a. Lends concrete substance to the fundamental questions in the philosophy of science, at the possible expense of a loss of generality

b. Makes science itself the ultimate arbiter of issues in philosophy of science

5. Only real shortcoming of this approach: regardless of which episode is chosen, virtually impossible to do justice to the material in less than two semesters
    a. E.g. first semester laying out background and context in order to make the achievement studied in the next semester clear
    b. The structure of this course

D. Reasons for Focusing on Newton's *Principia*

1. Various episodes can serve my purpose, but none so well as the revolution wrought by the *Principia*, for it brings out the key issues in the philosophy of science most clearly
2. The *Principia* really is the pivotal event in the history of science
    a. It really did transform the way in which science -- i.e. empirical inquiry -- is done
    b. It has served as the exemplar of how to develop a theory and adduce evidence for it throughout the subsequent history of physical science
    c. To understand what it did is to be in a position to understand what science has done generally
3. Another virtue: material covered in this course accessible at the relevant level of detail within two semesters
    a. Virtually no calculus in the *Principia*, and needless to say presupposes no subsequent developments in the history of science
    b. Material it does presuppose -- various developments in 17th century science -- is what we will be covering this semester
4. Another virtue: can serve to illustrate the discipline of history of science at its best
    a. A discipline that has developed largely in the 20th century, with many of its key figures specializing on Newton
    b. Extraordinarily high quality historical research on Newton since World War II
5. Though a course in the philosophy of science, and not the history of science, taught by a philosopher of science who is not trained as a historian of science, it should nevertheless put you in a position to read in history of science critically and intelligently

E. Pedagogical Objectives

1. Immediate objective of this semester is to answer various questions about science as it evolved in the 17th century
    a. What questions drove "scientific research" in the century, and where did they stand when Newton was drafting the *Principia*?
    b. What different conceptions were there of how to go about marshalling empirical evidence for theoretical claims?
    c. What were the most important methodological advances of the century, and how widely appreciated were they?