



University of Cambridge International Programmes

INTERNATIONAL SUMMER SCHOOL TERM I 2007

E10 THE ORIGINS OF MODERN SCIENCE: THE SCIENTIFIC REVOLUTION

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and Mathematical Statistics, University of Cambridge**

Course description

This course is about the changes in scientific thinking over the most exciting period of upheaval and discovery in the history of science before the twentieth century. In the history of science the 'Scientific Revolution' of the seventeenth century has an almost mythic status, not unlike the October Revolution was for the old Soviet Union. In the consciousness of modern science, it is where modern science (or for *some*, science itself) began, and it is when the great heroes of the founding of modern science – Copernicus, Kepler, Galileo, Newton etc. – banished millennia of superstition, philosophical speculation and hocus-pocus, and it is when modern theories and modern methods of science all were born, bringing light to where there had been darkness.

It's a nice image, and it makes for a rattling good tale for a couple of pages at the beginning of science textbooks, but the simplistic folk-history is pretty much completely wrong: the story is far, far more interesting than that, as much about continuities with previous science as it is about a 'revolution'. And – if you can keep a secret – what came *before* wasn't all so bad, and what came *after* wasn't all so modern, either. When you get close to these events, it is sometimes hard to find the 'revolution'. However, that *something* dramatic happened between the time of Copernicus' youth (the late fifteenth century) and the wide dissemination and adoption of Newton's physical theories (the first half of the eighteenth century) is very clear: the period was soon called 'the scientific revolution' by scientists themselves, and even by the late seventeenth century the magnitude of the changes were clear for all to see.

It is difficult to overstate the significance of the scientific work of this period. In many ways we still live in the shadow of this revolution, since the science that emerged from the Scientific Revolution – call it 'the mechanical philosophy' or Newtonianism – forms the ultimate basis of all subsequent science and scientific method. Even where Newton's theories have subsequently been superseded, the way of thinking and the methodology of science that emerged from this revolution remain the paradigms of

scientific thinking. Over the 'Revolution' not only were individual theories changed completely (the causal explanations of the behaviour of the planets, or the causes of projectile or free-fall motion or chemical phenomena, or the theory of matter, for example) but the very methods that science used to investigate nature and the deepest basis of the explanations of material phenomena changed completely.

However, when we get closer to the ideas, the major figures, the scientific thinking and methods of the time, and the intellectual and social culture within which science worked over these two centuries, the revolution becomes much less clear. Upon a closer examination, the drama of the 'before' and 'after' pictures recedes into unsuspected origins and continuities in scientific thinking. And all sorts of 'modern' ideas emerge in a context and within arguments and thinking that were anything but what we would call *modern*. Indeed, when looked at in their proper historical context, the *un-modernity* of the ideas and theories we take to be the origins of modern science is astonishing: the ideas of Copernicus, Kepler, Bacon, Harvey, Galileo, Descartes, Newton, Leibniz, and the rest of the traditional pantheon of Heroes Of The Revolution turn out to be deeply different when not viewed from a modern perspective. Which means that they are a great deal more interesting to understand: they weren't trying to do what we call 'modern science', but something else.

Of equal significance to the new theories about the workings of the physical world, over this period the changes in science and scientific practice also gave rise to a new social status for science and its practitioners, and the new science claimed a radically different role in society, both in its institutions and in its social prestige and power. Science had begun its emergence as a central pillar of European culture.

By examining the scientific, social, and intellectual context of the origins of the scientific revolution, we will be able to understand both how radical it was, and how much continuity and tradition was maintained as well; by looking at a number of disciplines like astronomy and cosmology, physics, physiology and medicine, and matter theory, along with natural philosophy and debates about methodology, the breadth and depth of the innovations and discoveries will be seen. But above all, these lectures will aim to show how difficult and strange these innovations were for contemporaries, how complex and exciting the processes were that gave rise to them, and how different from modern scientific thinking were many of these supposedly 'modern' scientists.

Although a great deal is going to be packed into this course (so please bring along your crash helmets and elbow pads), no technical or scientific background will be required but a good sense of humour will help.

Learning achievements:

As a result of the course, within the constraints of the time and resources available, students should be able to:

1. Compare the aspects of continuity and discontinuity of scientific thinking over the scientific revolution
2. Explain some of the different and varied origins of the scientific revolution
3. Explain the nature of the mechanical philosophy, its origins and its successes and failures
4. Compare the 'social' and 'internal' historiographic approaches to the history of the scientific revolution

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Lecture programme

1. Introduction; historiography; an overview of the history of early science
2. The classical inheritance: Greek natural philosophy, Plato and Platonism, Aristotle and Aristotelianism
3. The transmission of knowledge: Medieval and Renaissance science, and Renaissance humanism: the ancient texts re-discovered
4. Mathematical astronomy and the structure of the universe: an unexpected view of Copernicus
5. Astronomy, mathematical hypotheses, and physics: Tycho's observations and Kepler's conversations with God
6. From the ambitions of Renaissance engineers to Galileo and the telescope. And then, the Church
7. Galen, Vesalius, Fabricius, and Harvey: a medical revolution?
8. Not The Scientific Revolution: John Dee and Francis Bacon
9. Descartes and a safe, rational, experimental mechanical philosophy: the new science!
10. Newton and Newtonianism: failures, successes, promises and mythology

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Essay Topics

Please note: These topics are not meant to be exhaustive, and the lecturer will be willing to discuss other topics of interest to a student, *if* they are relevant to the course.

1. Renaissance Humanism is usually seen as a movement restricted to the literary arts. In what way was humanism also a scientific activity, and how did this come about?
2. Was Copernicus the 'last of the ancients' or 'the first of the moderns'?
3. Why were Kepler's ellipses so revolutionary? Discuss the 'physics' of Kepler's astronomy and its break with the past.
4. Discuss the changing role or status of mathematical knowledge over the sixteenth and seventeenth centuries.
5. Why was the work of Harvey so radical? Was he more or less radical than, say, Vesalius?
6. Why do Galileo's experimental studies figure so little in the *Dialogo*?
7. Were Francis Bacon's proposals essentially radical or conservative? Did his influence match his proposals?
8. Explain why what we call 'experimental methods' were not acceptable in science in 1500, and required in 1700.
9. Consider the reforms of science proposed by Descartes in his *Discours* of 1637: how realistic or usefully prescriptive is this work?
10. How did Newton explain the cause of gravity and the causes of planetary motions? Was he a 'mechanist' or not?
11. Assess the 'continuity' and 'discontinuity' theses about the nature of the Scientific Revolution.

Before you decide which question you are going to answer, please read carefully the following sections of your student handbook:

- 'Evaluation notes for Students and Institutions'
- 'How to write an essay' - guideline notes
- 'Plagiarism and Paraphrasing'

Please also consult your programme timetable for the time of your evaluation information session and make sure that you attend.

If you are unsure about any aspect of writing your essay, please discuss this with either your Course Director or a member of the Summer Schools staff.

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Reading in advance of the programme

Every participant is expected to prepare for each course by undertaking substantial preliminary reading. The following reading list has been compiled by your Course Director – a broad familiarity with these books will greatly enhance your understanding and enjoyment of the lectures, and good preparation by all members will contribute significantly to the success of the course: classes will be conducted on the assumption that reading has been undertaken. Complete ignorance of these books before your arrival in Cambridge would obviously represent a serious disadvantage.

Every text listed here will aid your preparation for the course. To help you plan your reading, they have been divided into categories of differing priority:

Books marked with two asterisks (**) are the highest priority to read. You will find it hard to follow the course if you have not read them before you arrive.

Books marked with one asterisk (*) are the next most important ones to read.

Of course, you are welcome to read relevant sources not listed here as general preparation for your course, but this should be *in addition to* the sources listed here. Remember, your Course Director will assume that you have read from this list.

The history of the scientific revolution has been studied in detail and from almost every imaginable point of view, so there are an enormous number of monographs on particular aspects of it (often on topics of breathtaking obscurity). There are also some excellent scientific biographies available – on Harvey, Galileo, Descartes, and Newton, for example. General texts that would make for an easy, up-to-date introduction and background reading, however, are very few. For this course I would like you to try to read a little bit about the history of science over this period generally (reading some parts of the ** books, for example), trying to dip in to the various topics of scientists that we shall cover so that you have some sense of the larger background picture before we begin. Please note, however that the relevant sections of the books marked with two asterisks (**) should be considered as the essential preliminary reading (and they are all not too expensive paperbacks), and you should have at least looked at one or two of these before the course.

Other books on this reading list are for ‘further reading’ should you be interested in wider preliminary reading.

- DEAR, Peter Robert **Revolutionizing the Sciences:
European Knowledge and its Ambitions,
1500–1700**
(2001 Palgrave, 0-333-71574-8) paperback £17.99
*A more sophisticated approach, sometimes
polemical and politicised, but always interesting*
- DEBUS, Allen G. * **Man and Nature in the Renaissance**
(1979 Cambridge University Press,
0-521-29328-6) paperback £17.99
*Treats the alternative natural philosophies
and the ferment of sixteenth century very well*
- DRAKE, Stillman **Galileo: a Very Short Introduction**
(2001 Oxford University Press,
0-19-285456-9) paperback £6.99
*This is an excellent, short introduction to Galileo,
and covers everything you need to know*
- HALL, A. Rupert ** **The Revolution in Science 1500-1750**
(1983 Longman new edition,
0-582-49133-9) paperback £35.99
*Recently revised, and still the best single textbook
covering the period; if you were to read only one
work before or during the course, this would be the
best choice. If you are going to purchase anything,
this is a good candidate*
- HALL, Marie Boas ** **The Scientific Renaissance 1450-1630**
(1994 Dover Publications, 0-486-28115-9) paperback
£11.50
*Though dated, this remains one of the easiest and
most reliable introductions to the earlier part of the
story; recommended. If you are going to purchase
anything, this is a good candidate*
- HENRY, John **The Scientific Revolution and the
Origins of Modern Science**
(2001 Palgrave, 2nd edn 0-333-96090-4)
paperback £31.99
Dry, but another useful introduction

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