ARIZONA STATE UNIVERSITY

GENERAL STUDIES PROGRAM COURSE PROPOSAL COVER FORM

Courses submitted to the GSC between 2/1 and 4/30 if approved, will be effective the following Spring.

Courses submitted between 5/1 and 1/31 if approved, will be effective the following Fall.

(SUBMISSION VIA ADOBE.PDF FILES IS PREFERRED)

DATE 04 April 2011

1. ACADEMIC UNIT: Division of Mathematical and Natural Sciences

2. COURSE PROPOSED: BIO 306 Modes of Biological Thought 3
   (prefix) (number) (title) (semester hours)

3. CONTACT PERSON: Name: Ken G. Sweat Phone: x36938
   Mail Code: 2352 E-Mail: kengsweat@asu.edu

4. ELIGIBILITY: New courses must be approved by the Tempe Campus Curriculum Subcommittee and must have a regular course number. For the rules governing approval of omnibus courses, contact the General Studies Program Office at 965-0739.

5. AREA(S) PROPOSED COURSE WILL SERVE. A single course may be proposed for more than one core or awareness area. A course may satisfy a core area requirement and more than one awareness area requirements concurrently, but may not satisfy requirements in two core areas simultaneously, even if approved for those areas. With departmental consent, an approved General Studies course may be counted toward both the General Studies requirement and the major program of study. (Please submit one designation per proposal)

   Core Areas                                      Awareness Areas
   Literacy and Critical Inquiry—L ☒   Global Awareness—G ☐
   Mathematical Studies—MA ☐ CS ☐    Historical Awareness—H ☐
   Humanities, Fine Arts and Design—HU ☐   Cultural Diversity in the United States—C ☐
   Social and Behavioral Sciences—SB ☐
   Natural Sciences—SQ ☐ SG ☐

6. DOCUMENTATION REQUIRED.
   (1) Course Description
   (2) Course Syllabus
   (3) Criteria Checklist for the area
   (4) Table of Contents from the textbook used, if available

7. In the space provided below (or on a separate sheet), please also provide a description of how the course meets the specific criteria in the area for which the course is being proposed.

   CROSS-LISTED COURSES: ☒ No ☐ Yes; Please identify courses: __________________________
   Is this a multisection course?: ☒ No ☐ Yes; Is it governed by a common syllabus? ________

   Chair/Director (Print or Type)   Chair/Director (Signature)

   Date: 4/4/11

Rev. 1/94, 4/95, 7/98, 4/00, 1/02, 10/08
Instructors: Ken Sweat CLCC 116 (Lecturer)
Email/Phone: KenGSweat@asu.edu; 602-543-6938
Office Hours: Monday 2:00 – 4:00pm and Tuesday 1:30 – 3:30pm or by appointment.
Lecture: 12:30 – 1:45pm Tuesday & Thursday; Sands 105.

Course Description: Modes of biological thought is a course designed to introduce the student to the philosophy of science, and how scientists, especially biologists, approach knowledge.

Attendance: Attendance at all lectures is essential to performing well in this course. It is the student’s responsibility to obtain information from missed lectures. Tardiness to class will not be tolerated. It disrupts the lesson, and can be especially disruptive of the efforts of other students. If it is unavoidable, please inform the instructor in advance. Reasonable accommodations will be made in cases of religious holidays or other emergency situations. It is the student’s responsibility to provide the instructor with documentation of holidays and or emergencies and a plan to cover the missed course material.

Withdrawal Policy: It is the students’ responsibility to withdraw themselves from the course should this be necessary. The deadline for an unrestricted withdrawal is 30 March 2007 (in person) and 1 April 2007 (ASU Interactive).

Text Books: Required for this course are the following:
Kuhn, T. The Structure of Scientific Revolutions, 1996
Mayr, E. This is Biology: the Science of the Living World, 1998
Chalmers, A. Science and Its Fabrication, 1990
Optional: the following text book is optional:
McMillan, V. Writing Papers in the Biological Sciences, 2006

Reading assignments appear on the schedule at the end of the syllabus. During the semester, various scientific papers will also be assigned.

Computers and this course: The vast majority of class materials will be posted on the course Blackboard website. Students are expected to have an ASURite ID and access the site regularly for information. Computers are available on campus in Technopolis located in the basement of the library. Technopolis staff can assist students who do not yet have an ASURite ID.

Assignments and Grading: Assessment of learning in this course will be through written assignments and classroom discussion. The following weights will be used to determine a student’s final grade:

Written assignments (3 at 20% each) 60%
Final Paper: 25%
Classroom participation: 15%

C-1.
Grading Scale. The grading scale that will be used for the course is:

- 97% ≤ A+  
- 93% ≤ A < 97%  
- 90% ≤ A- < 93%  
- 87% ≤ B+ < 90%  
- 83% ≤ B ≤ 87%  
- 80% ≤ B- < 83%  
- 77% ≤ C+ < 80%  
- 70% ≤ C ≤ 77%  
- 60% ≤ D < 69%  
- E < 60%

Classroom Participation: Each week, a series of questions will be posted to Blackboard regarding the reading assignment. Students are expected to be prepared to answer these questions individually during classroom discussions.

Homework: During the semester, three writing assignments will be made that will require a paper be completed outside of class time. Homework papers are to be at least five pages in length. Topics will be provided by the instructor when appropriate.

Final Paper: In lieu of a final exam, a final paper will be written and turned in on the day of the final. This paper will be at least seven pages in length.

Written Paper Format: For all written assignments in this course, the following format guidelines will be strictly enforced. Failure to follow guidelines can result in a 10% penalty per violation. Papers will be typed, in 12 point Times, Times New Roman, Helvetica or Arial font, on 22 x 28 cm (8.5 x 11 in.) white paper. Margins will be 2.54 cm (1 inch) top, bottom and both sides. Citations should use the Council of Science Editors same-year system. A brief description of this is found in the book “Writing Papers in the Biological Sciences” by McMillan or at (http://councilscienceeditors.org).

Incomplete and Late Assignments: An incomplete grade (I) will only be given to a student doing acceptable work (C or higher) who is unable to complete the course requirements due to illness or extenuating circumstances, and who only needs to make up a single assignment to complete the course requirements. Late assignments will be penalized 10% for each day they are late. If the delay was caused by a serious emergency or other dire situation, the instructor may choose not to penalize the assignment. Decisions are made on a case by case basis. The student is responsible for bringing to the instructor all documentation.

Students are required to read and act in accordance with University and Arizona Board of Regents policies, including:

- The Academic Integrity Policy: http://www.asu.edu/studentlife/judicial/integrity.html
- The Student Code of Conduct: Arizona Board of Regents Policies 5-301 through 5-308: http://www.abor.asu.edu/1_the_regents/policymanual/index.html#5
- The Computer, Internet and Electronic Communications Policy http://www.asu.edu/aad/manuals/acd/acd125.html
### Lecture Schedule:
(subject to change with notice – meet in FAB B17).

<table>
<thead>
<tr>
<th>date</th>
<th>Readings:</th>
<th>Written Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 January</td>
<td>Introduction</td>
<td>In class</td>
</tr>
<tr>
<td>22 January</td>
<td>Gopen &amp; Swan article</td>
<td></td>
</tr>
<tr>
<td>24 January</td>
<td>Kuhn: Preface, Chapters 1-2</td>
<td></td>
</tr>
<tr>
<td>29 January</td>
<td>Kuhn: Chapter 3-4</td>
<td></td>
</tr>
<tr>
<td>31 January</td>
<td>Kuhn: Chapters 5-6</td>
<td></td>
</tr>
<tr>
<td>5 February</td>
<td>Kuhn: Chapters 7-8</td>
<td></td>
</tr>
<tr>
<td>7 February</td>
<td>Kuhn: Chapters 9-10</td>
<td></td>
</tr>
<tr>
<td>12 February</td>
<td>Kuhn: Chapters 11-12</td>
<td></td>
</tr>
<tr>
<td>14 February</td>
<td>Kuhn: Chapter 13 and Postscript</td>
<td></td>
</tr>
<tr>
<td>19 February</td>
<td>Mayr: Preface, Chapters 1-2</td>
<td></td>
</tr>
<tr>
<td>21 February</td>
<td>Mayr: Chapters 3-4</td>
<td>Paper 1 to peers</td>
</tr>
<tr>
<td>26 February</td>
<td>Mayr: Chapters 5-6</td>
<td></td>
</tr>
<tr>
<td>28 February</td>
<td>Mayr: Chapters 7-8</td>
<td>Paper 1 peer review due</td>
</tr>
<tr>
<td>5 March</td>
<td>Mayr: Chapters 9-10</td>
<td>Paper 1 due to instructor</td>
</tr>
<tr>
<td>7 March</td>
<td>Mayr: Chapters 11-12</td>
<td></td>
</tr>
<tr>
<td>12 &amp; 14 March</td>
<td>Spring Break</td>
<td></td>
</tr>
<tr>
<td>19 March</td>
<td>Chalmers Preface, chapter 1</td>
<td>Paper 2 to peers</td>
</tr>
<tr>
<td>21 March</td>
<td>Chalmers chapter 2</td>
<td></td>
</tr>
<tr>
<td>26 March</td>
<td>Chalmers chapter 3</td>
<td>Paper 2 peer review due</td>
</tr>
<tr>
<td>28 March</td>
<td>Chalmers chapter 4</td>
<td></td>
</tr>
<tr>
<td>2 April</td>
<td>Chalmers chapter 5</td>
<td>Paper 2 due to instructor</td>
</tr>
<tr>
<td>4 April</td>
<td>Chalmers chapter 6</td>
<td></td>
</tr>
<tr>
<td>9 April</td>
<td>Chalmers chapter 7</td>
<td></td>
</tr>
<tr>
<td>11 April</td>
<td>Chalmers chapter 8</td>
<td></td>
</tr>
<tr>
<td>16 April</td>
<td>tba</td>
<td>Paper 3 to peers</td>
</tr>
<tr>
<td>18 April</td>
<td>tba</td>
<td></td>
</tr>
<tr>
<td>23 April</td>
<td>tba</td>
<td>Paper 3 peer review due</td>
</tr>
<tr>
<td>25 April</td>
<td>tba</td>
<td>Paper 3 due</td>
</tr>
<tr>
<td>30 April</td>
<td>tba</td>
<td></td>
</tr>
<tr>
<td>3 May</td>
<td>Exam week</td>
<td>Final paper due by noon</td>
</tr>
</tbody>
</table>

C-4.
Paper assignments for Modes of Biological Thought

Paper #1: (minimum five pages)

How does Kuhn’s concept of progress in science compare with your own concepts of progress in science? Explain how Kuhn comes to the conclusion that science does not progress, that it is simply a redefinition of the questions that are important to the particular discipline involved. As well, describe what Kuhn means when describes a paradigm shift, and how it relates to the concept of progress in science. Do you agree with Kuhn’s conclusion on progress in science? Use two historical examples of a major discovery in the physical sciences to support and elucidate your view.

Paper #2: (minimum five pages)

How does Mayr’s concept of progress in science compare with your own concepts of progress in science? Does Mayr present a plausible argument that biology is a different kind of science than Kuhn’s physics? Specifically, could Mayr’s analysis be used to dismiss the idea of paradigm shift in the manner that Kuhn defines it as irrelevant to the biological sciences? Do you agree or disagree that biology is fundamentally a different kind of science than physics? Use two historical major discoveries in the biological sciences to support and elucidate your view.

Paper #3: (minimum five pages)

Can there exist a universal set of rules that define science? Is science ‘less legitimate’ without a fixed set of universal rules? Why does Chalmers state that there cannot be one universal scientific method? Is he correct? How does Chalmers support his claim that scientific knowledge is still useful and different from other forms of knowledge, even without a universal scientific method? Cite an example of research from the biological sciences and one from the physical sciences and describe how they both either use or do not use the same scientific method.

Final Paper: (minimum seven pages)

Compare and contrast the views of science and progress in science presented in the course texts. What are the differences between Kuhn’s and Mayr’s view, and can these differences be explained by the different sciences the two authors work in? Is a universal scientific method necessary for either of these views of science? Do you think that the knowledge science synthesizes is unique and valuable, or is it equal to other forms of knowledge? How do these books compare to how you view science and progress in science? How have your views changed since the beginning of this semester? Use the historical examples from previous papers to support your view. Are the biological and physical sciences philosophically different, or does a universal method and concept of progress unite them?

All four papers contribute to the course meeting the criteria in C-2 & C-3
Assignment Rubric:

Each paper will be grade using the following rubric:

**Does the student answer the assignment completely?  35%**

The paper will be evaluated based on how well it answers the questions posed in the assignment. The paper must do so in a clear and coherent fashion, not as a simple list of one sentence answers unrelated to each other. The assignment questions are formulated to overlap each other, and the paper should answer them as a single narrative.

**Does the student list the appropriate historic discoveries relevant to the paper?  20%**

Do the examples from science history the paper describes fit the criteria for them given in the assignment. If the assignment asks for examples from the biological sciences, citing the change from a geocentric to a solar centric solar system would be an inappropriate example.

**Grammar, punctuation and spelling:  15%**

Does the paper use correct language, grammar and sentence structure. This part of the grade is for the basic mechanics of good writing.

**Is the paper body and are the citations formatted correctly?  15%**

Papers should have a title page with the title of the paper, student name and date the paper is due. Text subheadings should be bolded. Text should be in 12 point Times New Roman, Helvetica or Arial font, double spaced. Margins should be 2.54 cm. at top, bottom and both sides. Citations should use the Council of Science Editors same-year system. A brief description of this is found in the book “Writing Papers in the Biological Sciences” by McMillan or at (http://councilscienceeditors.org).

**Does the paper reach the required length?  5%**

Is the paper at least as many pages as the assignment calls for.

**Did the student peer review at least two other papers, and have at least two other students review their paper?  10%**

Students are responsible to have at least two other students peer review their papers, and must peer review at least two other students’ papers. Each student is responsible for bringing two (2) hard copies of their paper to class the day the paper is due for peer review. Students will also staple the peer reviewed drafts of their paper to the final draft submitted to the instructor for a grade. Students will have one week to review their peers papers, and one further week to revise their own paper based on the peer reviews.
Students should attach a copy of this page to each paper they peer review and use it to organize their comments about the paper.

**Does the student answer the assignment completely?**

Comments:

**Does the student list the appropriate historic discoveries relevant to the paper?**

Comments:

**Grammar, punctuation and spelling:**

Comments:

**Is the paper body and are the citations formatted correctly?**

Comments:

**Does the paper reach the required length? 5%**

Comments:
Rationale and Objectives

Literacy is here defined broadly as communicative competence in written and oral discourse. Critical inquiry involves the gathering, interpretation, and evaluation of evidence. Any field of university study may require unique critical skills which have little to do with language in the usual sense (words), but the analysis of spoken and written evidence pervades university study and everyday life. Thus, the General Studies requirements assume that all undergraduates should develop the ability to reason critically and communicate using the medium of language.

The requirement in Literacy and Critical Inquiry presumes, first, that training in literacy and critical inquiry must be sustained beyond traditional First Year English in order to create a habitual skill in every student; and, second, that the skills become more expert, as well as more secure, as the student learns challenging subject matter. Thus, the Literacy and Critical Inquiry requirement stipulates two courses beyond First Year English.

Most lower-level [L] courses are devoted primarily to the further development of critical skills in reading, writing, listening, speaking, or analysis of discourse. Upper-division [L] courses generally are courses in a particular discipline into which writing and critical thinking have been fully integrated as means of learning the content and, in most cases, demonstrating that it has been learned.

Students must complete six credit hours from courses designated as [L], at least three credit hours of which must be chosen from approved upper-division courses, preferably in their major. Students must have completed ENG 101, 107, or 105 to take an [L] course.

Notes:

1. ENG 101, 107 or ENG 105 must be prerequisites
2. Honors theses, XXX 493 meet [L] requirements
3. The list of criteria that must be satisfied for designation as a Literacy and Critical Inquiry [L] course is presented on the following page. This list will help you determine whether the current version of your course meets all of these requirements. If you decide to apply, please attach a current syllabus, handouts, or other documentation that will provide sufficient information for the General Studies Council to make an informed decision regarding the status of your proposal.
Proposer: Please complete the following section and attach appropriate documentation.

## ASU - [L] CRITERIA

TO QUALIFY FOR [L] DESIGNATION, THE COURSE DESIGN MUST PLACE A MAJOR EMPHASIS ON COMPLETING CRITICAL DISCOURSE -- AS EVIDENCED BY THE FOLLOWING CRITERIA:

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Identify Documentation Submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CRITERION 1:** At least 50 percent of the grade in the course should depend upon writing, including prepared essays, speeches, or in-class essay examinations. *Group projects are acceptable only if each student gathers, interprets, and evaluates evidence, and prepares a summary report.*

1. Please describe the assignments that are considered in the computation of course grades -- and indicate the proportion of the final grade that is determined by each assignment.

2. Also:

   Please circle, underline, or otherwise mark the information presented in the most recent course syllabus (or other material you have submitted) that verifies this description of the grading process -- and label this information "C-1".

C-1

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Identify Documentation Submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CRITERION 2:** The composition tasks involve the gathering, interpretation, and evaluation of evidence

1. Please describe the way(s) in which this criterion is addressed in the course design

2. Also:

   Please circle, underline, or otherwise mark the information presented in the most recent course syllabus (or other material you have submitted) that verifies this description of the grading process -- and label this information "C-2".

C-2

<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Identify Documentation Submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>✗</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CRITERION 3:** The syllabus should include a minimum of two substantial writing or speaking tasks, other than or in addition to in-class essay exams

1. Please provide relatively detailed descriptions of two or more substantial writing or speaking tasks that are included in the course requirements

2. Also:

   Please circle, underline, or otherwise mark the information presented in the most recent course syllabus (or other material you have submitted) that verifies this description of the grading process -- and label this information "C-3".

C-3
<table>
<thead>
<tr>
<th>YES</th>
<th>NO</th>
<th>Identify Documentation Submitted</th>
</tr>
</thead>
<tbody>
<tr>
<td>☒</td>
<td></td>
<td>CRITERION 4: These substantial writing or speaking assignments should be arranged so that the students will get timely feedback from the instructor on each assignment in time to help them do better on subsequent assignments. <em>Intervention at earlier stages in the writing process is especially welcomed</em></td>
</tr>
</tbody>
</table>

1. Please describe the sequence of course assignments--and the nature of the feedback the current (or most recent) course instructor provides to help students do better on subsequent assignments.

2. Also:

   Please **circle, underline, or otherwise mark** the information presented in the most recent course syllabus (or other material you have submitted) that verifies **this description** of the grading process--and label this information "C-4".
Explain in detail which student activities correspond to the specific designation criteria. Please use the following organizer to explain how the criteria are being met.

<table>
<thead>
<tr>
<th>Criteria (from checksheet)</th>
<th>How course meets spirit (contextualize specific examples in next column)</th>
<th>Please provide detailed evidence of how course meets criteria (i.e., where in syllabus)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. At least 50 percent of the grade in the course should depend upon writing, including prepared essays, speeches, or in-class essay examinations.</td>
<td>Course grade is based on four writing assignments (85%) and in class participation (15%).</td>
<td>See syllabus under Assignments and Grading, page 2.</td>
</tr>
<tr>
<td>2. The composition tasks involve the gathering, interpretation and evaluation of evidence.</td>
<td>Writing assignments direct students to assess the validity of Kuhn's descriptions of scientific revolutions, Mayr's definition of biology as a science different from the physics Kuhn is part of, and the conclusion of Chalmers that science can produce objective knowledge without a universal method.</td>
<td>Details of the individual writing assignments are given in a class handout included with this form.</td>
</tr>
<tr>
<td>3. Please provide relatively detailed descriptions of two or more substantial writing or speaking tasks that are also included in the course requirements.</td>
<td>Students are assigned essays to compare the philosophies of Kuhn, Mayr and Chalmers to their own, and assess how these philosophies influence the possibility that scientific endeavors can obtain objective knowledge.</td>
<td>Details of the individual writing assignments are given in a class handout included with this form.</td>
</tr>
<tr>
<td>4. These substantial writing or speaking assignments should be arranged so that the students will get timely feedback from the instructor on each assignment in time to help them do better on subsequent assignments.</td>
<td>I generally try to get assignments back on the next class period, and always within 1 week. It should be noted as well that students are also responsible to have their papers 'pre-edited' before submitting to me by two of their classmates within a 1 week time period.</td>
<td>Please note on syllabus course schedule the timeline for peer evaluation and the time between assignments.</td>
</tr>
</tbody>
</table>
Contents

Guide to Topics Covered viii
Preface xiii
1 What Is the Meaning of "Life"? 1
2 What Is Science? 24
3 How Does Science Explain the Natural World? 45
4 How Does Biology Explain the Living World? 64
5 Does Science Advance? 79
6 How Are the Life Sciences Structured? 107
7 "What?" Questions: The Study of Biodiversity 124
8 "How?" Questions: The Making of a New Individual 151
9 "Why?" Questions: The Evolution of Organisms 175
10 What Questions Does Ecology Ask? 207
11 Where Do Humans Fit into Evolution? 227
12 Can Evolution Account for Ethics? 248
Notes 273
Bibliography 293
Glossary 305
Acknowledgments 313
Index 315
Contents

Preface vii
I. Introduction: A Role for History 1
II. The Route to Normal Science 10
III. The Nature of Normal Science 23
IV. Normal Science as Puzzle-solving 35
V. The Priority of Paradigms 43
VI. Anomaly and the Emergence of Scientific Discoveries 52
VII. Crisis and the Emergence of Scientific Theories 66
VIII. The Response to Crisis 77
IX. The Nature and Necessity of Scientific Revolutions 92
X. Revolutions as Changes of World View 111
XI. The Invisibility of Revolutions 136
XII. The Resolutions of Revolutions 144
XIII. Progress through Revolutions 160
Postscript-1969 174
Index 211
# Contents

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The Politics of the Philosophy of Science</td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Philosophy of science as a political issue</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>The positivist strategy</td>
<td>3</td>
</tr>
<tr>
<td>1.3</td>
<td>Historically contingent methods and standards</td>
<td>6</td>
</tr>
<tr>
<td>1.4</td>
<td>The critique of pseudoscience</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>Against Universal Method</td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Introductory remarks</td>
<td>11</td>
</tr>
<tr>
<td>2.2</td>
<td>The appeal to human nature</td>
<td>12</td>
</tr>
<tr>
<td>2.3</td>
<td>The appeal to physics and its history: positivism and falsificationism</td>
<td>13</td>
</tr>
<tr>
<td>2.4</td>
<td>Variable methods and standards in physics</td>
<td>20</td>
</tr>
<tr>
<td>2.5</td>
<td>Note</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>The Aim of Science</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Introductory remarks</td>
<td>24</td>
</tr>
<tr>
<td>3.2</td>
<td>Science as a quest for generality</td>
<td>26</td>
</tr>
<tr>
<td>3.3</td>
<td>Early attempts to establish theoretical generalizations</td>
<td>29</td>
</tr>
<tr>
<td>3.4</td>
<td>Generality and experiment: Galileo</td>
<td>34</td>
</tr>
<tr>
<td>3.5</td>
<td>The substitution of growth for certainty</td>
<td>36</td>
</tr>
<tr>
<td>3.6</td>
<td>The aim of science</td>
<td>38</td>
</tr>
<tr>
<td>3.7</td>
<td>Notes</td>
<td>40</td>
</tr>
</tbody>
</table>

Preface xi
4 Observation Objectified
   4.1 Empiricist assumptions under attack 41
   4.2 The theory-dependence of observation 42
   4.3 Objective observation as a practical achievement 46
   4.4 The significance and problematic character of Galileo's telescopic data 50
   4.5 Galileo's observations of Jupiter's moons 54
   4.6 Planetary sizes as viewed through the telescope 56

5 Experiment
   5.1 The production and rejection of experimental results 61
   5.2 Implications for empiricism 66
   5.3 Implications for Popperian philosophy of science 67
   5.4 Defending experiment from sceptical attack 70
   5.5 The experimenter's regress 72

6 Science and the Sociology of Knowledge
   6.1 Sociology and scepticism about science 80
   6.2 The sociologists' inadequate portrayal of their opponents 82
   6.3 The social origins of scientific knowledge 86
   6.4 The inappropriate emphasis on belief 89
   6.5 Sociological explanation restricted to bad science 91

7 Two Sociological Case Studies
   7.1 Statistical theory and social interests 96
   7.2 Freudenthal's social explanation of Newton's *Principia* 104
   7.3 Concluding remarks 112
   7.4 Note 113

8 The Social and Political Dimension of Science
   8.1 Introductory remarks 115
   8.2 Objective opportunities and individual choice 116
   8.3 The politics of scientific practice 120
   8.4 Cutting science down to size 122
   8.5 Note 125