SOUTHEAST MISSOURI STATE UNIVERSITY

Department of Biology BI225

Research Methods in Biology New: Fall 1999

I. Catalog Description and Credit Hours: Scientific reasoning and its application to problem solving and discovery in biology, including biological literature searching and electronic information retrieval techniques. Two hours lecture, one two-hour laboratory. (3)

II. Interdisciplinary Nature of the Course: As a 200 level Living Systems course, no interdisciplinary component is required.

III. Prerequisite: BI190, CH185, MA134, BO200 – pre- or co-requisite.

IV. Purposes or Objectives of the Course: The purpose of the course is for students to:

A. Develop an understanding of what science is and what science is not. (US Objectives: 2, 4, 5, 7, 8, 9)

B. Develop an understanding of the development of scientific thought. (US Objectives: 4, 5, 7, 9)

C. Develop an understanding of the difference between science and technology. (US Objectives: 2, 4, 7, 9)

D. Develop an appreciation for the scientific method and its application. (US Objectives: 2, 3, 6, 7, 8, 9)

E. Gain experience at data collection, data analysis and formal report writing. (US Objectives: 2, 3, 7, 8, 9)

F. Develop an understanding of some basic simple statistical methods in data analysis. (US Objectives: 2, 8, 9)

G. Develop an appreciation of the relationship between scientific research and other means of knowing. (US Objectives: 6, 8)

H. Gain experience at co-operation and communication with other students and with faculty. (US Objectives: 2, 3, 5, 6, 7, 9)

I. Develop the ability to make informed, intelligent value judgments incorporating critical thinking and scientific reasoning. (US Objectives: 2, 3, 7, 9)

J. Develop skills at use of the library for seeking primary and secondary biological literature. (US Objectives: 1, 2, 4, 7, 8, 9)

K. Gain experience at the use of electronic information retrieval systems. (US Objectives: 1, 2, 7)

L. Gain experience at electronic communication with the world of biologists and the biological information systems available. (US Objectives: 2, 3, 7, 9)

V. Expectations of Students:

A. Students will work individually or in groups, as instructed and the situation dictates, participate actively in class and group discussions and exercises, complete all assignments, write acceptable reports, and pass quizzes and exams.

B. Each Laboratory contains a Preparation section with questions embedded in the text, students will read and complete the Preparation prior to coming to class (the text serving much as a Programmed Learning Guide). During class, this Preparation is reviewed, and students have the opportunity to modify their written answers (in the spirit of science as conjecture-refutation-modification.) This material is later collected for assessment.

C. During class, additional exercises occur during which students write responses to questions and material presented by the instructor. Alternatively, students may conduct individual or group activities requiring written responses. Many of these worksheets will be collected for assessment.

D. Students will also write two formal reports during the semester based on research projects that they conduct. The first of these is a Pass/Fail exercise to assure appropriate development of report-writing skills, while the second is based on the long-term project that student groups undertake.

VI. Course Content or Outline (Hours/Periods*):

A. Epistemology: How we know what we know: daring to be wrong; revising opinions; the consequences of error; fact, truth and reality; proof and the limitation of perceptions. – US Objectives 2, 3, 6, 7, 8, 9 - (4)

B. Science as the falsification of competing hypotheses. – US Objectives 2, 3, 6, 7, 8, 9 – (2)

C. Observation, generalization, inference, hypotheses, variables and graphing techniques. – US Objectives: 2, 3, 7, 8, 9 – (2)

D. Looking for patterns/generalizations; generalizations about cell types. – US Objectives 2, 3, 7, 8, 9 – (2)

E. Testing hypotheses with numerical data; variability, sampling, measures of central tendency. – US Objectives 2, 3, 7, 8, 9 – (2)

F. Deriving and testing hypotheses; use of controls; falsification or support; exercise and cardiac response. – US Objectives 2, 3, 7, 8, 9 – (6)

G. Statistical analysis, type I and II error, analysis of variance, experimental design, report-writing. – US Objectives 2, 3, 7, 8, 9 – (6)

H. Computer-assisted analysis of variance and regression using Statistical Analysis System. – US Objectives 2, 3, 7, 8, 9 – (2)

I. Library research as hypothesis testing; plagiarism; citation and documentation, audience adaptation. – US Objectives 1, 2, 6, 7, 9 – (2)

J. Subjectivity in science, analysis of written reports and published papers. – US Objectives 1, 2, 3, 6, 7, 9 – (2)

K. Mid-Term Exam (2)

L. The search for hypotheses; seed germination and plant growth. – US Objectives 2, 3, 7, 8, 9 – (2)

M. Primary and secondary literature; library organization. – US Objectives 1, 2, 6, 7, 9 – (2)

N. Development of Research Proposal – US Objectives 2, 3, 7, 9 – (2)

O. Biological Abstracts, Zoological Record and paper abstracting/indexing methods. – US Objectives 1, 2, 3 – (2)

P. Presentations of Research Proposals – US Objectives 2, 3, 7, 8, 9 – (2)

Q. Electronic information retrieval: Kent Library Databases; First Search, Medline, etc; Government Documents. – US Objectives 1, 2, 3, 7, 8, 9 – (2)

R. The internet as a research tool in biology. – US Objectives 1, 2, 3, 6, 7, 9 – (2)

S. Conduct of Research – US Objectives 1, 2, 3, 7, 8, 9 – (6)

T. History of scientific thought; the organization of science; scope and limitations of scientific methodology; Videos - "Backbone of Night", "Knowledge and Certainty", "Music of the Spheres". – US Objectives 2, 3, 4, 6, 7, 8, 9 – (4)

U. Models in scientific thought; fraud in science; pseudo-science. – US

Objectives 2, 3, 4, 5, 6, 7, 8, 9 – (2)

V. Responsibilities of scientists; biologists as advocates for a fragile planet. - US Objectives 2, 3, 4, 5, 6, 7, 8, 9 – (2)

W. Discussion of data analysis and reports. – US Objectives 1, 2, 3, 7, 8, 9 – (2)

X. Final Research Report presentations – US Objectives 2, 3, 7, 8, 9 – (2)

Total Hours = 64
Total Contact Hours = 64

* Laboratory class periods count 2 hours for 1 credit. The course will meet in two two-hour blocks. Half of the time is devoted to lecture/discussion/group activities, and half to laboratory research activities.

VII. Textbooks:

A. Ambrose, H.W. II, and Ambrose, K.P. Current edition, A Handbook of Biological Investigation, Hunter Textbooks, Inc., Knoxville, TN.

B. Laboratory Manual: Journet, A.R.P. current edition, Research Methods in Biology. Southeast Missouri State University, Cape Girardeau, MO.

VIII. Basis for Student Evaluation:

A. Mid-Term and Final Exams (40%)

B. Reports/Abstracts (25%)

C. Participation in Group Project (5%)

D. Worksheets/Assignments (30%)

E. Grading scale

1. A: 90 - 100%
2. B: 80 < 90%
3. C: 70 < 80%
4. D: 60< 70%
5. F: 00 < 60%

BI225 ACTIVITIES AND UNIVERSITY STUDIES OBJECTIVES

Objective 1: Demonstrate the ability to locate and gather information.

Emphasis: SIGNIFICANT

Content
Using materials developed by faculty in both the Department of Biology and Kent Library, classroom presentation and discussion of primary and secondary literature, library organization, biological abstracting and indexing materials, electronic information retrieval methods (Kent Library Databases, Agricola, Medline, etc.; Government Documents), accessing and using the internet. (Time allocation - 8 hours)

Teaching Strategies
These will involve classroom introductions and demonstrations of the techniques, incorporating hand-outs. Text readings where appropriate will also be employed. Much of this will be undertaken by library personnel in the library.

Students Assignments:
In connections with their developing research activities and involving other specific assignments where appropriate, students will be assigned exercises that require they use all the techniques introduced.

Evaluation of Student Performance
All student assignments will be graded for evidence of use, and the effectiveness with which they have used the techniques.

Objective 2: Demonstrate capabilities for critical thinking, reasoning and analyzing.

Emphasis: SIGNIFICANT

Content
As has been effectively argued in the literature in science education, the hypothetico-deductive process of scientific discovery is formal operational thinking. This course is designed to provide students with constant exposure to critical thinking through all of the activities they undertake; with 'open-book exams and quizzes, there is no memorization! The course requires student discussion of epistemology, concepts of proof, the scope and limitations of scientific discovery, the processes of observing, generalizing and drawing inferences, hypothesizing, testing hypotheses, the understanding and application of statistical techniques to analyze scientific data, experimental design, the analysis of written material and the development of their own research projects and research reports, library research as hypothesis testing, the application of information retrieval techniques. Throughout the discussion, the emphasis is on application, comprehension, analysis, synthesis and evaluation. (Time allocation - 30 class periods - 60 hours)

Teaching Strategies
These activities form the essence of the course, involving students in written preparation exercises that address these topics, followed by classroom discussion of each, and review of the written material. The laboratory course as a whole, each exercise, and the manual itself, have all been developed from the theoretical base of

Piagetian ideas regarding cognitive development, he consequent paradigm of constructivism, and the taxonomy of learning objectives developed by Bloom. As a result, the essential concrete operational limitations of students are recognized as a range of activities designed to address firstly the concrete and familiar, and then promote in them higher order critical thinking skills are employed. The principle is that students are involved in active and personal discovery leading often to disequilibration, followed by the construction of a new and (we hope) more sophisticated understanding and appreciation for the ideas central to the course.

Students Assignments:
Student preparation, class activities and homework assignments require that students read and explore in detail all of these ideas. The assignments are arranged in such a manner that students with limited critical thinking skills can, with time and a willingness to give some effort, develop their critical thinking skills.

Evaluation of Student Performance
Student written work is collected and graded on at least a weekly basis and evaluated for the effectiveness with which they have performed the preparation, or modified their views as a consequence of classroom discussion and exercises. All assignments and exams are open-book exercises requiring at a minimum the application of the ideas discussed, but focusing generally on comprehension, analysis, synthesis, and evaluation. The basis for evaluation of student written and oral work is more the justification for the idea presented than the idea itself.

Objective 3: Demonstrate effective communication skills.

Emphasis: SIGNIFICANT

Content
Students are advised on techniques for communicating in writing their answers to preparation questions. They are also required to spend approximately 50% of the class time on active and cooperative learning when they discuss in pair, small groups, or amongst the class as a whole, the ideas that form the basis of the course. During these discussions, techniques for communicating and clarifying ideas, and responding thoughtfully to the ideas of other students, are discussed and modeled by the instructor.

Instructions and discussion of formal writing exercises (research proposals and reports) before and while students undertake several of these activities.

Students are instructed on techniques for electronic communication through on-campus conference boards, internet newsgroups and electronic mail. Electronic student-student and student-faculty communications are encouraged.

Students give two formal class presentations, one of their research proposals, and one of their research reports which are accompanied by discussion of presentation techniques, audience adaptation and the use of visual aids.

Both oral and written guidelines are given for the formal communication activities.

Teaching Strategies
Teaching strategies for this objective are based on active learning. Through a combination of formal instruction followed by student exploration and practice, and then student and instructor feedback, the skills of students at communication are promoted. Instruction includes classroom presentation, discussion, preparation, and Appendices in the manual. In preparation for each class, students have assignments involving them in reading and writing answers to key questions from that reading. A significant amount (as much as 50%) of classroom time is spent on group and class discussion of ideas. Techniques that derive from the literature on active learning, cooperative learning groups, and learning cycles are used extensively.

Student Assignments:
Throughout the semester students have assignments that require they communicate with the instructor and with one another, both verbally and in writing. Written preparation is required for almost every class period, followed by review and modification of the written answers. In-class writes are common exercises to clarify ideas and form the basis for discussion. Two formal complete scientific reports are written, plus one research proposal, all of which have a write-rewrite component.

Evaluation of Student Performance
Student cooperation is evaluated during the conduct of their major research projects. Written proposals and reports are evaluated as are the presentations themselves, both by the instructor and other students. Electronic communication assignments are evaluated.

Objective 4: Demonstrate an understanding of human experiences and the ability to relate them to the present.

Emphasis: CONSIDERABLE

Content
The historical context of scientific thinking is addressed in a unit on the origin of scientific thought, the influence of the 'Dark Ages,' and the role of certainty in scientific thinking. Additionally, discussion of the Popperian view of science places this in some historical and philosophical context. Also, the review of library organization addresses the historical development of cataloguing techniques.

Teaching Strategies
Teaching strategies involve several videos with discussion sheets and discussions on the history of scientific reasoning from naturalistic or religious ideas through the current view. A lecture on library organization also occurs.

Students Assignments:
Students have reading assignments and worksheets to complete before and after the videos on the history of scientific reasoning.

Evaluation of Student Performance

BI225 Assignments and worksheets are collected for evaluation. Furthermore, all material covered may appear on exams.

Objective 5: Demonstrate an understanding of various cultures and their inter-relationships.

Emphasis: SOME

Content
In the unit on biologists as advocates for a fragile planet, a discussion of the role of indigenous peoples as stewards of their environment occurs. This also deals with population growth in different cultures, and the various problems associated with population regulation. A discussion of cultural biases in science occurs.

Teaching Strategies:
Teaching involves the use of films or other literature resources that address the environmental problems, accompanied by group and class discussion.

Students Assignments:
Written assignments and discussion are based on this topic.

Evaluation of Student Performance
Worksheets and assignments are evaluated. All material discussed and ideas presented and evaluated may be tested.

Objective 6: Demonstrate the ability to integrate the breadth and diversity of knowledge and experience.

Emphasis: SOME

Content
The implications of understanding the scope and limitations of science, and how the process of science relates to everyday methods of developing and evaluating opinions are discussed frequently. In the section of epistemology, scientific knowledge and discovery are compared with methods in other disciplines. The role of science and the implications of understanding the scientific method in the development of public and political opinion are discussed.

Teaching Strategies
These ideas are introduced through preparation questions in the laboratory manual worksheets, reviewed in group and classroom discussion.

Students Assignments:
In-class and homework assignments are based on the preparation and class discussion.

Evaluation of Student Performance

All student worksheets and assignments are graded. All material may appear on exams.

Objective 7: Demonstrate the ability to make informed, intelligent value decisions.

Emphasis: SIGNIFICANT

Content

The entire justification for teaching students how the process of science is undertaken, and what constitute its scope and limitations, is so that students can make intelligent decisions about the nature of scientific evidence, and the commentaries of politicians and political commentators regarding 'proof' in science. Furthermore, since scientific hypothetico-deductive reasoning has been described as exactly identical to formal operational reasoning (sensu Piaget), teaching this analytical method of reasoning IS teaching how to identify assumptions, sort and evaluate the evidence that leads to making decisions and developing values. All examples of scientific reasoning, from observation through generalization, hypothesis development and testing, inference drawing and analysis are presented in relation to everyday experiences and problems that students might experience, as humans or as consumers. As a course in scientific process and reasoning, this is a course in developing the ability to make informed intelligent value decisions.

Teaching Strategies:

The basic teaching techniques employed throughout the course involve students in written preparation, group and classroom discussion and review of their answers and ideas. Questions relating scientific reasoning to everyday thinking are scattered throughout the course in almost every activity. In the discussion of scientific thinking, the balance between subjectivity and objective is constantly discussed, while an extensive student centered discussion of quality in hypothesis development illustrates different values that are brought to scientific reasoning and evaluation.

Students Assignments:

Students are assigned preparation activities, engage in class discussion, and review their answers. Many specific questions address decision-making processes and valuing.

Evaluation of Student Performance

All worksheets and assignments are evaluated, as are the formal reports and abstracts. All ideas discussed may appear on tests. The focus of this course is less on 'right' versus 'wrong' answers than the means by which answers are developed, and the justification that is offered in support of answers.

Objective 8: Demonstrate the ability to make informed, sensitive aesthetic responses.

Emphasis: SOME

Content:
There is an aesthetic value to reasoned analysis. The emphasis in this course is on scientific reasoning, the process of conjecture and refutation as a powerful tool for viewing the universe. It is the intent of the course to convey to students not merely the process, but also the value and beauty inherent in logical thought for its own sake.

Teaching Strategies:
The practice of conjecture and refutation is the heart of the course, since student practice throughout the semester the process of 'daring to be wrong' and then testing the opinion that they dared to have.

Students Assignments:
Preparations, classroom discussion, and practical exercises conducted in and out of class require that students practice this skill.

Evaluation of Student Performance
All student preparation exercises, worksheets and assignments are evaluated.

Objective 9: Demonstrate the ability to function responsibly in one's natural, social and political environment.

Emphasis SIGNIFICANT

Content:
The ability to understand the process, scope and limitations of scientific thought and investigation is crucial to making social and political decision's in today's world. Since the process of conjecture and refutation is at the heart of problem-solving in all areas of human endeavor, the analytical skills addressed in these courses are essential to functioning responsibly in the environment. The discussion of the role of biologists as stewards of the biological world focuses attention on this particular social and political issue.

Teaching Strategies:
Throughout the course preparation questions and classroom discussions are designed to focus student attention on the socio-political significance of understanding how to think scientifically, and how to evaluate the scientific pronouncements and criticisms of others.

Students Assignments:
In addition to the preparation and classroom discussion, several exercises pose students with hypothetical or historically real situations in which they have to apply their scientific skills in the application of appropriate scientific reasoning, or the evaluation of the scientific reasoning of others.

Evaluation of Student Performance
All students' preparation, worksheets and assignments are evaluated, and all topics may appear on tests.