A PROBLEM-BASED COURSE FOR GRADE 13 BIOLOGY

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FOR

GRADE 13 BIOLOGY

By

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ABSTRACT

The students of the Self-Reliant Learning Program of the Halton Board of Education participate in an alternative secondary school program. They work on individualized, student-centered programs and proceed at a self-determined rate. The students range in age from 17 to 70 years, have a greater sense of their educational needs and direction and may bring to the classroom wider experiences than the students of a regular secondary school.

A problem-based course has been developed to assist the students in developing skills for dealing with problems while gaining knowledge of biology.

The limited field testing that has been carried out indicates that the students in the course are improving their organizational and problem-solving skills and showing improved understanding of biological concepts.

The educational rationale and an evaluation of the program are presented along with the materials comprising the seven units of the course.

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CHAPTER 1

THE SELF-RELIANT LEARNING PROGRAM

The Self-Reliant Learning Program of the Halton Board of Education was established in September, 1983 as a senior secondary school alternative. The program was designed to provide general and advanced level courses in grades eleven, twelve and thirteen, to students unable or unwilling to attend regular day or night schools. Originally, three staff members were selected to provide courses in Mathematics, Science and English to approximately sixty students. It was anticipated that the majority of the students would be of senior high school age (17 to 20) with a few older students also attending. The program would differ from the regular school in that no formal classes would be held; instead, students would schedule appointments with their instructors at least once a week. During these appointments, completed work would be evaluated, difficulties discussed and new work assigned. The student would then be free to complete the work in a place and at a rate which he would determine for himself. Such a program would allow maximum flexibility in rates of progress and scheduling of school time around full or part-time work or other commitments.

The demand for this type of educational alternative was underestimated. In the first year of operation, enrolment rose to 120 students by the end of September, and additional instructors were added. More staff allowed an increase in the numbers and types of courses offered. Although the emphasis remained on the core area subjects, over forty different courses were offered in the areas of Mathematics, Science, Arts, Communications and Social Science. It was at this time that I joined the program in October, 1983 with the responsibility of offering courses in Biology and Mathematics.

During the ensuing years of operation the program has evolved considerably as the result of our experiences with the students and changes made in the Ontario Ministry of Education funding policies for secondary alternative programs. In its present form, resulting from a reorganization implemented in September of 1985, the Self-Reliant Learning Program continues to offer courses to students who are able to determine their own timetable, but each student is now required to spend five and one-half hours per week in a supervised classroom study environment for each course taken. Students schedule their in-class time which is spent working through course material, laboratory activities and discussing the work completed with the instructor. As a result, appointments are no longer made, but each student makes up a weekly timetable that best fulfills her needs and meets the minimum time requirement. The school day has been extended to allow more flexibility in timetabling.

Such individualized timetabling allows a student to take courses while working full or part-time, participating in athletic training or even attending another secondary school within the county. The flexibility of the program has been attractive to many older members of the community who wish to return to school and has resulted in about fifty percent of the total enrolment being twenty years of age or older. (Table I)

TABLE I: DISTRIBUTION OF STUDENTS BY AGE

As of February 12, 1986

Age	Number
19 and under	122
20-24	61
25-29	18
30-34	16
35-39	7
40 and over	17
Total	241

In this third year of operation, we are able to identify five distinct groups of students who participate in the program.

1. Students of above average abilities who find the rate of progress of an average classroom plodding, dull and lacking in challenge.
2. Students who are heavily involved in extra-curricular activities unrelated to school in the areas of art, music and athletics. The time committed to these activities prevents them from attending a regular secondary school.
3. Young mothers who had withdrawn from school before completing their education and are unable to attend regular classes due to the demands of their families and/or employment.
4. Adults who have found that they must complete their secondary education in order to advance in their occupations or make career changes.
5. Students who are enrolled in a regular secondary school but take a portion of their program with the Self-Reliant Learning Program due to problems with scheduling, or who need a course unavailable in their home school.

The students of the program are a special group, not only in the differences in age distribution from a regular school, but in their approach to the subject studied. Even if they are attending a regular school and are of usual age for a secondary student, each has made a decision to seek out an educational alternative to satisfy an identified need.

The greater motivation that each student has is characterized by a desire to master the course material. Few are satisfied simply to earn a credit; each wishes to learn all he can about the topic being studied and is not satisfied until he feels completely comfortable with all aspects of the topic. Many are able to extend the knowledge beyond the classroom due to their greater experience, and are able to bring more knowledge to the classroom. However, the students who have been away from school for a number of years must readjust and once again learn how to learn and develop self-confidence in their ability to learn.

I joined this program after having taught Biology and Mathematics for eight years in a traditional secondary school. As a result of my observations, made during the first two years of operation, of the different types of teaching and learning occurring within this environment and with this group of students I decided that an approach to the teaching of grade thirteen Biology that made best use of the different educational climate was needed.

The remainder describes a problem-based course in Biology for use by the students of the Self-Reliant Learning Program. A brief rationale for problem-based learning and a description of how this method can be adapted for these students are given. The Biology course which I have designed along with the teaching materials to be given to the students is presented.

CHAPTER 2

PROBLEM-BASED LEARNING

Problem-based learning has been used as an instructional technique by the Faculty of Medicine, McMaster University since its inception. In this chapter, I will examine some of the literature that describes the application of problem-based learning at McMaster University and discuss how this approach can be adapted for use at the secondary school level.

Problem-based learning provides an alternative approach to the conventional presentation of material. The goals include learning how to find and evaluate information relevant to a problem and correlate the information in forming a proposed solution. The students become familiar with a wide variety of resources and are encouraged to stress relationships rather than facts. Courses emphasizing content have often been found to result in students being unable to generalize and being unable to use the knowledge gained (Schmidt,1983). A student who is able to do this will have gained problem solving skills independently of the course. Learning these skills will now become a part of the objectives of the course.

The problem-based approach to learning assumes that the student is a responsible, motivated adult (Barrows,1980).

This is necessary as the student must assume greater responsibility for learning than students with traditional classroom instruction. Each must determine the depth and breadth of study needed with few guidelines and must be able to cope with the frustrations that may result when confronted with a problem that appears to be insoluble. The student must be helped to realize that he is learning more than the content of the course and be able to see that his skills in information gathering and analysis improve with practice. Each student must be able to see that problem-solving can begin before the specific information is acquired as information gathering is part of the solution.

Learning from tackling problems will not be a new experience for students, but will be a new and formal application of their daily experience. Schmidt (1983) describes seven steps in problem-based learning that form a model for student progress:

1. Clarify terms and concepts not readily comprehensible.
2. Define the problem.
3. Analyze the problem.
4. Draw a systematic inventory of the explanations inferred from step 3.
5. Formulate learning objectives.
6. Collect additional information from outisde the group.
7. Synthesize and test newly acquired information.

A distinction must be made between problem-based learning and problem solving as it might be assumed that these are inextricably linked, but this is not so. Problem-based learning can occur without the solution of the problem. Similarly, problem solving occurs in many circumstances, not just those of a problem-based course.

Engel (1981) describes problem solving as "an intellectual approach to making decisions in the face of a situation in which the nature and interplay of its components are not immediately obvious." Problem solving is not subject specific. Once learned, its techniques may be applied to a wide variety of situations; part of its value lies in this generalization. A body of knowledge is necessary for the application of problem solving, but the general principle can be applied in many disciplines. Problem solving can be a goal in itself as well as a way of getting at the content of a course.

Engel goes on to define problem-based learning as the "process of acquiring understanding, knowledge, skills and attitudes in the context of an unfamiliar situation, and applying such learning to that situation". This does not require that the problem be solved. The problem is the focus for the study of the subject and serves, as well, to integrate the information. The problem also helps to make the learning relevant and the solution, (if one is possible), provides in itself a reward for learning.

It is not clear whether problem-solving can be taught, but what is clear is that different learning outcomes may result from different instructional methods (Schmidt,1983). Therefore, a course which emphasizes the unifying concepts of a discipline as well as the specific content is more likely to result in the student having a greater understanding of these concepts.

The application of problem-based learning to a secondary school Biology course - specifically a course to be offered by the Self-Reliant Learning Program, must result in a course that is substantially different from course offerings at McMaster Medical School in more than just content. For one thing, the emphasis at McMaster University is on group work. Each member of the group researching and contributing to the solution of a common problem that has been reduced to its components. In comparison, the students of the Self-Reliant Learning Program work alone as timetabling group time is often impossible.

The McMaster students participate in a student-centered program. Barrows (1980) describes a student-centered course as one in which the students determine the content of the course, with direction from the instructor, and identify the problem itself from their observations on a simulated or real patient or a "problem box" containing the information relevant to a patient's medical problem. This degree of freedom of choice is not practical in a secondary school, partly due to the restrictions of the Ontario Ministry of Education guidelines for courses and also due to the level of study. A secondary school student working alone requires more guidance in determining the content of a course and the task must be reduced to take into consideration the length of time the student has to complete the course.

A third difference results from the need for the medical students to solve the problem. The disease or condition must be diagnosed and treated, the patient must be cured. Such urgency is not felt by the grade thirteen Biology student and many problems to be studied cannot be actually solved by them. However, the high school student can formulate an hypothesis proposing a possible solution. Problem-based learning can be adapted to this setting. A problem can be used as the focus for the study of a unit or material, be examined and a solution proposed, even if the solution cannot be attained. A problem-based course can allow the fulfillment of the learning goals of a secondary school course in teaching a student to gather, evaluate and apply knowledge to new situations.

CHAPTER 3

PROBLEM-BASED LEARNING IN GRADE 13 BIOLOGY

This present revision of the grade 13 biology course has occurred at this time for two principal reasons:

1. My dissatisfaction with the course that was in use, and
2. the implementation in 1988 of the Ontario Schools -- Intermediate and Senior (O.S.I.S.) revised guidelines for senior Biology.

During the eight years that I taught Biology in the traditional secondary school, I made many attempts to improve the quality of the course offered through many modifications. However, due to the limitations of class size and the restrictions of the required curriculum, the course was teacher-centered with little involvement of the student in the learning process other than being recipients of facts delivered largely through lectures with few laboratory activities.

The course which I offered through the first two years at the Self-Reliant Learning Program was based on an Ontario Ministry of Education correspondence course which I modified to be consistent with the Halton Board of Education core program. Students read specified sections of a textbook and accompanying study notes, then answered questions based on the material. Little laboratory experience was included. Although this course was adequate in the sense that the students acquired the basic factual knowledge, I recognized several shortcomings.

1. The students had difficulty in understanding the relationships between the facts or applying the facts to new situations.
2. The course did not increase students' curiosity or interest in Biology as they did not tend to look beyond the textbook for additional knowledge.
3. There was poor communication between the students and myself as the course was so tightly constructed that all of the answers to their questions were provided and there was no need to involve the instructor in the learning process.
4. The course did not challenge the students or help them to learn how to learn.

I decided that a new course with a different approach was necessary. The problem-based model was selected as it appeared to allow the development of a course that would meet the needs of the students, eliminate the shortcomings of the previous course, and meet my need to present a course that is interesting and challenging. Although the revised O.S.I.S. guideline for senior Biology will not be implemented until the fall of 1988, I decided to design a new course based on the validation draft of this guideline.

In comparison with the previous guideline (High Schools 1,1960) the new guideline is much more proscriptive. Not only is the content specified, but certain mandatory activities are listed. Certain attitudes and skills must be taught and the applications and societal implications of each topic considered. Consequently, increased involvement of the teacher is required as it is difficult to teach attitudes through written materials.

As well as the student learning new skills, the instructor must assume a different role. The teacher must become a resource for the student as he approaches each problem. The instructor should guide the student in the search for facts bearing on the problem and may also provide facts when requested. Providing information too readily will not encourage the student to use other references, while not providing enough may cause the student to become frustrated. I have found that the most useful role for the instructor is to help the students evaluate the quality of the information gathered, identify areas where more knowledge is needed, help the students understand the information they have gathered; specific information is provided only after the student has determined what information is needed.

The instructor must encourage, reward, reinforce and shape the student's responses. This can only occur if adequate time is available for discussion as the student progresses though each unit. The rewards for the teacher are potentially as great as for the student.

The implementation of a problem-based course should have additional benefits as well as alleviating the listed shortcomings of the previous course. Such a course should result in the student having improved motivation, better retention, and the development of the "learning habit"--learning for personal gain rather than rewards such as exams and other formal evaluation. As well, many of the students taking this senior course in Biology intend to pursue a career in the health sciences, and an increasing number of colleges and universities are using problem-based courses in this discipline.

CHAPTER 4
THE COURSE

THE COURSE ORGANIZATION

The course presented is based on the validation draft of the Ontario Schools - Intermediate and Senior (O.S.I.S.) guidelines for the Ontario Academic Credit (OAC) in Biology, distributed in September, 1984. The course requires that seven units be studied, six are compulsory core units and the seventh is optional in content. The units are:

CORE

1. The Chemical Basis of Life
2. The Metabolism of Cells
3. Plant Physiology
4. Genetics
5. Evolution
6. Invertebrate Physiology

OPTIONAL

1. Microbiology
2. Animal Behaviour
3. Ecology
4. Local Unit

Ecology was chosen as the optional topic for several reasons. The content for this unit is specified in more general terms than that of the other optional choices. With this unit's placement at the end of the course, the student will have the opportunity to select his own problem within the area of study and decide how it should be approached. This is consistent with the general plan of the course which is to provide specific guidance initially, then reduce the amount of direction given as the student progresses. A unit in ecology also provides an opportunity for the student to design and carry out a field study.

Each unit has approximately equal weighting and is designed to be completed in about 16 hours of classroom time. In a semestered program, this allows the student three weeks of time to complete each unit. Most find that this time is insufficient to do all of the work required and either schedule additional time or work at home. The in-school time is used to complete activities and to use the resource material available.

Organization of a Unit

Each unit is organized with 1) an introduction briefly describing the area of study; 2) the problem; 3) a description of the background knowledge that is necessary directs the student to specific facts from chemistry or a previous unit that should be reviewed; 4) a list of primary, secondary and tertiary resources. Primary resources are readings from the textbook to provide the facts relevant to the problem. Secondary resources give additional information presented in an alternative format to assist the understanding of the content. The tertiary resources are intended as enrichment material for the student wishing to go beyond the requirements of the course; 5) the activity list specifies the required activities to be completed and, finally, 6) a list of content objectives as a checklist of content for which the student will be responsible.

As the course progresses, the amount of guidance provided by the unit outline diminishes. The students will determine which resources are relevant, what background knowledge is required and design some of their own activities. As part of the first unit, a strategy for attacking the problem is outlined. It is emphasized that this is just a suggested strategy, and the students are free to alter the approach to suit their own learning styles. Figure I illustrates the suggested approach.

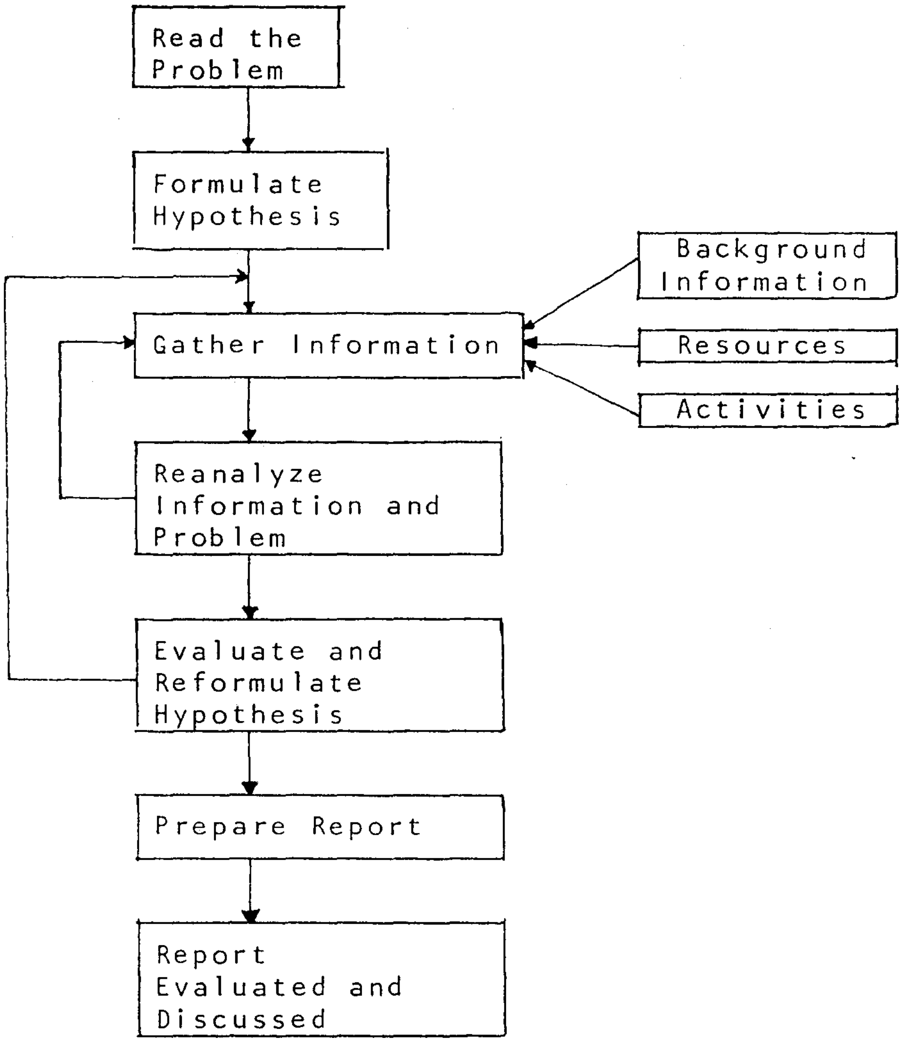


Figure 1: Flowchart for Problem-Based Learning

The proposed solution to the problem is presented in the form of a report. A written, essay-style report is acceptable but the students are required to be creative and may choose instead to design and carry out a series of experiments, produce a model, prepare a videotape or use any other form they wish, with the instructor's permission. The report is graded for content, appropriateness, logic and creativity.

EVALUATION

1. The Report

The reports presented by the students comprise forty percent of the total evaluation for the course.

2. Unit Tests

A unit test is part of the summative evaluation of each unit. The students are encouraged to use the list of content objectives as a checklist for the test. As a final exam is a requirement of all courses of the Self-Reliant Learning Program, the unit test is provided partly as an experience to help the student prepare for the exam. Many of the students experience a high level of test and exam anxiety due to their high expectations, lack of continuity in their education, and/or previous lack of success. The content list appears to help them deal with this anxiety as well as the weakness of problem-based learning regarding the preparation of students for content-oriented exams. The unit tests comprise thirty percent of the total evaluation.

3. The Final Exam

The exam is structured to allow the evaluation of both the factual knowledge gained and the student's ability to deal with problems. Forty percent of the exam consists of multiple choice questions to quickly evaluate specific knowledge. The remaining sixty percent is given to essay style questions. In order that the student can demonstrate his ability to determine what information is relevant to a problem, and organize that information, a list of possible exam questions is given to him two days in advance of the exam. The exam makes up the final thirty percent of the evaluation.

CHAPTER 5

AN EVALUATION OF THE COURSE

The new problem-based course was implemented in September, 1985. Two students who began working on the course then are now nearing completion. Eight additional students have started since January, 1986. This field-testing has given me the opportunity to carry out an evaluation of the course in two ways. 1) An informal evaluation through discussions with the students and my observations of their progress and, 2) a formal evaluation through the use of a course evaluation questionnaire.

Informal Evaluation

With only two students enrolled in the course through the fall of 1985, I have been able to discuss the course with the students as they progress through each unit. Observations of the students who started more recently have tended to validate the observations made on the first two students.

When the students are introduced to the course in an initial interview with me, most are apprehensive when the problem-based nature of the course is explained. This apprehension seems to be caused by a fear of an unknown, to them, learning method. The magnitude of the task at hand and ignorance of the expectations of the instructor also appear to contribute to this apprehension. However, when the rationale for the problem-based approach is explained, the apprehension diminishes and is frequently replaced with enthusiasm as they recognize the challenge that is presented and the value of the approach. When the structure of the first unit is examined, the students are reassured when they realize that fairly specific directions are given as part of the unit and are not concerned when I explain that the amount of guidance diminishes as they become more adept at information gathering.

In beginning the first unit, students usually are unsure of the expectations of the instructor for the report, when they should do the activities and how to go about gathering the information. A short discussion with the instructor usually settles the confusion. In the first few units the instructor must try to objserve the student's progress, without intruding, in order to be of assistance in helping the students determine when the activities should be scheduled.

The students will be concerned initially by an apparent slow rate of progress. Extra time should be allowed for the first units as some time is spent in defining the task and developing an organized approach to it. It should also be pointed out to the students that as well as learning the content of the first unit, they are having to develop some problem-solving skills and this will slow them initially but their rate of progress will improve in successive units. It appears to reassure the student if it is explained to them that the initial slowness is common to most of the other courses offered by the Self-Reliant Learning Program.

The instructor must be ready to deal with the frustration the students may feel. Frustration from not progressing as rapidly as desired, from the magnitude of the problem and its lack of solution, from difficulty in understanding some of the complex content of the course and frustration with the instructor may all occur.

The instructor, in appearing to avoid giving a "straight" answer when questionned about a problem, can be a major source of frustration to the student and could lead to their withdrawing from the course if the frustration is not recognized. It is something that must be considered when the instructor meets with the student. It is helpful to the student if the reasons for the instructor's apparent evasiveness are explained, not only at the outset, but whenever the student appears to be frustrated by the answer received.

The students are also frustrated by their own feelings of lack of progress. Even after successfully completing several problems they may feel that they have not made any improvements either in the knowledge or skills gained. The knowledge achieved can be measured by tests and the results of these can be an encouragement to the student, but their improved skills in dealing with problems are not as easily measured and it is very important that the instructor provide an informal evaluation of this skill development as the student progresses.

The fact that the problem is not actually solved by the student but only an hypothesis proposed can be frustrating. The students would like to know what the "right answer" is and may not be satisfied by the explanation that a right answer may not exist, or lies beyond their level of expertise.

However, in spite of these frustrations, most students appear to enjoy the challenge of the course and are pleased with their progress at the completion of each unit. It is important to point out to them the gains that they have made in improving their approach to a problem and acquiring of knowledge as a result of completing the unit.

From my observation of the way in which successive units are approached, the students are showing considerable improvements in their ability to deal with problems. The identification of the necessary information and its collection become much easier. The students become much more adept at determining the relationships within the information. Their ability to apply the facts collected in a unit to a new problem presented on a test produces much more complete answers than those that were written by students taking the previous course. Questions that require the recall of facts are also done well, indicating that both the problem-based and knowledge objectives of the course are being met.

As their instructor, I am very pleased with each student's progress and reactions to the challenges of the problem-based course. My own role has developed, as I had anticipated, to allow me to participate in the learning process with each student.

Formal Evaluation

The two students that started the course in September, 1985 have each completed the following course evaluation. The other students will be asked to complete it as they finish the course.

BIOLOGY SBI5A1 COURSE EVALUATION

1. Date course started ______________________

   Units completed ______________________

2. How many hours does it take to complete each unit? ________

3. Do the unit outlines give enough help in location information? ______________________

4. How would you rate the textbook? (cirlce one)

   poor fair good very good excellent

5. What are the weaknesses of the textbook?

   ____

   What are its strengths?

   ____

6. How do you rate the secondary resources?

   poor fair good very good excellent

7. What additional resource material have you found helpful?

   ____

8. Have you used any of the tertiary resources? __________

   If yes, which ones? ______________________

9. Do the activities help you solve the problem? __________

10. How could the activities be improved? ______________________

    ____

!!. How did you rate your problem-solving skills before taking the course? poor fair good very good excellent

12. How do you rate your problem-solving skills now?

    poor fair good very good excellent

13. What aspects of the course did you like best?

____

14. What aspects of the course did you least like?

____

15. What changes would you make to the course?

____

The students' responses on the evaluation forms tend to confirm my observations. The time taken to complete each unit was somewhat longer than the three weeks anticipated. However, both of the students are adults with many commitments outside the school which tend to slow their progress. Both felt that some improvements in the choice of textbook could be made as they found the reading level high and had difficulty understanding the explanations of some of the complex relationships. Each found the secondary resource material helpful. They each used some of the tertiary resources and felt that the activities helped in the solution of the problems. One commented that she would like additional activities and audio-visual resources and less reading. Both indicated that they felt that their problem-solving skills have improved.

In discussing the evaluation the students each felt pleased with her progress in the course but commented on the amount and difficulty of the work required.

CHAPTER 6

THE FUTURE

Changes Planned

The course presented here is not in its final form. The general format of the course will not be changed but certain detailed changes will be made, some planned at this point, others that will be made as the need becomes apparent. The changes planned at this time include increasing the quantity and range of secondary and tertiary resources. The tertiary resources now consist largely of reprints from Scientific American and many of these articles go beyond the depth needed by the average grade 13 student. More articles and books suitable to the interests and abilities of this group of students are needed. In addition, it would be desirable to include some audio-visual resources such as videotapes illustrating some of the major concepts and possibly slide-tape tutorials covering some topics such as aerobic respiration and photosynthesis which have been shown by previous experience to cause difficulty for most students.

A review of the textbook in use is also planned. The course utilizes the fourth edition of J. W. Kimball's "Biology" and a fifth edition is now available. (The fourth edition is used as many students already have copies of this text when they enrol in the course.) Other appropriate texts are available and will be examined as possible replacements or as additional secondary resources.

Another major, planned change is to increase the degree of choice in the course. At present each unit has a single, required problem. The desirable change would be to provide a choice of problems for each unit including, perhaps, an option in which the student may determine their own problem with the approval of the instructor. As well, the seventh unit, Ecology, could be made one of four choices, the others being microbiology, animal behaviour, and a unit in which the student could determine the area of study as well as the problem. Changes of this nature would not occur before the fall of 1988.

A more comprehensive student evaluation of this course will be carried out as more students participate. Each unit will be evaluated individually and changes will be made as weaknesses show up.

A progress inventory will become part of the evaluation of each student's progress in the course. This will examine the individual skills that are components of the study of a problem and the students will be asked to rate themselves on each of these skills. This may assist the students in seeing their progress in this area and may help alleviate their feelings of frustration.

Further Applications of Problem-Based Learning in Secondary Schools:

The O.S.I.S. guidelines require that there will be a prerequisite course for the Ontario Academic Credit Biology course to be given at the grade eleven level. This course will be added to the Self-Reliant Learning Program. The organization of that course could also be problem-based as the students enrolling in that course will have similar backgrounds and goals.

A problem-based course could not be readily adapted for use in the regular secondary schools as many reasons prevent this, particularly the problem presented by the number of students in each class. In a regular secondary school, a senior biology class consists of between twenty-five and thirty-four students. With just five periods of seventy minutes per week, there would not be sufficient time available for the teacher to work as closely as is needed with each individual student. In addition, a problem-based course is designed for the self-sufficient student, and while many of the students found in a regular school fit this criterion, many do not. Problems would also result from the strict timeline that is imposed by a regular school and difficulties would arise when students were unable to complete the course in the time allowed. In an alternate school, this problem can be anticipated and extra time scheduled. Problems would also result from the heavy demand for resources, if students required the same materials at approximately the same time.

However, elements of the problem-based approach could be applied. A problem-based unit could be a part of the course as an introduction to the method. To avoid the pressure on resources, different problems could be available or students could be organized to work in groups. Concepts that have shown themselves in the past to be difficult could be presented by the teacher in a lecture to prevent the students' progress being slowed. The students could be required to prepare a day-to-day timetable describing the achievement required in order to be able to complete the problem in the time given, and some leeway could be given for the students to complete the problem in their own time after the allowed time has expired. The approach could be successful in a limited application by a creative teacher.

A problem-based course could also be used as an alternative in a regular school for a very small number of students who might be better served by this approach. For example, a disabled student who finds it difficult to attend regular classes or the student who is bored by the lack of challenge found in a regular approach could be timetabled outside the scheduled class time.

CHAPTER 7

THE COURSE OUTLINE

The following sections present the actual material given to the students as they work through the course. They begin with the course outlines which describes the organization of the course, some of the rationale, the evaluation and the suggested timing. Following this are the outlines for the seven units which include the problems, resources, objectives and a list of activities.

SELF-RELIANT LEARNING PROGRAM - BIOLOGY COURSE OUTLINE

INTRODUCTION

This course is designed primarily for students intending to continue in a life sciences program at college or university. The course examines the major concepts of the science of life and will introduce you to the study of physiology and biochemistry. It is important that you have a reasonable background in chemistry, and must have completed SCH4A1, Grade 12 chemistry.

The design of the course is such that you will be asked to investigate seven major problems in biology. In doing so, you will not only gain factual knowledge, but will gain expertise in the process of scientific investigation of a problem. You will be provided with a resouce list for each problem, a list of experiments to be completed, a suggested strategy for approaching the problem and a set of objectives which will outline the facts and concepts with which you will need to become familiar.

After completing this course you should be able to:

1. analyze a problem
2. determine what knowledge you already have that relates to a problem.
3. formulate an hypothesis relating to the possible solution of a problem.

4. determine what knowledge is necessary to support your hypothesis.
5. collect and evaluate information.
6. design and carry out experiments.
7. organize your information to support your hypothesis and prepare a report.

Seminar, tutorial and activity sessions will be held when appropriate.

TOPIC OUTLINE

Unit	Title
1	The Chemical Basis of Life
2	Metabolism of Cells
3	Plant Physiology
4	Genetics
5	Evolution
6	Vertebrate Physiology
7	Ecology

EVALUATION

You will be required to prepare a report upon completing each unit, and will write a test on that unit. Each report must be completed to the satisfaction of the instructor before you take the unit test. In addition, there will be a final exam of 3h in length which will cover the content of the entire course. Your final mark will be determined as follows:

Unit reports	40%
Unit tests	30%
Final Exam	30%

TIMING

The course is designed to be completed in one semester (5 months). Each unit should be completed in approximately three weeks, requiring about 16h of in-school time (additional research time may be required). If you wish, you can complete the work at a faster or slower pace.

TEXT

Biology by John W. Kimball (4th Edition) will be the primary resource and should be purchased. Other texts will be used as reference materials and may be borrowed.

SBI5A1 Unit 1 The Chemical Basis of Life

1. INTRODUCTION

Much of this course deals with the chemical nature of living systems. In this unit, you will be introduced to the major biological molecules: carbohydrates, fats, proteins and nucleic acids. You will learn how they are constructed, react with other molecules and are identified. This will provide you with the basis for Unit 2, where we will see how these compounds are the building blocks of living cells.

2. STRATEGY

As the structure of this course is quite different from that of most courses you will have completed, some explanation of how to proceed is necessary. In order to solve the problem presented in the unit you must become something of an expert. The course does not require that you read certain sections of a book and then answer a number of questions but, rather, asks you to examine a number of sources and gather information that you are going to use to solve one large problem. Here are some steps that you may wish to follow in order to achieve that result. Of course, you are free to approach the problem in any way you wish.

i) Read the problem. A solution will not be immediately apparent, but keep the problem in the back of your mind as you proceed through the next steps.

ii) Make an inventory of knowledge that you have that may help you with the problem. Try to think of what you will need to learn in order to be able to understand the problem and a possible solution. Examine the list of terms and concepts listed as background knowledge. If you are unfamiliar with any of these, take some time to investigate each, using the source materials listed. You must be comfortable with the background material before proceeding.

iii) Examine the resource list. I suggest that you examine the primary resources very carefully. Read the indicated sections of the books carefully. You may find it helpful to take notes as you work through these sources, much as you would in attending classes in a traditional school. The secondary sources are optional and are suggested as additional material to further explain and support the concepts presented by the primary resource list. The tertiary resources are suggested to you as an extension beyond the strict requirements of the course, but may be investigated if you are particularly interested in the topic, or just wish to extend your knowledge. Don't forget that your instructor is available as a resource in all three of the categories.

iv) Complete the required activities. You may choose to do the experiments as you work your way through the resources or save them up until you have completed your research. You must make an appointment with your instructor to do the activities and have them checked off as completed.

v) Check the test objectives. These can be used as a checklist of the facts you should know. Check it now to see if your research has been complete.

vi) Prepare your report. You may find that as you work on your report that additional problems arise and more information is necessary. Stop and collect this information before continuing. Your report can take any form. You could write an essay, construct a model, make an audio or videotape or movie, design and carry out a set of experiments, make a presentation to the other students enrolled in the course or present the solution to the problem in any form you wish. BUT, before starting work, you must discuss the nature of your report with the instructor and receive permission to proceed.

vii) Submit your report. Your report must be satisfactorily completed before you proceed. While it is being marked, go back to your test objectives to prepare for the test. The evaluation of your report will be discussed with you before you do the test, and any questions you have regarding the objectives will be answered then.

viii) Do the test. The test questions will be based on the objectives given to you and may not include all of the work that you have done in solving the problem, but may include material not related to the problem.

3. PROBLEM 1

As a research director of the biochemical division of a large drug manufacturing company, you have been presented with the following situation. A local surgeon has contacted you to ask your assistance in managing a patient. The patient has had surgical repairs to his small intestine and must not eat for an extended period of time. The surgeon asks you to assist him in designing a diet for this patient which can be administered intravenously; that is, directly into the bloodstream, bypassing the normal digestive mechanism. As the substances that are to be administered in this fashion must be simple molecules rather than the complex ones normally found in food, the design of this diet is quite complex. Your task is to determine the constituents of this diet, in terms of the specific molecules that must be included, and explain what will be the fate of each once it has entered the patient's body. Don't forget to consider the effect the solution may have on the homeostatic environment of the patient's body.

4. BACKGROUND KNOWLEDGE

As this unit leans heavily on knowledge of chemistry, it may be necessary for you to review your grade 12 chemistry text in order to familiarize yourself with the following terms and concepts.

a) atom, ion, molecule, crystal, polar molecule, hydrogen bonding, covalent bonding and isomers

b) neutralization and oxidation/reduction

c) energy and electron flow in reactions

d) the 1st and 2nd laws of thermodynamics

e) pH and buffer

5. RESOURCE LIST

PRIMARY:

Kimball - Biology

Chapter	Sections	Pages
3	3.1-3.13	20-42
4	4.1-4.5	43-63
6	6.9-6.10	101-109

SECONDARY: (available from the instructor)

Biological Science: Molecules to Man (BSCS Blue)

Chapter	Sections	Pages
7	7.4-7.12	125-140
11	11.1-11.10	198-215

TERTIARY: (available from the instructor)

Kendrew, J.C. "The Three-Dimensional Structure of a Protein" from "The Living Cell", Scientific American Readings

6. ACTIVITIES

The following laboratory activities must be completed:

1.1 Construction of Molecular Models

1.2 Identification of Biological Compounds

1.3 Analysis of Common Substances

1.4 The Effect of Temperature, pH and Substrate Concentration on Enzyme Activity

1.5 Identification of Amino Acids Using Paper Chromatography

7. TEST OBJECTIVES

After completing this unit you should be able to:

a) Define or explain the following terms: atom, ion, molecule, polar molecule, hydrogen bonding, covalent bond and isomers.

b) Recognize and draw the following functional groups: alcohol, carbonyl (in the aldehyde and ketone positions), carboxyl, amino and sulfhydro.

c) Name and draw an example of a molecule containing the above functional groups and state the importance of the group to the molecule's function.

d) Describe the four major types of chemical reactions by giving an example of each, stating its importance to living systems and describing the energy flow.

    i) neutralization

    ii) oxidation/reduction

    iii) condensation

    iv) hydrolysis

e) Define oxidation and reduction in terms of electron flow.

f) State the first two laws of thermodynamics and explain how they affect biological systems.

g) Be able to recognize and draw examples of ester, ether (glucoside) and peptide linkages.

h) Describe examples of anabolic (endergonic) and catabolic (exergonic) reactions.

i) Describe how polymerization can occur, in biological molecules, in terms of condensation reactions.

j) Define the terms monosaccharide, disaccharide, fat, protein, and nucleic acid and give an example of each.

k) Describe the formation of the important biological polymers starch, glycogen, cellulose, proteins, fats and nucleic acids from their component molecules.

l) Describe the role each of the major organic molecules plays in the functioning of organisms.

m) Define the terms buffer and pH, and explain their role in maintaining homeostasis in organisms.

n) Define the term enzyme and give two examples of reactions catalyzed by enzymes.

o) Describe how the shape of enzymes is determined by hydrogen bonding and sulfur bridges.

p) Describe the lock-and-key model of enzymatic specificity.

q) Describe the effect of heat and pH changes on the shape and activity of proteins (denaturation).

r) Explain how amino acids can be identified by paper chromatography.

SBI5A1 Unit 2 The Metabolism of Cells

1. INTRODUCTION

In this unit, you will see how the molecules that you studied in Unit 1 are combined to make up a living cell, and see what role each type of compound plays in the metabolism of an organism. You will also examine the interaction of a cell with its environment and examine the ways that cells can produce usable energy.

2. THE PROBLEM

Now you're going to be an engineer. As this unit concerns energy, you're going to solve the world's energy crisis forever. The earth has a vast capacity to produce sugars and the energy tied up in the sugars produced by photosynthesis represents a renewable source of energy. The problem is the getting the energy in a form that can be easily used. Now, I'm not going to ask you to design an entire alternative energy system, just part of it.

Suppose that another scientist has invented a process that will produce electricity using ATP as a raw material. She has not, however developed a method of obtaining the large quantities of ATP to be used by her process. You must design a process that will produce the ATP. You may use living cells, parts of cells, or no cells at all, but you will need to convince me that it will work.

3. BACKGROUND KNOWLEDGE

A review of the chemistry of solutions will be helpful and you should be familiar with the following terms: solute, solvent, concentration, and molarity. In addition, you should review the methods for preparing a solution of given concentration. Also, you will need to familiarize yourself with the substructure of a cell and study the structure and function of the following organelles: cell membrane, nucleus, cytoplasm, mitochondria, chloroplasts, ribosomes, endoplasmic reticulum, lysosomes and vacuoles. This information is found in Chapter five of Kimball's Biology.

4. RESOURCE LIST

PRIMARY: Kimball, Biology

Chapter	Sections	Pages
6	6.1-6.8	92-100
8	8.1-8.12	124-138
	8.16-8.18	140-142

SECONDARY: BSCS Blue, Chapters 8 and 10

TERTIARY: Scientific American Readings: The Living Cell

1. Brachet: The Living Cell
4. Robertson: The Membrane of the Living Cell
6. Green: The Mitochondrion
8. Lehninger: How Cells Transform Energy

ALSO: Isaac Asimov "Wellsprings of Life"

5. ACTIVITIES

You must complete the following:

2.1 Diffusion Through a Semi-permeable Membrane

2.2 Measurement of Rates of Osmosis

2.3 Synthesis of Coacervates

2.4 Examination of Electron Micrography

2.5 Fermentation

2.6 The Effect of the Environment on Membrane Permeability

2.7 Examination or Mitochondria

6. TEST OBJECTIVES

After completing this unit, you should be able to:

a) Define and give an example of the following: solution, solute, solvent, selectively permeable membrane, hypotonic, hypertonic, isotonic, diffusion and osmosis.

b) Predict what will occur in terms of movement of molecules through a selectively permeable membrane.

c) Describe the structure and functioning of a typical living membrane.

d) Describe the fluid-mosaic model of the cell membrane and how it accounts for the membrane's characteristics and selective permeability.

e) Explain the effect of environmental factors such as heat, pH and organic solvents on membrane permeability.

f) Explain passive transport in terms of motion of particles.

g) Describe the processes of pinocytosis and phagocytosis and their importance.

h) Describe the process of active transport using a scientific model to account for the characteristics of the process.

i) Define anaerobic respiration and show how the reactions are consistent with the first and second laws of thermodynamics.

j) Describe examples of anaerobic respiration and their importance to the ecosystem.

k) Define aerobic respiration and show how these reactions are consistent with the first two laws of thermodynamics.

l) Describe the importance of aerobic respiration.

m) Be able to describe the processes of anaerobic and aerobic respiration in terms of the fate of the atoms of the glucose molecule. (It is not necessary to memorize the names of the intermediate molecules or their structures.)

n) Describe the role of ATP in a living organism.

o) Describe the importance of the surface area to cell volume ratio in limiting cell size.

SB15A1 Unit 3 Plant Physiology

1. INTRODUCTION

This unit answers the question that may have popped up in your mind during your study of the last unit -- where does all the glucose come from in the first place? The answer, of course, is from plants through the process of photosynthesis. We will examine this process in detail, and also look at the basic structure of plants and their importance to the ecosystem.

2. THE PROBLEM

NASA has called upon you to assist in the solution of a critical problem affecting their planned manned mission to Mars. As this flight will require 5 months of travel time in each direction, as well as 2 months of time on the surface of Mars to allow for scientific experimentation and observation, it is impossible for the mission spacecraft to carry sufficient food and oxygen to allow for the survival of the 6 astronauts who will take part in the voyage.

Your part of the mission is to develop a system by which food materials can be produced, as well as take care of the problem of the oxygen requirements of the astronauts, and the removal of carbon dioxide from the atmosphere of the spacecraft.

Good Luck! NASA has awarded you a $4 million contract to solve the problem, and will require a complete, detailed description of how your system will solve these problems.

3. BACKGROUND KNOWLEDGE

This unit again deals with the substructure of cells. It would be helpful for you to review the material from the last unit dealing with cell structure and emphasize the differences in structure between plant and animal cells. As you proceed through this unit it will be important to consider, also, the similarities and differences between respiration and photosynthesis, as the link between them will become the focus of this unit.

4. RESOURCE LIST

PRIMARY: Kimball, Biology

Chapter	Sections	Pages
9	9.1-9.9	144-163
10	10.1-10.4	164-168
12	12.1-12.3	211-212
	12.9-12.17	217-228

SECONDARY:
Biological Science: Molecules to Man (BSCS Blue)

Chapter	Sections	Pages
9	9.1-9.11	162-181
20	20.1-20.6	394-403
23	23.1-23.2	444-447

TERTIARY:

Scientific American: The Living Cell

Arnon, D.I.: The Role of Light in Photosynthesis

Bassham, J.A.: The Path of Carbon in Photosynthesis

Lehninger, A.L.: How Cells Transform Energy

5. ACTIVITIES

You must complete the following activities:

3.1 Observation of Plant Tissues

3.2 Chloroplasts

3.3 The Effect of Environmental Factors on the Rate of Photosynthesis

3.4 The Extraction of Chlorophyll

6. TEST OBJECTIVES

After completing this unit, you should be able to:

a) describe the process of converting energy from solar to chemical potential energy in the form of ATP.

b) explain the mechanisms by which ATP and NADPH are produced by the light reactions of photosynthesis.

c) explain the basic mechanism by which carbon dioxide is reduced by the light reaction.

d) identify the chloroplast as the site of photosynthesis in plant cells and describe the structure of the chloroplast, and the location of chloroplast containing cells in plants.

e) describe the structure of the transport vessels of plants (xylem--vessels and tracheids; rays--vertical and lateral).

f) describe how materials (gases, water, minerals, ions and macromolecules) are transported to the site of photosynthesis. e.g. through leaf pull, capillarity and translocation.

g) describe the experimental evidence that explains how the rate of photosynthesis is affected by carbon dioxide concentration, light intensity and quality, and light duration.

h) explain why plants are the earth's most important source of oxygen.

i) describe the importance of the interrelationship between photosynthesis and aerobic respiration.

j) explain how glucose can be used as a raw material to synthesize macromolecules, i.e. carbohydrates, fats, proteins, and others.

k) explain the importance of plants to humans by describing examples of the importance of plants as food, fuel, useful chemicals and esthetic value.

SBI5A1 Unit 4 Genetics

1. INTRODUCTION

Now we are going to change our focus from the cells and processes within cells of organisms to look at the whole organism and the effect that the composition of the cells, specifically the nucleic acids have on the entire organism.

The study of genetics has a history extending only a little more than one hundred years and has the potential for the greatest influence on the future of man's development through the development of genetic engineering. Any thoughts that you might have of biology being a static or slowly developing science will be dissolved by your study of genetics.

2. THE PROBLEM

There are many interesting problems that we could examine in genetics. Rather than directing you to examine a problem of my choice, I would like to have you examine an aspect of genetics that is of interest to you. Areas of interest that I might suggest to you include the history of genetic study; an examination of how DNA fulfills the requirements necessary to be the genetic material, and how this was determined; how genetic engineering is carried out; what are the potential gains of this that could result from genetic engineering; what are the dangers of experimentation in genetic engineering; the benefit/cost of prenatal genetic screening; genetic mapping and evolution; or any other topic related to genetics, but not evolution, as that is the next unit.

You must research the area thoroughly and present your information in an acceptable format. I strongly encourage you to limit your investigation to a single facet of a problem and study this in great depth rather than tackling too big an area. Be sure to discuss your plans with me before starting your research.

3. BACKGROUND KNOWLEDGE

In this unit it is essential that you are very familiar with the structure of DNA, RNA and proteins. You may wish to go back to Unit 1 to review these structures.

4. RESOURCE LIST

PRIMARY:

Kimball - Biology

Chapter	Sections	Pages
14	14.4	253-257
	14.7	259-265
15	15.1-15.9	266-277
16	16.1-16.8	278-292
17	17.1-17.3	296-311
18	18.1-18.9	312-323

SECONDARY:

Biological Science: Molecules to Man (BSCS Blue)
With your sharpened analytic and information gathering skills, you should be able to locate the relevant sections.

TERTIARY:

Scientific American: The Living Cell
Mazia, How Cells Divide
Allfrey and Mirsky, How Cells Make Molecules
Nirenberg, The Genetic Code: II

In addition I highly recommend you read The Double Helix by James D. Watson, the co-discoverer of the structure of DNA.

5. ACTIVITIES

You must complete the following activities:

4.1 Problems in Genetics
4.2 Dihybrid Cross in Drosophila
4.3 Meiosis and Mitosis

6. TEST OBJECTIVES

After completing this unit, you should be able to:

a) Describe the structure of the DNA and RNA molecules and list their similarities and differences.
b) List the nucleotides found in DNA and group them as purine or pyrimidine.

c) Describe how the sequence of nucleotides found in DNA can affect the structure of a protein.

d) Explain how DNA can contain a genetic message.

e) Describe how changes in the DNA can result in mutations.

f) Describe the stages of meiosis and mitosis and explain the importance of meiosis to genetic variation.

g) Explain the importance of momologous chromosomes to meiosis.

h) Explain the importance of crossing over.

i) Explain the term reduction division.

j) Describe the process of gametogenesis in male and female animals.

k) List the genetic composition of all the gametes that can result from a dihybrid genotype.

l) Explain the relationship between genotype and phenotype.

m) Explain how sex is determined in chickens, bees, fruit flies, and humans.

n) Show the predicted results of a dihybrid cross:

   i) where the pairs of alleles are in different chromosomes

   ii) where the alleles are too closely linked to allow for crossing over between them

   iii) where they are linked on the same chromosome but there are 90% non-recombinants and 10% recombinants.

o) Describe the risks and benefits of technologies such as cloning, amniocentesis, in vitro fertilization, sperm and egg banks, embryo transplants, gene therapy and recombinant DNA research.

p) Explain the cause of some genetic diseases in humans; for example, Down's Syndrome, Huntington's Chorea and muscular dystrophy.

q) Describe the Hardy-Weinberg principle and illustrate it using a common trait in humans.

r) Construct a gene map given test cross information.

s) Describe how factors such as selection, mutation, genetic drift and migration can influence the Hardy-Weinberg equilibrium.

SBI5A1 Unit 5 Evolution

1. INTRODUCTION

Where did we come from, what is our place in the animal kingdom, and how did this come to be? These are the sort of questions that are examined by the study of evolution. We will examine some of the scientific theories that attempt to explain this and the observations that have led to these theories.

2. THE PROBLEM

You are a junior research assistant to the eminent biologist, Dr. W. W. Fossil, an expert in the study of the evidence of evolution. Dr. Fossil has been invited to appear on the CBC program "The Nature of Things". The program will be examining the scientific basis for the theory of evolution and comparing it to the non-scientific theories of man's development.

Your role is to prepare the information for Dr. Fossil to present. This will require you to examine the alternative theories in order that Dr. Fossil will be able to rebut their arguments. It is expected that part of the program may be devoted to a face-to-face debate with the leading spokesman for the fundamentalist theories.

3. BACKGROUND KNOWLEDGE

Just your curiosity and analytic skills, but make sure you understand the Hardy-Weinberg principle.

4. RESOURCE LIST

PRIMARY:

Kimball - Biology

Now that you have had some experience in digging material out of the text, I'm going to leave you to choose the relevant sections from the text.

SECONDARY: Asimov- Buying Jupiter, Ch. 1

TERTIARY: ditto

Try to locate some pamphlets or readings that support the non-Darwinian point of view. Dr. Chris McGowan or the Royal Ontario Museum may be able to provide you with some interesting reading from both points of view.

5. ACTIVITIES

You must complete the following activities:

5.1 A Model of Natural Selection

5.2 The Hardy-Weinberg Principle

6. TEST OBJECTIVES

After completing this unit, you should be able to:

a) Describe Lamarck's theory of the inheritance of traits and give examples of its application.

b) Describe the Darwin/Wallace theory and give examples of its application.

c) Use Darwin's theory of natural selection to explain the existence of fourteen different species of finches on the Galopagos Islands.

d) Define species and discuss variability within a species and give examples.

e) Explain the colour changes that have been observed in pepper moths using the principles of natural selection.

f) List at least three isolating mechanisms, give examples of each and explain how they are necessary for new species to occur.

g) Explain how such factors as migration, mutation and genetic drift violate the Hardy-Weinberg principle and lead to evolution.

h) Describe the Hardy-Weinberg principle in terms of evolution.

i) State the modern theory of evolution and compre it to Darwin's theory.

j) Use the modern theory of evolution to explain evidence from an area of biology such as comparative embryology or paleontology.

SBI5A1 Unit 6 VERTEBRATE PHYSIOLOGY

1. INTRODUCTION

In this unit, you will apply all you have learned about the structure and functioning of individual cells to the functioning of a larger, multicellular organism. Although the emphasis will be on human systems, the functioning of these systems is very similar to that of any vertebrate animal.

2. THE PROBLEM

Diabetes is usually called a disease, and can be the result of disease, but is the result of the failure of a homeostatic mechanism in the body, not the result of the action of an infectious bacterium or virus. As your part of a research team which is attempting to develop an artificial pancreas, you must determine fully the role of the normal pancreas, examine the changes that occur in diabetes, and determine exactly what must be the capabilities of the artificial organ. You do not have to consider any of the engineering aspects of making the organ work, just what it must do.

3. BACKGROUND KNOWLEDGE

You will be examining the detailed functioning of the circulatory, excretory, endocrine, nervous and excretory systems, and before you begin you should review the anatomy of these systems.

4. RESOURCE LIST

PRIMARY: Kimball, Biology

Happy Hunting!

SECONDARY: ditto

TERTIARY: etc.

5. ACTIVITIES

You must complete the following activities:

6.1 Feedback Mechanisms

6.2 Tonicity and Cells

6.3 Osmosis and Water Balance

6.4 Kidney Dissection

6. TEST OBJECTIVES

After completing this unit, you should be able to:

a) define the term homeostasis and explain how it results in maintaining a state of dynamic equilibrium.

b) explain the importance of controlling the internal and external environments in both unicellular and multicellular organisms.

c) give the tolerance ranges for various metabolic states; e.g. normal blood pH is 7.4, while small variations from this may result in a coma.

d) explain the homeostatic control of at least four metabolic conditions; e.g. water balance, pH, body temperature, blood glucose, ions (Ca^{++}, K^+, and Na^+).

e) describe and give examples of positive and negative feedback mechanisms.

f) describe several mechanisms, both physical and behavioural, that allow multicellular organisms to adjust to changes in environmental conditions.

g) explain how cellular processes such as active transport and osmosis help regulate an organism's internal environment.

h) describe the action of the nephron of the kidney in filtering out waste materials while retaining essential solutes.

i) define the terms endocrine and exocrine glands and give an example of each.

j) explain the significance of the pituitary and hypothalamus glands to the regulation of hormonal feedback systems; e.g. ADH (anti-diuretic hormone), TSH (thyroid stimulating hormone), etc.

k) describe the processes that regulate the supply of ATP within a cell and the importance of ATP to active transport.

l) describe how the nervous system allows animals to receive, interpret and respond to environmental stimuli.

m) describe various disorders that result from malfunctions of homeostatic control systems and methods of treatment; e.g. diabetes mellitus is the result of a pancreatic malfunction and is treated with insulin; nephron malfunction is treated by dialysis; etc.

SBI5A1 Unit 7 ECOLOGY

1. INTRODUCTION

Well, you've made it to the final problem. Ecology should be an area of biology of interest to everyone, as it is the area dealing with our everyday environment, which, in turn affects our quality of life. The study of ecology is extremely complex, as the environment is so complex. In this unit we will learn how to study tne environment and analyse the ecosystem. We will also consider what we, as individuals, can do to affect our own environment.

2. THE PROBLEM

There are many important issues in ecology that surround us daily. Issues such as acid rain and toxic waste disposal are front page news almost every day. These are the big issues in ecology that are getting so much publicity. It is very difficult for us as individuals to have much influence on these major issues, although we should be interested in them, as they affect us. There are also many smaller, but equally important issues that affect us daily. These may include concern for the quality of air inside our own home, teaching our children respect for the environment, being part of an organization that is concerned about local environmental issues, and so on.

For your problem to solve in this unit, I'm going to set you free to locate your own problem. I'm also going to give you a choice of two directions to follow.

1. You may wish to investigate one of the large or small environmental issues such as those described above, and after analyzing the problem propose a possible solution, taking into account as many factors as possible.

OR 2. Study the environment around you by designing and carrying out a field study of some community nearby. Some suggestions about how to do this are described in activity 7.4.

3. BACKGROUND KNOWLEDGE

Before studying a specific problem, you will need to familiarize yourself with the basic principles of ecology.

4. RESOURCE LIST

PRIMARY: Kimball, Biology
Happy Hunting!

SECONDARY: There are many texts and lab manuals in the room which will be of aid in designing the experiments and investigations for the field study.

5. ACTIVITIES

7.1 A Model Ecosystem

7.2 Interactions in Ecosystems

7.3 The Media and Ecology

7.4 Field Study

TEST OBJECTIVES

After completing this unit, you should be able to:

a) describe an ecosystem in terms of its biotic and abiotic components.

b) using an example of an ecosystem, explain the interactions among organisms, energy flow, and biogeochemical cycles.

c) describe an example of ecological succession.

CHAPTER 8

THE ACTIVITIES

The following materials are provided to the student as they need them, to describe the activities that must be carried out as part of each unit. Most of these are laboratory activities, but some are assignments of a different nature. The initial activities give very direct instructions, but as the student proceeds the instructions are reduced and the student is expected to design some of their own activities.

ACTIVITY 1.1: THE CONSTRUCTION OF MOLECULAR MODELS

Adapted from "In the Laboratory - the Spectrum of Life" J. R. Carlock and H. A. Moore

INTRODUCTION:

The following exercise in model building will allow you to become more familiar with the molecular structure of some important biological compounds and the common reactions they undergo. This will also introduce you to a scientific model. In this case the model is something that you can handle, but a scientific model may be just an idea with no concrete representation. In either case the purpose of a model is to allow you to visualize something that you would not be able to see any other way, or only see with difficulty, and to allow you to make some predictions about the behaviour of the real system as a result of your observations of the behaviour of the model.

PURPOSE:

To construct models of common biological compounds.

MATERIALS AND EQUIPMENT:

A molecular model kit.

PROCEDURE AND OBSERVATIONS:

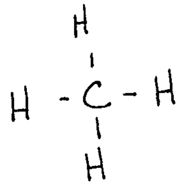
This exercise gives you the opportunity to construct the model first, then compare it with the formula drawn in the column on the right side of the page. When reading the instructions given in the first box (no.1), keep the remainder of the sheet covered with a blank sheet of paper. After you complete your first model and have entered its structure in the space to the right of the first box, move the covering paper down and compare your formula with the formula given in the second box. Then follow the instructions in box 2. Move the paper down a notch and compare your second model with the formula printed to the right of box 3. Each new box gives you the correct answer to the work you have just done and directs you to the next step. If at any time your results do not agree with the formula given, stop and back up until you locate the spot where you went astray. As you work, keep in mind that what you are using produces a model of the real molecule which is similar to it in many respects, but very different in others. It is a mistake to regard the model as an accurate representation of the real system, just enlarged for your convenience. This is especially true of the bonds between atoms, which are like real bonds in that they hold the atoms together, but a real chemical bond has no substance to it; there is nothing but a force holding the atoms together.

PART I: SIMPLE ORGANIC COMPOUNDS

Organic compounds are composed of molecules containing the elements carbon, hydrogen and oxygen. Because carbon has the property of being able to bond to four other atoms at one time, including other carbon atoms and to form multiple bonds, the diversity of compounds that can be created with these three elements is infinite. Almost all of the compounds found in living things are composed of these three elements, with other elements included for special functions.

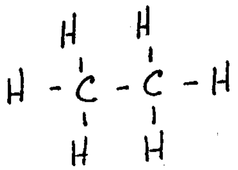
1. Construct a molecule of the simplest compound containing only carbon and hydrogen. Compounds composed of only carbon and hydrogen are called hydrocarbons. Using "C" for carbon and "H" for hydrogen, make a diagram of your molecular model in the space at the right. This is the structural formula for your model.

2. No simpler arrangement of atoms is possible for a one-carbon hydrocarbon. The numbers of hydrogens cannot be reduced since all bonds must be completed. Your formula should represent methane. Now construct the next simplest model by adding one additional carbon atom and the necessary hydrogen atoms.



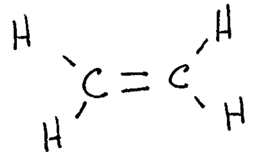
(Methane)

3. Your model now represents ethane. Other two-carbon compounds contain double or triple bonds joining the carbons. Construct a model of a hydrocarbon with a double bond.



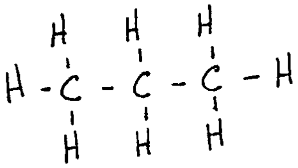
(Ethane)

4. Your double-bond model depicts ethene (also called ethylene). Double-bonded carbons occur in some fat molecules. Compounds with multiple bonds are called unsaturated compounds. For the present we will construct only saturated compounds. Make a three-carbon saturated hydrocarbon.



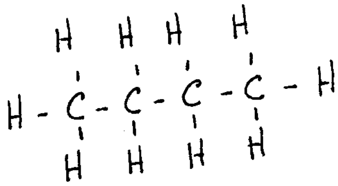
(Ethene)

5. The three-carbon model represents propane. Now make a model of a four-carbon hydrocarbon.



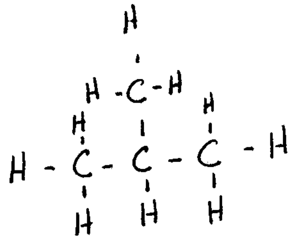
(Propane)

6. You have demonstrated butane. You may notice that you can construct this model with more than one arrangement of atoms. (Changing the angles between the carbon atoms may make the model look different, but it is still the same compound, it would have the same chemical properties. This is an example of how a model may mislead us into making a wrong prediction!) To construct a different compound you must rearrange the bonds between atoms.



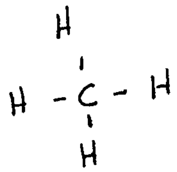
(Butane)

7. Have you produced a model of iso-butane? Molecules formed of the same atoms put in different arrangements are called isomers. Extend your series of hydrocarbon molecules all the way up to a 10-carbon model. Make only the straight-chain isomer without side branches. Large numbers of isomers of the larger molecules are possible.



(Iso-butane)

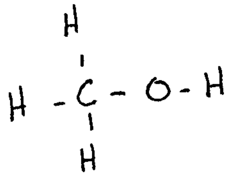
8. Take apart your large model, leaving the simplest hydrocarbon methane.



(Methane)

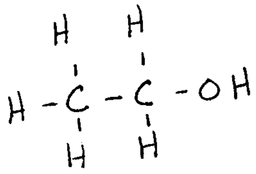
9. Incorporate an oxygen atom into your model of the methane molecule.

10. Adding one oxygen atom forms the model of methyl alcohol. The significant structure of an alcohol is the -O-H bonded to a carbon. Notice that I said "an alcohol"; many different alcohol molecules are possible. Construct a model of ethyl alcohol by starting with an ethane molecule.



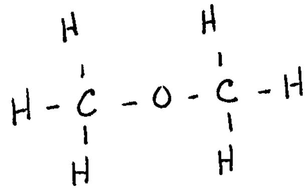
(Methyl Alcohol)

11. The oxygen could also bond between the two carbons, forming an isomer of ethyl alcohol. Make this model.

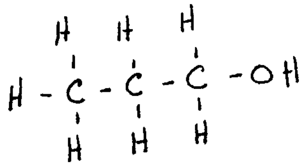


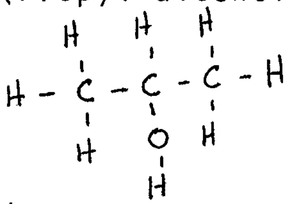
(Ethyl Alcohol)

12. The two hydrocarbon fragments united through an oxygen form an ether. Ethers are not of frequent occurance in biologically important compounds. Now construct a three-carbon alcohol.

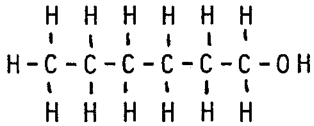

(Dimethyl Ether)

13. You should end up with a model of one of these two isomeric forms of propyl alcohol. Many other alcohols are derived from the larger hydrocarbons. Construct a six-carbon alcohol.

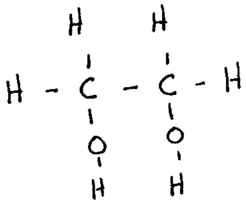

(Propyl alcohol)


(Iso-propyl alcohol)

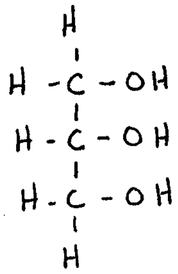
14. What you have built is only one of many possible isomers. In addition, there may be more than one alcohol group in a molecule. Only one -O-H group may occur on the same carbon. Now, model a two-carbon double alcohol.


hexyl alcohol

15. You have built a model of ethylene glycol, a commonly used anti-freeze compound. Now construct a three-carbon polyalcohol (poly=many).

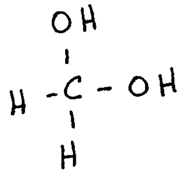

(Ethylene Glycol)

16. Your model depicts glycerol (or glycerin), a basic structure of fat.

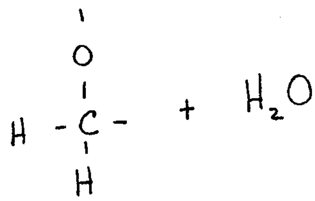


17. Earlier, you learned that only one -O-H group can occur on a single carbon. However, so that you may examine the chemical events involved, construct a one-carbon compound with two -O-H groups on the carbon.

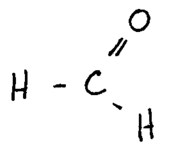
18. Such molecules, as pictured here, probably do form but rapidly decompose. In so doing, a molecule of water splits out. Now make a model of a water molecule using only atoms from the -OH groups. The hydrogens attached directly to the carbon are not involved.



19. With a molecule of water split off, the remaining open bond lines can be joined to form a double bond between C and O.



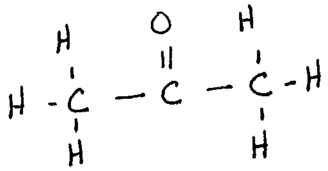
20. It would be more convenient to trade the symmetrical carbon and oxygen atoms for double bond models. Compounds having this structure are aldehydes. The significant group of an aldehyde is the double bonded oxygen to a carbon with a single additional hydrogen, -CH=O.



(Formaldehyde)

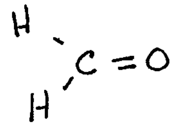
21. Close relatives of the aldehydes are called ketones. The simplest of these is called acetone. Construct acetone by building a three-carbon hydrocarbon with an oxygen atom replacing both hydrogen atoms bonded to the middle carbon.

22. The -OH of an alcohol, -CH=O of an aldehyde and the double bonded oxygen of the ketone are called functional groups. Their presence as part of a hydrocarbon results in the molecule having specific properties, therefore affecting the function of the molecule. Construct a model of formaldehyde that we will use to demonstrate another functional group.



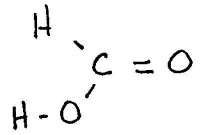
(Acetone)

23. Additional oxygen can be bonded to the aldehyde carbon. Add one oxygen to your model of formaldehyde without losing any of the other atoms.



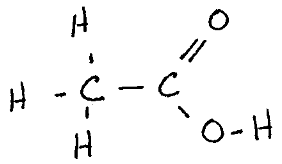
(Formaldehyde)

24. A compound having a carbon atom with both =O and -OH groups is called an organic acid. The hydrogen of the -OH group can ionize, a characteristic of all acids. Now model the two-carbon acid.



(Formic Acid)

25. You should have a model of acetic acid. You can model organic acids based on a whole series of hydrocarbons. Note that the acid group occurs on an end carbon in the commonly occurring organic acids.



(Acetic acid)

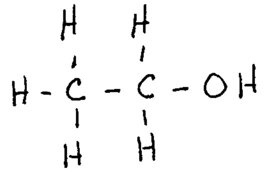
26. Now you have been introduced to the basic structure of organic compounds and their functional groups. As you proceed to Part II, watch for the presence of these functional groups as part of larger, more complex molecules.

PART II: LIPID STRUCTURE

In this section we are going to use some of the models that you constructed in Part I; in addition we will see how they can react with one another to produce even more complex molecules.

1. Construct a model of ethyl alcohol. Write the formula for your model in the space at the right.

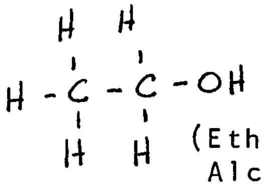
2. Check your model against the formula for ethyl alcohol presented at the right. Now, leaving your model in place on the table, construct a model of acetic acid. Place the acid group at the left end of the acetic acid molecule and position this model on the table so that the acid group adjoins the alcohol group of your model of ethyl alcohol.

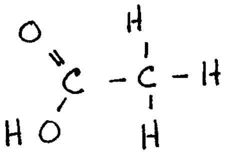


(Ethyl Alcohol)

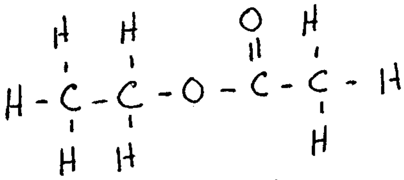
3. Remove the -OH group of the acid and the H of the -OH group of the alcohol. These removed bits join together to form a molecule of water. Join the remaining molecular fragments together at the open bonds. Your model should

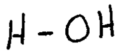
look like the structure shown at the right. This is called a condensation reaction, as water is produced as a result of the joining of the two large molecules.


(Ethyl Alcohol)

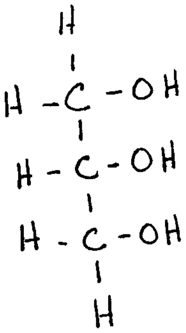

(Acetic Acid)

4. Compounds formed from an acid and an alcohol joined together through the elimination of water are called esters. The ester you have modelled is called ethyl acetate. Now model a molecule of glycerol, the three-carbon polyalcohol.

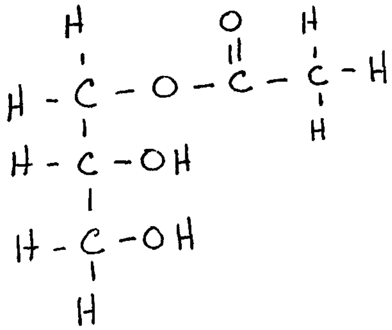

(Ethyl Acetate)


(Water)

5. Keeping the glycerol molecule intact, place a model of acetic acid near the top -OH group in the same manner as you did in the second step of this study. Remove the appropriate atoms to form a molecule of water, and then join the fragments of glycerol and acetic acid.

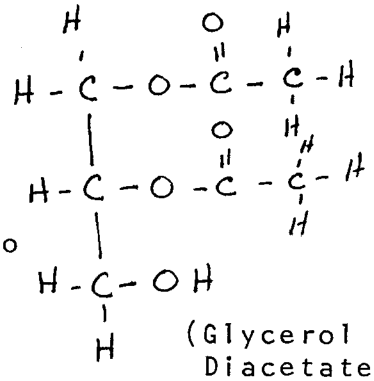

(Glycerol)

6. You have modelled a molecule of glyceryl monoacetate (you don't need to memorize all these names). The glycerol portion of this molecule still has the potential for adding more acetic acid molecules. Construct another acetic acid molecule and join it to the second alcohol group in the same manner as before.



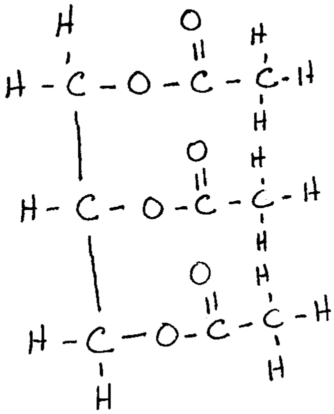
(Glycerol Monoacetate)

7. Your model with two acetates should match the formula at the right. Now add a third molecule of acetic acid to your model in the same manner.



(Glycerol Diacetate)

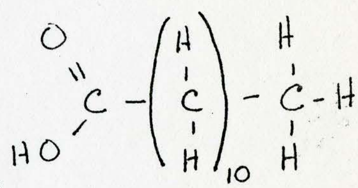
8. You have structured a triacetate molecule and it should match the formula shown here. This is a simple fat. You can construct other fats by joining other straight chain acids to the glycerol molecule. You will discover that those acids with an even number of carbon atoms are the major component of natural fats.



(Glycerol Triacetate)

9. The acid components of fats are called fatty acids. Some of the fatty acids have long carbon chains, so biochemists customarily take a short cut in representing such large fatty acids. You will see why as you draw (and construct if you wish) a 12-carbon fatty acid. Write the formula in the space at right.

10. Somewhat unwieldy, isn't it. Here is the biochemist's short cut. Remove the entire hydrocarbon tail from the acid group - that is all 11 carbons and 23 hydrogens. In their place, indicate their presence as shown at the right. Notice that the functional group remains and all important characteristics have been retained. The section in the brackets can be of any length. The variable sections of organic molecules are often referred to as "R" groups. Using this short cut method, draw the structural formula of a fat containing a fatty acid of 12 carbons, one of 8 carbons, and one of 26 carbons.



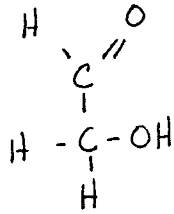
(Lauric Acid)

PART III: CARBOHYDRATE STRUCTURE

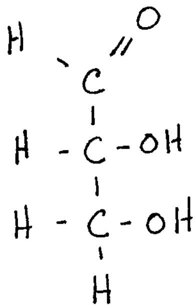
Sugars and starches belong to the class of molecules called carbohydrates. They are the important energy compounds for both plants and animals. Their structure is complex, each molecule containing several functional groups.

1. Model a two-carbon compound that is both an aldehyde and an alcohol, with each functional group attached to a different carbon atom.

2. Your model should match the formula given at right. Now construct a model of a three-carbon compound which is an aldehyde with two alcohol groups, one functional group per carbon. For convenience, make it a vertical model with the aldehyde at top.

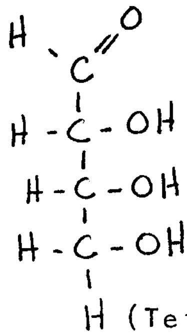


3. You have modelled the simplest of all possible carbohydrates, a three-carbon sugar (a triose) called glyceraldehyde. Many other sugars are built on the same pattern with additional carbon atoms carrying alcohol groups. Make a model of a four-carbon sugar - a tetrose.



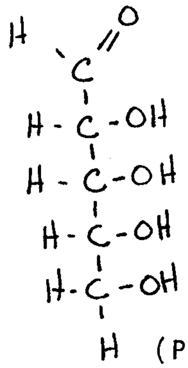
(Glyceraldehyde)

4. Does your model match the formula at the right? Now construct a five-carbon sugar - a pentose.



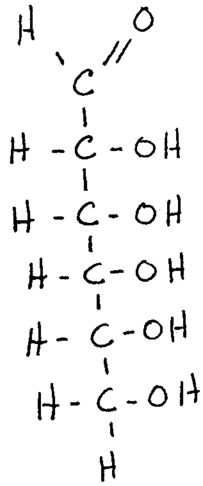
(Tetrose)

5. Compare your pentose model with the formula shown here. Add another carbon atom to form a hexose.



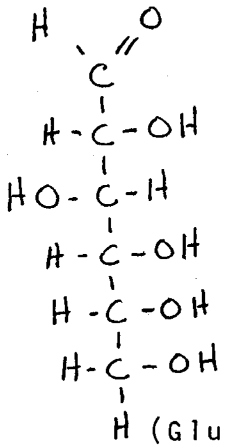
(Pentose)

6. Your six-carbon sugar model is represented by the formula at right. Perhaps you have already noticed that some of the carbons in this compound have four different atoms, or groups of atoms, occupying the bonds. This being the case, stereoisomers can be formed around each of these carbons (stereoisomers are formed by rearranging the functional groups attached to a carbon atom). Number the carbons from 1 to 6 starting with the aldehyde carbon. The particular isomer you have modelled here is called allose.



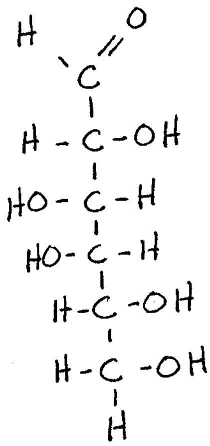
(Hexose)

Now reverse the positions of the -OH and -H groups on the third carbon.



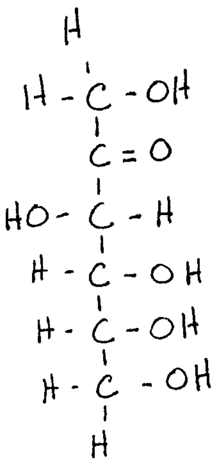
(Glucose)

7. Now you have modelled the hexose called glucose, a stereoisomer of allose. The -H and -OH on the fourth carbon can also be reversed in position to produce another stereoisomer.



(Galactose)

8. This is called galactose. There are a number of other isomers of the aldehyde hexose sugars. There are also ketone polyalcohol sugars that are isomers, but not stereoisomers of the aldehyde hexoses. Model one of these sugars by putting the ketone group on the second carbon atom.

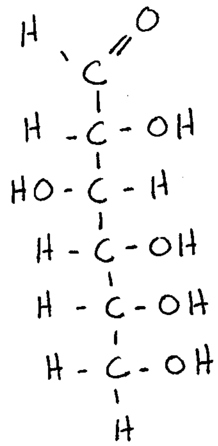


(Fructose)

9. Your model might well be the isomer called fructose. There are other possibilities, but fructose is the isomer most commonly encountered, is the sweetest tasting of all the sugars, and is found in maple syrup.

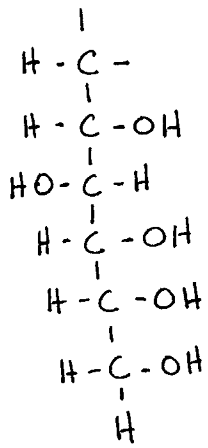
10. The stable form of these sugars results from a geometric arrangement to form a ring structure. Reconstruct your model of glucose from the fructose model and write down the formula.

11. In solution, the double bond oxygen of the aldehyde group opens. Make this change in your model after studying the formula at right. To do this, you would have to trade the double bond carbon and double bond oxygen atoms for carbon and oxygen models that have the bonds in symmetric arrangement (-O-).

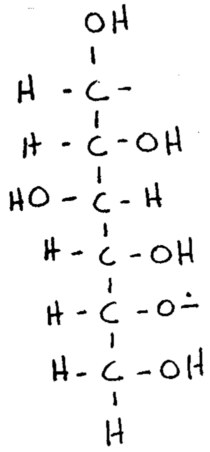


(Glucose)

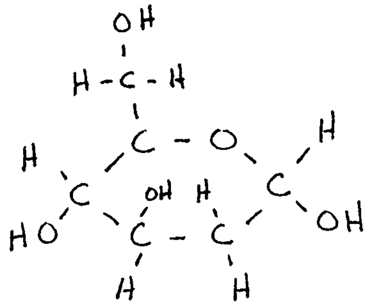
12. Your model should now look like the formula shown here. You should have two bonds open, one on the first carbon atom and one on the oxygen attached to that carbon. Now remove the hydrogen of the -OH group which is on the fifth carbon and bond it to the unoccupied oxygen bond of the first carbon atom.



13. The glucose model can now become a ring by connecting the open bond on the no.1 carbon with the open bond on the no.5 carbon.



14. The ring structure of glucose can be shown by the formula at right. Hexose sugar molecules also can be joined to each other to form disaccharides, formed of two hexose molecules. Two glucose molecules bonded together form the disaccharide maltose. We won't try to construct this model because of its complexity. Other common disaccharides are lactose (found in milk) and sucrose (cane sugar).

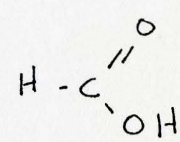


PART IV: PROTEIN STRUCTURE

The basic structural unit of a protein is a molecule which includes both an acid group and a functional group containing nitrogen, an amine group. Hence, this unit is called an amino acid. There are 20 different amino acids, all containing acid and amine functional groups and a variable organic portion, an R group.

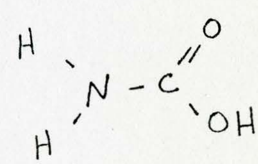
1. To begin with, construct the one carbon organic acid, formic acid. Write the formula for this acid at right.

2. Does your formula match the one given here? If not, correct your model and then proceed by substituting an amine group (-NH2) for the hydrogen attached to the carbon atom.



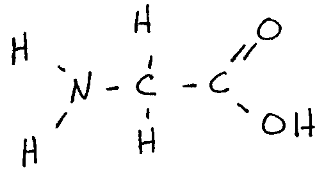
(Formic Acid)

3. Theoretically, you have constructed the simplest of all amino acids, and its formula would match the one at right. However, this amino acid is never found in nature. The simplest known amino acid has two carbons with



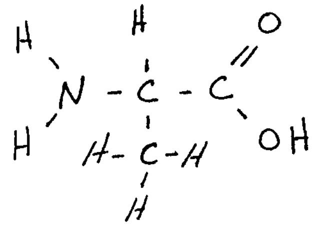
the acid group on one carbon and the amine group on the other carbon. Construct a model of this amino acid.

4. You now have a model of glycine. There are many other amino acids that have more than two carbons. In all the naturally occurring ones found in protein, the amine group is always located on the carbon atom adjoining the acid carbon. With this information in mind, construct a model of a three-carbon amino acid.



(Glycine)

5. You have modelled alanine. Some amino acids have much larger hydrocarbon residues attached to the main amino acid structure. Other functional groups may be included. The structures of the other 18 amino acids are shown on page 50 of your textbook.



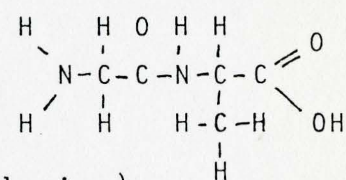
(Alanine)

6. Now let's see how amino acids can join together to form a protein. Amino acids unite through the elimination of water

(condensation) between adjoining amino acids. You can show this reaction by using the two models you have constructed, glycine and alanine.

7. Place the glycine model on the left and remove the -OH group from the acid group. From the alinine model on the right, remove an -H from the amine group. Join these atoms to form water, and join the open bonds on the remaining fragments.

8. The dipeptide you have modelled should look like the formula shown at right. Construct a model of a third amino acid, using the formulas from your text and form a bond between it and the dipeptide. Notice that you could attach it to either of the amino acids present. In this way other amino acids can be joined, resulting in the production of a long, linear chain, each link in the chain being an amino acid.



(Glycine) (Alanine)

The structure of a protein is analagous to that of a train. Each car of the train is an amino acid, and depending on the order and type of cars that we add to the train, we form a different type of train, or protein.

Separate the two amino acids and reattach them with the glycine on the right and the alanine on the left. Note that this produces a compound with different chemical properties as the carboxyl functional group of the glycine is now exposed rather than that of alanine.

ACTIVITY 1.2: IDENTIFICATION OF BIOLOGICAL COMPOUNDS

Adapted from "Investigations in Biology"

G. D. Benson et al

INTRODUCTION:

This activity will provide you with the chance to try some analytical tests which will allow you to detect the presence of carbohydrates, proteins and fats in unknown samples.

PURPOSE:

To test for the presence of carbohydrates, proteins, and fats.

PART I: IDENTIFICATION OF CARBOHYDRATES

Carbohydrates are molecules composed of carbon, hydrogen, and oxygen atoms in the ratio of 1:2:1 respectively, or a simple multiple of this ratio. Molecules of carbohydrates range in size from small three-carbon monosaccharides to extremely large polysaccharides of high molecular mass. Carbohydrates are important in that they are a source of energy for most organisms. In addition to this, some carbohydrates form the basis of cell wall material in plants.

The presence of certain carbohydrates called reducing sugars can be detected using Benedict's solution. The free aldehyde groups of the reducing sugars are oxidized by the metallic ion present in Benedict's solution. The reactions result in the formation of a coloured precipitate.

MATERIALS:

1% glucose solution
1% fructose
1% sucrose
1% starch
10% corn syrup
iodine solution
Benedict's solution

PROCEDURE:

A. Reducing Sugar Test

Place 3 ml of each solution in a separate, appropriately labelled test tube. Put 3 ml of distilled water in another tube as a control sample. To each tube add 5 drops of Benedict's solution. Heat the mixture in a hot water bath for 2 to 3 minutes and observe any colour changes.

B. Starch Test

Place 5 drops of each solution on a drop plate. Put 5 drops of distilled water on the plate as a control sample. Add 1 drop of iodine solution to each sample. Observe any colour changes other than that due to the colour of the of the iodine solution.

OBSERVATIONS:

Record your results in a chart similar to the one shown for each test performed.

Type of Test:

	Sample	Observations	Interpretations
1.			
2.			
3.			

QUESTIONS:

1. What are the structural differences among the three classes of carbohydrates?
2. What is the structural difference between excess carbohydrates as they are stored in plants and in animals?
3. Explain why Benedict's solution gives a positive test only with reducing sugars.
4. Glucose and fructose combine chemically to produce a molecule of sucrose. How would it be possible to modify sucrose to produce a positive reducing sugar test?

PART II: LIPID IDENTIFICATION

Lipids, many of which are formed by the chemical union of one glycerol molecule and three fatty acids, are essential substances within the body. Some lipids form a portion of each cell membrane as well as acting as the major energy reserve for many organisms.

MATERIALS:

vegetable oil

distilled water

paper

PROCEDURE:

Translucence Test

Place a small sample of the substance to be tested on a piece of unglazed paper, label it, and spread it as thinly as possible over a small area. After 5 minutes, hold the paper up to the light and look for any translucent spots.

OBSERVATIONS:

Record your results in chart form, as in Part I.

QUESTIONS:

1. Describe the chemical composition of a fat molecule.
2. Suggest some possible reasons a diet including large quantities of saturated fatty acids might be avoided.

PART III: IDENTIFICATION OF PROTEINS

Proteins are complex polymers of amino acids. They are composed of carbon, hydrogen, oxygen, nitrogen and in some cases, sulfur.

MATERIALS:

10% egg albumin	0.02 M $CuSO_4$
1% gelatin	6 M NaOH

CAUTION: Copper Sulfate ($CuSO_4$) is poisonous if swallowed and Sodium Hydroxide (NaOH) is caustic (causes burns in contact with skin). Wear eye protection when handling Sodium Hydroxide solution.

PROCEDURE:

Biuret Test

Label test tubes with the names of the solutions to be tested; include distilled water as a control sample. To 2 ml of each solution add 2 ml of 6 M NaOH and 4 drops of 0.02 M $CuSO_4$ and gently shake the tubes to mix the solutions. The appearance of a violet or violet-pink colour indicates the presence of proteins and specifically, the presence of peptide bonds between the amino acids.

OBSERVATIONS:

Record your result in a chart as in Parts I and II.

QUESTIONS:

1. Compare and contrast coagulation and denaturation of proteins and list agents involved in these reactions.
2. Describe some of the functions of proteins.
3. What is a polymer?

ACTIVITY 1.3: ANALYSIS OF COMMON SUBSTANCES

INTRODUCTION:

In this activity you will apply the techniques that you learned in activity 1.2 to analyze some common substances for the presence of reducing sugars, starch, fat and protein.

MATERIALS:

Select some samples of common foods from home. Your selection should include at least 5 substances, some of which should come from the following list:

milk	carrot	nuts
potato	onion	meat
bread or cracker		

PROCEDURE:

Review the procedures that you used in the previous lab, and apply those techniques to the samples you have. Solid foods should be crushed before testing for sugar, fat or protein. Separate your food sample into enough pieces to allow you to run each test more than once if you are unsure of the result the first time.

OBSERVATIONS AND CONCLUSIONS:

Construct a chart similar to the one shown below. Prescence of a compound in the sample can be shown by + (positive test) and absence by - (negative test).

	Sugar	Starch	Fat	Protein	Sample
1.					
2.					
3.					

ACTIVITY 1.4: ENZYME ACTIVITY

Adapted from "Investigations in Biology"

G. D. Benson et al

INTRODUCTION:

One of the distinguishing features of living organisms is the presence of organic catalysts called enzymes. The vast majority of enzymes isolated to date have been found to be proteins; most are soluble in water or a dilute salt solution. However, some groups of enzymes (e.g. in mitochondria) are bound together by phospholipid-protein complex and this makes them insoluble in water. Some enzymes consist solely of protein, others contain a non-protein organic molecule called a coenzyme. Still others contain a metallic ion known as a cofactor. Separately the protein portion, the coenzyme or cofactor remain inactive, but combined they form an active unit known as a holoenzyme.

In this lab, we will examine the characteristics of catalyst and enzyme action, and the effect of changes in the environmental conditions on the action of the enzyme.

MATERIALS

3% hydrogen peroxide	potato
manganese dioxide	weak acid
fresh or frozen liver	weak base

PROCEDURE:

A. Catalytic Reactions

First let's examine the effect of an inorganic catalyst, manganese dioxide. Add 2 ml of hydrogen peroxide to two test tubes. Place 0.1 g of sand in one test tube and add 0.1 g of manganese dioxide to the second tube. Observe and record the rates of reaction. What gas evolves?

B. The Effect of an Enzyme

Add 2 ml of hydrogen peroxide to each of two clean test tubes. In one place a small piece of liver and in the other a small piece of potato. Record the rates of reaction and compare these results to those with manganese dioxide. DO NOT DISCARD THESE MATERIALS.

C. Re-using an Enzyme

Divide the liquid portion of the previous tube in B. containing the liver into two test tubes. Cut the liver from procedure B. into two equal portions and add these to the two test tubes. To the first add a fresh piece of liver and to the second add 1 ml of hydrogen peroxide. Record your observations and explain the reaction in the test tube containing the fresh liver. What would happen if additional hydrogen peroxide were added to the second tube?

D. Effect of Increased Surface Area

Place a small piece of liver in one test tube and a small piece of potato in a second. Add a pinch of sand to each tube and crush these materials with separate stirring rods. Add 2 ml of hydrogen peroxide to each tube, then observe and record the rates of these reactions. Compare the results with those of the uncrushed liver and potato in part B.

E. The Effect of Temperature

Place a small piece of liver in a test tube and heat it for 5 minutes in a boiling water bath. Add 2 ml of hydrogen peroxide to the boiled liver and record the results.

Place a small piece of liver into each of two test tubes. Place one test tube in a $37^{\circ}C$ water bath for 5 minutes and the second test tube in an ice water bath for the same length of time. Remove both test tubes from the water bath and add 2 ml of hydrogen peroxide to each tube. Record the rates of the reactions.

F. The Effect of pH

Place a small piece of liver into each of two test tubes. Add a pinch of sand and crush the liver as in part D. To one tube add a 1 ml of dilute acid and to the other, 1 ml of dilute base. Add 2 ml of hydrogen peroxide to each and observe and record the rates of these reactions. Compare the results to those of the crushed liver in part D.

G. The Effect of Substrate Concentration

The material that an enzyme works on is known as its substrate. To each of two test tubes add a small piece of liver. To the first test tube add 1 ml of water and 1 ml of hydrogen peroxide. To the other test tube add 2 ml of hydrogen peroxide. Observe and record the rates of these reactions.

OBSERVATIONS:

Record your results in a chart similar to the one shown below. Rates of reaction can be designated as follows: 0-no reaction; 1-slow; 2-moderate; 3-fast; 4-very fast.

	OBSERVATIONS	RATE OF REACTIONS	INTERPRETATIONS
A. Sand MnO_2			
B. Liver			
C. Used & Fresh Liver			
Used Liver & H_2O_2			
D. Crushed Liver			
Crushed Potato			
E. Boiled Liver			
Liver at $37^{o}C$			
Liver at $0^{o}C$			
F. Liver in Acid			
Liver in Base			
G. H_2O_2 and Water			
H_2O_2 only			

QUESTIONS:

1. How do you account for the difference in rates in each part?
2. Can H_2O_2 be broken down by catalysts other than those found in living systems? Explain your answer.
3. Describe the effect of temperature and surface area on the rate of enzyme action.
4. The body temperature of a dog is approximately $40^{\circ}C$. Would your results be different if you had used pieces of dog liver in this investigation?
5. At what pH is the liver enzyme most active?
6. Pepsin is an enzyme secreted into the stomach. Discuss the pH range in which this enzyme would be most active, and suggest what happens to the enzyme as it leaves the stomach.
7. What is the effect of substrate concentration on enzyme activity?

ACTIVITY 2.1: DIFFUSION THROUGH A SEMIPERMEABLE MEMBRANE

Adapted from "Investigations in Biology"

G. D. Benson et al

INTRODUCTION:

Each cell is surrounded by a plasma membrane and all nutrients and waste products must pass through this membrane to get in or out of the cell. However, not all substances can penetrate this membrane. Whether or not a particular substance will pass through it, depends on the structure of both the membrane and the substance. A membrane is said to be impermeable if it will not permit any substance to pass through, and semipermeable if it will allow some but not all substances to pass through it. The properties of the membranes in living organisms are much more complex than those of non-living membranes. Living membranes are selectively permeable, and they control the passage of substances in and out of cells.

PURPOSE:

To demonstrate the rates at which molecules diffuse through a semipermeable membrane.

MATERIALS:

5% glucose

5% starch

0.085 M NaCl

1% gelatin

0.035 M $AgNO_3$

6 M NaOH

0.02 M $CuSO_4$

Benedict's solution

iodine solution

dialysis tubing

string

PROCEDURE:

Cut a 15 cm strip of dialysis tubing and open it to form a tube. Tie one end with string to form a sack. Place 3 ml each of glucose, starch, NaCl, gelatine and vegetable oil into the tubing. Tie off the sack, test for water tightness, wash the sack, and place it is a 250 ml beaker so that the tied ends are uppermost. Fill the beaker with distilled water warmed to 37°C. Remove 10 ml of the water in the beaker and test for the substances that you placed in the dialysis tubing. (You can test for the presence of the chloride ion by adding 2 drops of silver nitrate to 2 ml of the water from the beaker. A cloudy precipitate indicates the presence of salt.)

Withdraw 10 ml samples at 5 minute intervals, and repeat the tests.

OBSERVATIONS:

Record your observations in a chart such as the one below.

Molecular Group	Time in Minutes 0	5	10	15	20	25	30
Glucose							
Starch							
Lipid							
Gelatin							
Chloride ion							

QUESTIONS:

1. What differences would you expect in the results if cold water were used instead of warm?
2. In a cell, turgidity is due to internal pressure. Describe the state of turgidity of the dialysis sack over the duration of the investigation. If there were changes, suggest why these occurred.
3. Account for the differences in the rates of diffusion observed in this investigation.

ACTIVITY 2.2: MEASURING RATES OF OSMOSIS

INTRODUCTION:

Now it's time to show off your innovative talents. Rather than giving you a procedure to follow, I'm going to let you design this lab. The purpose is to measure the rate of osmosis in a system, or compare the rates of osmosis in systems under different conditions.

In preparing for the lab, I would like you to write up an outline which will be similar to the ones that you have been given up to this point. It should include a brief introduction, a statement of purpose specific to the lab you are going to do, a list of materials needed, a detailed outline of the procedure you will follow, and the way in which you will organize your observations (charts, graphs or whatever).

You may use any reference books you wish to help give you ideas of how to proceed, but I don't want you to be following the exact procedure laid out in one of these books. There should be a bit of original work in your experiment.

After you have done some thinking, and collecting of information from the various sources, discuss your ideas with me before doing any writing. You must have your method and outline approved by me before doing the actual experiment.

ACTIVITY 2.3: SYNTHESIZING COACERVATES

Adapted from "Biological Science, Molecules to Man"

A. E. Lee et al

INTRODUCTION:

Under certain conditions, the proteins, carbohydrates, and other materials in a solution may group together into the organized droplets called coacervates. Because coacervates have some of the properties of living things, droplets like them might have been an important step in the origin of life. In this investigation, you can produce coacervates and study the conditions under which they form.

MATERIALS:

1% gelatin

1% gum arabic

0.1M hydrochloric acid

pH test papers

microscope, slides and cover slips

PROCEDURE:

1. Mix together 5 ml of the gelatin solution and 3 ml of the gum arabic solution in a test tube. Gelatin is a protein gum arabic is a carbohydrate, a carbon compound related to sugars and starches. Measure the pH of this mixture.

2. Place a drop of the liquid on a slide and observe it under low power of the microscope.
3. Carefully add acid, drop by drop, to the test tube. After the addition of each drop of the acid, mix well and then wait a few seconds to see if the mixture becomes cloudy. If the liquid in the tube remains clear, add another drop of acid. Continue adding acid a drop at a time until the mixture becomes cloudy.
4. When the material becomes cloudy, take another pH reading. At this point, carefully observe a drop of the liquid under the microscope. Look for coacervates, structures such as those shown on page 141 of BSCS Blue. If you cannot see them, try adjusting the light and using high power. If you still do not observe coacervates, repeat the procedure from the beginning, for you may have added the acid too rapidly. When you are successful, record your observations and make sketches of the coacervate droplets.
5. When you have finished your observation of the coacervates, add more acid to the test tube, one drop at a time. Mix after adding each drop and measure the pH after every third drop. Continue until the solution becomes clear again. When the liquid becomes clear again, examine a drop under the microscope, and measure the new pH.

QUESTIONS:

1. How do the materials that you used to make coacervates compare with those that might have been present in the ancient ocean?
2. In what pH range did the coacervate droplets form?
3. Did the pH change as expected as a result of adding more acid to the solution between coacervate formation and clearing?
4. When hydrochloric acid was added beyond a certain point, the coacervates disappeared. What might you add to the test tube to make the coacervates reappear?

ACTIVITY 2.4: ELECTRON MICROGRAPHY

INTRODUCTION:

Electron micrographs can give us highly detailed photographs of objects that have been highly magnified. The degree of magnification extends far beyond the capability of a light microscope but there are disadvantages in using the electron microscope. For electron microscopy, the specimen must be dead and the tissue fixed with paraffin or plastic, sliced extremely thinly, and stained. All of these manipulations may change the appearance of the material from its real state. It is also difficult to visualize the specimen in three dimensions when we only see two, and have not had the opportunity to examine the specimen before it was sectioned. This would be like imagining the shape of an entire cow from the appearance of a slice of roast beef. Shapes also change. A vessel that may be a cylinder may look elliptical when sliced on an angle.

PROCEDURE:

Obtain from your instructor a set of electron micrographs and examine them carefully. Compare what you see with the appearance of similar tissues as seen with the light microscope. Draw neat diagrams representing the comparison of the two views for two different specimens.

ACTIVITY 2.5: FERMENTATION IN YEAST

Adapted from "Biology Laboratory Manual"

S. L. Weinberg

INTRODUCTION:

From ancient times, yeast has been used to make dough rise. The yeast is kneaded into the dough, which is then set aside to rise. Yeasts are fungous plants. They obtain energy for metabolism and reproductions through fermentation--anaerobic respiration.

In this exercise you will use yeasts in a sugar-rich culture medium. The mixture is incubated overnight to activate the yeast cells. A control, the same culture medium, but without yeast cells, will be incubated in the same manner.

You will observe some phases of the yeast's activity and try to determine some factors that will affect the way bread rises.

MATERIALS:

culture medium	limewater
dry yeast	litmus paper
iodine	microscope

PROCEDURE:

1. Prepare the culture medium by dissolving 10 g of sugar in 150 ml of lukewarm water in each of two flasks. In one flask add a package of dried yeast, and stopper the flasks

with a plug of cotton. Leave in a warm place overnight.

2. Fill a test tube with the yeast culture until it overflows. Invert the test tube in a small beaker containing a small amount of the culture medium. Make sure there is no air bubble at the top of the tube. If there is, then dump out the tube and repeat.
3. Prepare a control set-up using the culture medium which does not contain yeast.
4. Smell both mixtures and describe the odours.
5. Test both mixtures with red and blue litmus paper. Explain the results.
6. Place a drop of iodine stain on a clean slide. Add a drop of yeast culture and a cover slip. Find the yeast cells under the microscope. Note the shape of the cells. Find the cell wall, cytoplasm, and vacuole. What other structures do you see?
7. Observe the mixture carefully to see any signs of budding, the manner in which yeast cells reproduce. If you see any, describe the process.
8. After an hour or so, return to the fermentation tubes. Describe any changes that you see. To test any gases that may be present, lift the test tube so that the liquid empties out. Quickly place your thumb over the mouth of the test tube and turn it right side up. Add 3 ml of limewater and shake. Describe and explain the results.

QUESTIONS:

1. Summarize what you observed about the structure of yeast cells.
2. Explain how yeast can cause bread to rise.
3. Why does bread not continue to rise after it is baked?
4. Why was it necessary to set up a control experiment?
5. Account for the presence of any gas in the control test tube.

ACTIVITY 2.6: ENVIRONMENT EFFECT ON MEMBRANE PERMEABILITY

INTRODUCTION:

It's do-it-yourself time again. This time, I would like you to design an experiment to demonstrate the effect of changes in temperature, pH or organic solvents on membrane permeability. Again, do your research, then write up a design for your proposed experiment. Don't forget to describe how you will analyze and present your data. You may wish to use the basic method that you developed for measuring the rate of osmosis in activity 2.2, or an alternative method that you think may work better. Again, you must have your design approved before proceeding with the actual experiment.

ACTIVITY 2.7: EXAMINING MITOCHONDRIA

Adapted from "Biology Laboratory Manual"

S. L. Weinberg

INTRODUCTION:

Mitochondria are called the powerhouses of aerobic cells. They contain the enzymes which regulate oxidation and the release of energy.

Mitochondria are very delicate. They are rarely seen in prepared and stained slides, because the process of preparation usually destroys them. They may be observed in living cells, however, especially when coloured with certain so-called vital stains. Janus green and methylene blue are vital stains.

These stains are coloured when they are chemically in an oxidized state. When the mitochondria are actively engaged in oxidizing organic compounds, mainly by the removal or hydrogen, the stains act as hydrogen acceptors. They are thereby reduced chemically and become colourless.

MATERIALS:

microscope, slides, and cover slips

razor blades

fresh celery stalk

5% sucrose solution

methylene blue or Janus green B stain

PROCEDURE:

1. Cut a thick two-or three-cell-layer slice from the outer section between two of the strings. To do this, first cut a 1/4 inch cube of celery and place it on a slide in a drop of sugar solution. Hold it with forceps and use the razor blade to trim away the strings. You should now have a thin section of pith without strings in it.
2. Transfer the section to a cover slip. Add enough sugar solution to cover it. Mount on a slide and observe under the microscope.
3. What structures do you see in each slide? Draw one cell.
4. Add vital stain. Apply a drop at one side of the cover slip. Apply a strip of filter paper or blotting paper at the other side to draw the stain through the preparation.
5. Observe the cells again. Describe the mitochondria.
6. Continue to observe for five or ten minutes. What change occurs?

QUESTIONS:

1. Summarize what you have learned about the structure and function of mitochondria.

2. Why was the sugar solution necessary to demonstrate the function of the mitochondria?

3. Explain the changes that took place in the colour of the stain.

ACTIVITY 3.1: OBSERVATION OF PLANT TISSUES

INTRODUCTION:

All living things are composed of cells. This statement forms part of the Cell Theory of Matthias Schlieden and Theodore Schwann which was formulated in the early 19th century. Of course, the cells that form different organisms are themselves different, and are composed of different proteins, fats, and nucleic acids. Within a single organism we also have many different types of cells, which differ in appearance as well as function.

A group of cells, which may be of different types, that are organized to cooperate in performing a common task are referred to as a tissue. Within an animal there are four different types of tissues. Epithelial tissue forms the skin covering the body and lining any of the body spaces including small spaces such as blood vessels. Muscle tissue provides for movement, nervous tissue for communication and connective tissue for support and a variety of other functions which are illustrated on page 83 of your textbook. These tissues are composed of unique cells, which can be recognized by their appearance under the microscope. With practice, identifying each of these tissues becomes as easy as recognizing a friend in a crowd.

Plants also have a variety of tissue types, each of which is specialized to assist in carrying out specific functions. These tissue types are less familiar to us, but there are six distinctly different plant tissues. Meristematic tissue allows for growth, protective tissue for an obvious purpose, parenchyma tissue as a site of photosynthesis and food storage, collenchyma and scierenchyma for support and xylem and phloem for transport of material.

In animals, the various tissues are more easily recognized because they tend to be arranged in discreet groupings. For example, if you are examining a piece of muscle, you would expect to find muscle tissue. In a plant, it is less easy to recognize the individual tissues because they tend to be interspersed, and a sample of a stem or leaf is likely to contain most of the various tissues.

The purpose of this lab is to examine some tissue samples from plants and to see if you can find these various tissue types.

MATERIALS:

microscope

prepared slides of plant tissues

PROCEDURE:

Examine the prepared slides of plant stems, leaves and roots and identify each of the types of tissue present in each specimen. Draw large, fully detailed and labelled diagrams of one stem, leaf and root cross-section. Use the appropriate magnification and indicate the power of the lens used on the drawing.

QUESTIONS:

1. Describe the appearance of the cells of each tissue type. You may wish to make up a chart to describe these.
2. How do the organization of tissues in veins of leaves, stems and roots differ?
3. Describe how the organization of tissues in a leaf assist the leaf in carrying on the process of photosynthesis.

ACTIVITY 3.2: OBSERVING CHLOROPLASTS

INTRODUCTION:

As you know, chloroplasts are the sites of photosynthesis. They contain the chlorophyll pigments used to trap light energy, and therefore give plants their green colour. Because of their relatively large size, chloroplasts are easily observed using a light microscope. In this activity, you will examine the chloroplasts of a living plant cell, and compare the structures you observe to photographs made with the electron microscope.

MATERIALS:

microscope, slides and cover slips
samples of elodea or other thin -leafed aquatic plant
micrographs of plant cells

PROCEDURE:

PART I: Chloroplasts in living cells

Place a leaf or portion of a leaf of a thin-leafed aquatic plant on a microscope slide. Add a drop of water, and a cover slip. Observe the leaf using low, medium and high powers.

Examine the position, number and movement of the chloroplasts you see. Draw and label a diagram of several of the cells that you see.

Reduce the amount of light entering the microscope and carefully observe any effect this has on the motion of the chloroplasts.

PART II: Electron micrographs

Examine carefully photographs of chloroplasts from your textbook, or other reference texts. Draw and label a diagram of a single chloroplast and compare it to your diagram of the entire cell.

QUESTIONS:

1. Why was it necessary to use an aquatic plant for this experiment?
2. What does the motion of the chloroplast indicate?
3. How is the structure of a chloroplast adapted to its function?

ACTIVITY 3.3: ENVIRONMENTAL FACTORS AND THE RATE OF PHOTOSYNTHESIS

INTRODUCTION:

It's do-it-yourself time again. As you already know, there are several factors in a plant's immediate environment which will influence the rate at which photosynthesis will occur. Using the resource materials available, design an experiment that will demonstrate the effect of one of these factors. As before, you must have your plan approved before proceeding.

ACTIVITY 3.4: EXTRACTING CHLOROPHYLL

Adapted from "Investigations in Biology"

G. D. Benson, et al

INTRODUCTION:

Pigments are compounds that can be divided into two groups, the water-soluble and fat-soluble pigments. These compounds absorb and reflect specific wavelengths of light, the latter accounting for the specific colours they exhibit. The most common water-soluble pigments found in the cell vacuoles are the anthocyanins and anthoxanthins. The red colour of beets and the yellow colour of poppies are attributed to these types of pigments respectively. Several lipid-soluble pigments occur in structures called plastids. The major ones in this group are the chlorophylls a, b, c, and d, the carotenoids, and the xanthophylls. These exhibit green, orange, and yellow colours respectively.

PURPOSE:

To demonstrate the presence of carotenes, xanthophylls and chlorophylls in leaves.

MATERIALS:

spinach or lettuce leaves

acetone

solvent (9 parts petroleum ether to 1 part acetone)

mortar and pestle

sand

micropipette

chromatography paper

PROCEDURE:

Tear three leaves into small pieces and place them in a mortar. Add 5 ml of acetone and a pinch of sand, and grind them thoroughly. The resulting acetone-pigment extract should be as concentrated as possible. Decant the acetone-pigment extract into a 50 ml beaker. Discard the sand and plant material. Using a micropipette or dropper place a drop of the extract on a piece of filter paper that has been cut to fit inside a test tube. The end to which the extract is applied should be cut to form a V. The extract is then applied 3 to 5 mm from the pointed end of the filter paper. Reapply the extract at least five times, allowing it to dry between applications.

Using a clip as a hook, fasten the strip of filter paper to the stopper. Place sufficient solvent in the test tube to reach the tip of the filter paper, but not enough to touch the pigment spot. Make sure that the strip hangs freely and does not touch the sides of the tube. Position the tube vertically and observe the movement of the solvent front. When this front is within 1 cm of the top of the filter paper, remove the paper and mark the position of the front. Note the location of the four pigments on the paper. Chlorophyll (a) will appear as a green-blue colour, chlorophyll (b) as a green-yellow colour, carotenes as orange-red and xanthophylls as light yellow. Measure the total distance the solvent travelled and the distance each pigment travelled. Calculate the migration rate (R_+) for each pigment, using the following formula:

$$R_+ = \frac{\text{Distance Pigment travelled}}{\text{Distance Solvent travelled}}$$

OBSERVATIONS:

Record the R_+ value for each in a chart similar to the one shown .

Pigment	Observations			Interpretations
	Distance Pigment Travelled	Distance Solvent Travelled	R_+ Value	
Chlorophyll (a)				
Chlorophyll (b)				
Carotene				
Xanthophyll				

QUESTIONS:

1. Which pigment travelled fastest? Explain how you can tell.

2. What are the specific roles of chlorophyll (a) and chlorophyll (b) in photosynthesis?

3. Why does a geranium appear green?

4. Account for the change in colour of leaves in the fall.

5. Which colour(s) of light are best absorbed by chlorophyll?

ACTIVITY 4.1: PROBLEMS IN GENETICS

INTRODUCTION:

Genetics, of course, is the study of heredity. In studying genetics, we will examine the mechanism by which characteristics are passed from one generation to the next, and also examine some patterns of inheritance. This will allow us to predict the probability of a certain characteristic being expressed in offspring and also show us how characteristics can be linked, tending to be inherited together. We'll begin my examining the simplest case of single gene inheritance, and progress to genetic mapping.

PART 1: SINGLE GENE INHERITANCE

Before we look at actual patterns of inheritance, we need to define a few terms and establish the mechanics of heredity. You will already have examined the mechanism of mitosis, by which a cell can exactly reproduce itself, and mieosis, which is the process of production of gametes. Mieosis results in an equal division of the chromosomes, one of each pair being found in each resulting gamete. Because chromosomes are found in pairs, every organism has two copies of the gene governing each characteristic.

A gene is the information governing a certain characteristic. An allele is the specific information that an individual has. For example, we all have a gene controlling whether our earlobes are attached or not. Some of us have the attached allele, others have the free allele. A locus can be thought of as a location, the place on a chromosome where the gene is located. For example, humans have 46 chromosomes, 22 pairs plus 2 sex chromosomes. Located on these chromosomes are all of the loci governing the characteristics of a person. Most of the loci contain alleles controlling the production of enzymes and structural proteins that do not affect the physical appearance of the organism. Other loci, however, contain information for physical characteristics. In humans there are very few characteristics controlled by a single locus, but some of the common ones are blood type, ability to roll your tongue, shape of the earlobes and which thumb you place on top when you clasp your hands. The locus is the location on the chromosome where the information is located, and the allele is the actual information located in the locus. Normally we do not use the term gene. So, we all have a locus determining blood type, but we may have different alleles resulting in different blood types.

All of the alleles possessed by an individual constitute the genotype. The genotype will affect the phenotype, the appearance of the individual. Individuals with the same phenotype do not necessarily have the same genotype. This is because certain alleles are dominant while others are recessive. A dominant allele is one that is expressed in the phenotype even if the other, recessive allele is present.

For example, in common garden green pea plants, the locus controlling the height of the plant has two possible alleles, one resulting in a tall plant (T) and one dwarf (t). The tall allele is dominant because, if a plant has a phenotype of Tt, (one tall allele, one dwarf) then the plant will be tall. Recall that every organism will have two alleles for a given locus. A capital letter is used to designate the dominant gene, a small letter the recessive. Notice that the same letter is used to indicate the two alternative alleles of the same locus. Dwarf is not indicated by d, as this would indicate a different locus from the tall (T) locus.

As there are two alleles for this locus, we have three possible genotypes for pea plants when we are considering height. These are TT (both alleles are for tall), Tt (one allele is for tall, the other dwarf), and tt (both alleles are for dwarf). TT and tt are considered to be homozygous (homo= same) meaning that the zygote formed by the union of two gametes contained identical alleles for the height locus. Tt is considered hererozygous or hybrid (hetero=different) as the two alleles are different. These terms allow us to designate the three different genotypes. TT is homozygous dominant, Tt hererozygous and tt homozygous recessive.

All right then - this has established the terminology; let's see how we can predict the outcomes of some matings. To use our example of height in pea plants, what are the possible outcomes of a cross between two hererozygous (Tt) plants? Plants produce male and female gametes (reproductive cells; in animals the egg and sperm cells, in plants the pollen and ova) through mieosis. This results in the separation of pairs of alleles. In our example then, the gametes that result from mieosis of the Tt parent will be either T or t. Now let's see how these gametes can be combined. (Note that the gametes produced by each parent will be same in genetic composition.) If a T gamete combines with another T gamete, then the result is a homozygous dominant offspring (TT). If T combines with t, then the offspring is hererzygous (Tt), or if two t gametes combine, then the result is homozygous recessive (tt).

All of this information can be presented in chart form, in a Punnett's Square:

Tt X Tt

Male Gametes

		T	t
Female Gametes	T	TT homozygous dominant Tall	Tt heterozygous Tall
	t	Tf heterozy-gous Tall	tt homozygous recessive Dwarf

This cross results in a 1:2:1 ratio of genotypes, a 3 tall:1 short ratio of phenotypes.

Now it's time for you to do some calculating. For each question, determine the composition of the gametes, then construct a Punnett's square and determine the genotypic and phenotypic ratios.

1. Determine the genotypic and phenotypic ratios for the other possible crosses of the pea plants (TT X TT, TT X Tt, etc.)

2. In rats, black coat colour is dominant to white. Determine the genotype and phenotype ratios that result from crossing two hybrid black rats.

3. In guinea pigs, coat colour is the result of two co-dominant genes. Co-dominance means that neither alternative dominates the other, but the hybrid has a different result from either homozygote. Yellow coat colour is the result of the homozygous genotype C^yC^y, white from the homozygous genotype C^wC^w and cream colour from the heterozygote C^yC^y. What genotype and phenotype ratios would result from matings of two cream-coloured guinea pigs?

4. The shape of radishes may be long (S^LS^L), round (S^RS^R) or oval (S^LS^R). If long radishes are crossed to oval radishes, calculate the expected genotype and phenotype ratios.

PART II: MULTIPLE ALLELES

In some cases there are more than two possible alleles for a locus. For example, plummage colour in mallard ducks is dependent on a set of three alleles: M^R for restricted mallard pattern, M for mallard and m for dusky mallard. There exists a dominance hierarchy for these alleles, such that M^R is dominant to M which is in turn dominant to m. (M^R M m). This produces some interesting results in crosses. Let's predict the results of a cross between a restricted mallard hybrid (M^Rm) and a homozygous mallard (MM).

M^Rm X MM

		Male Gametes (M^Rm)	
		M^R	m
Female Gametes (MM)	M	M^RM Restricted Mallard	Mm Mallard
	M	M^RM Restricted Mallard	Mm Mallard

Human blood groups are another example of multiple alleles, this time with co-dominance built in as well. There are three possible alleles, leading to four possible blood groups. Your blood group is determined by the presence of antibodies, which are in turn determined by the presence of certain genes. The antibodies are anti-A and anti-B; some people produce both A and B, but most people do not produce either of these antibodies and are designated O. The A and B genes are co-dominant and are both dominant to O. This can be shown in a dominance hierarchy as (A=B) O.

The genotypes and resulting phenotypes possible are:

Genotype	Phenotype (Blood Group)
AA	A
AO	A
BB	B
BO	B
AB	AB
OO	O

This blood grouping information is sometimes used to determine the identity of the father in a paternity suit. The information can prove that a certain person is not the father, but cannot prove that he is. Can you explain this?

5. Determine the possible blood group of the child of a couple where the father is heterozygous type A and the mother is homozygous type B.
6. A multiple allelic series is known in the Chinese primrose, where A (Alexandria type, white eye) a^n (normal type, yellow eye) a (Queen type, large yellow eye). List all the genotypes possible for each of the phenotypes in this series, then determine the result of a cross between a heterozygous normal type and a heterozygous Alexandria type (Aa).

PART III: SEX LINKAGE

Up to this point, we have only been considering alleles located on the 22 pairs of autosomes (non-sex chromosomes). The inheritance of characteristics found on the sex chromosomes, X and Y, is somewhat different. Recall that these are the chromosomes that determine the sex of the offspring. A zygote receiving an X chromosome from each parent will therefore have the genotype XX and will be female. If the zygote receives a Y chromosome from the father (why the father?) then it will have the genotype XY and be male.

An allele located on the Y chromosome will only be found in males, but the Y chromosome is very small and there are very few of these loci, none of them common. If the locus located on the X chromosome, then we get a pattern of inheritance that is sex-linked. Every male will express the characteristic as there is only one copy of the gene, but the female must be homozygous to express a recessive sex-linked gene as she has two copies of the gene.

This is the pattern of inheritance of haemophilia, the bleeder's diesase in which the blood of the sufferer lacks a protein needed to allow clotting. This allele is located on the X chromosome and is a recessive allele, so the female must be homozygous recessive (X^hX^h) in order to have the disease, the male will always have the condition if the allele is present (X^hY). The female may be a carrier of the allele, that is be heterozygous (X^hX) and not suffer from the disease as the normal allele carried on the other X chromosome will produce the necessary clotting factor. There is however, a chance that her male children will suffer from haemophilia. Queen Victoria was a carrier of haemophilia.

A slightly different case is that of male pattern baldness. This is the typical baldness of men, starting with the receding hairline, then the bald patch on the crown of the head, meeting up to result in the usual sunroof. This is called a sex-limited recessive trait, as it is inherited on the X chromosome, and in addition will only occur in the presence of the male hormone testosterone. This type of baldness can not be expressed in the female, even if she is homozygous X^b, as no testosterone is present.

7. Determine the chance of a haemophilia carrying woman having a child that suffers from haemophilia.

8. Determine the chance of a man suffering male pattern baldness having a child that also will exhibit baldness.

PART IV: THE DIHYBRID CROSS

Now let's see what happens if we look at two characteristics at once. A dihybrid is an individual that is heterozygous for two different characteristics. For example, the pea plant that we used as an example in Part I has many other characteristics besides height. The flowers can be pink or white, the seed smooth or wrinkled, yellow or green or dozens of other variation. A plant that is dihybrid in height and seed colour would be tall, as tall is dominant to dwarf, and have yellow seeds, as this is dominant to green. If T indicates tall, t dwarf, and Y yellow, y green seed, then the genotype of our dihybrid plant is TtYy.

Determining the predicted offspring from a mating of two of these plants requires a little more analysis of the situation, as the location of the alleles will affect the result.

a) Alleles on different chromosomes

If the allele for height is located on a different chromosome from the allele for seed colour, then the chromosomes will assort independently. This means that during meiosis, the gametes can receive any of the possible combinations of height and seed colour. The inclusion of one allele in the gamete has no effect on the inclusion or exclusion of the other. If we then look at the possibilities, a gamete can receive either the T or t allele, and either the Y or y allele. It must get one allele for each characteristic. The possible gene combinations in the gamete are TY, Ty, Yt, and yt. Using these gametes, we can construct a Punnett's square.

TtYy X TtYy

	TY	Ty	tY	ty
TY	TTYY tall yellow	TTYy tall yellow	TtYY tall yellow	TtYy tall yellow
Ty	TTYy tall yellow	TTyy tall green	TtYy tall yellow	Ttyy tall green
tY	TtYY tall yellow	TtYy tall yellow	ttYY dwarf yellow	ttYy dwarf yellow
ty	TtYy tall yellow	Ttyy tall green	ttYy dwarf yellow	ttyy dwarf green

This will produce the characteristic phenotype ratio for a dihybrid of 9 tall yellow : 3 tall green : 3 dwarf yellow : 1 dwarf green. Notice that the double homozygous recessive occurs only in 1 in 16 plants.

9. Tall tomato plants are produced by the action of a dominant allele D, and dwarf plants by its recessive allele d. Hairy stems are produced by a dominant gene H and hairless stems by its recessive allele h. Determine the results of a cross of two dihybrid tall hairy-stemmed plants, if the alleles are located on different chromosomes.

10. Black coat colour in Cocker Spaniels is governed by a dominant allele B and red coat colour by its recessive allele b; solid pattern is governed by the dominant allele of an independently assorting allele S; spotted pattern by its recessive allele s. A solid black male is mated to a solid red female and produces a litter of six pups; two solid black, two solid red, one black and white, and one red and white. Determine the genotypes of the parents. (hint: the unknown portion of a genotype should be indicated by a dash -. Do a Punnett's square starting with the offspring and work back to the parents.)

b) Alleles on the same chromosome:

Initially you might expect that alleles that are located on the same chromosome must stay together through mieosis, and therefore, cannot be separated. If the alleles for height and seed colour were on the same chromosome and the parent plant had TY on one chromosome and ty on the other chromosome of the homologous pair, then the parent would be a dihybrid, but the only gamete types would be TY and ty. However, one phase of the process of mieosis is crossing over. During this phase, one strand of each of the pairs of chromosomes is broken, and a joining-up takes place with the corresponding strand of the other chromosome of the pair. This is the only thing holding the pairs of chromosomes together at this stage of mieosis. If the breaking and joining-up occurs between the two alleles, then the genes can be rearranged. We get two possible combinations:

1) TY and ty gametes which are the parental type (the same arrangement as the parent chromosomes, which are the gametes that would result without crossing over
2) Ty and tY which are called the recombinant types as the genes have been rearranged and recombined. The percentage of recombinant gametes depends on the distance between the alleles on the parental chromosomes.

At least one crossing-over must occur between each pair of chromosomes during mieosis. If the loci are very close together, the chances of the crossing-over occurring between them is very small. If they are located far apart, as near each end of the chromosome, then the chance of a cross-over between them is very large, in fact it can be a 100% chance of a cross-over, or even greater as more than one cross-over can occur. If the chance is 100% exactly, then the results are identical to those when the alleles are located on different chromosomes, there will be equal numbers of parental and recombinant type gametes. The percentage of recombinant types gives us a measure of the distance between the alleles, and are called map units. If two alleles are located such that a cross-over occurs 90% of the time, then the alleles are said to be 90 map units apart.

Now let's see if we can predict the outcome of a dihybrid cross when the alleles are located on the same chromosome with the probability of a cross-over between the two alleles being 20%. We will assume that the genes are arranged as above, one chromosome having TY, the other ty. Because the cross-over only affects one of the two chromatids of the chromosome, only 10% of the gametes will be recombinant types. (Only 1/2 of the chromatids can rearrange at any one time). Therefore, 10% of the gametes will be Ty or tY (5% each) and 90% of the gametes will be the parental types TY or ty (45% each). We can use these numbers in the Punnett's square by applying some mathematics of probability, the probability of the combination occurring is the product of the probabilities of the individual gametes occurring. By the way, probabilities are always expressed as a decimal rather than a percentage and the number must be equal to, or less than 1. A probability of 1 is a certainty, there is no alternative.

Male Gametes

		Parental		Recombinant	
		TY .45	ty .45	Ty .05	ty .05
PARENTAL	TY .45	TTYY .2025 tall yellow	TtYy .2025 tall yellow	TTYy .0225 tall yellow	TtYY .0225 tall yellow
	ty .45	TtYy .2025 tall yellow	ttyy .2025 dwarf green	Ttyy .0225 tall green	ttYy .0225 dwarf yellow
RECOMBINANT	Ty .05	TTYy .0225 tall yellow	Ttyy .0225 tall green	TTyy .0025 tall green	TtYy .0025 tall yellow
	tY .05	TtYY .0225 tall yellow	ttYy .0225 dwarf yellow	TtYY .0025 tall yellow	ttYY .0025 dwarf yellow

The total frequency for each of the phenotypes can be calculated by summing the individual probabilities. This will result in a phenotype ratio of 0.7025 tall yellow : 0.0475 dwarf yellow : 0.0475 tall green : 0.2025 dwarf green. Compare this with the phenotype ratio generated in Part a) and you can see the effect of the alleles being located on the same chromosome. To further interpret this ratio, what we are saying is that if we planted 1000 seeds resulting from the cross of the two dihybrid parent plants (tall yellow, TtYy) we would expect to see 702 tall yellow plants, 47 dwarf yellow, 47 tall green and 202 dwarf green plants. (These don't sum exactly to 1000 due to round-off error.) In the original parent chromosomes, tall and yellow were linked as were dwarf and green; notice that these combinations predominate in the offspring, because we said at the outset that only 10% of the gametes show the effect of the chromosome rearrangement.

11. In drosophila the alleles for two dominant genetic conditions are located on the same chromosome 30 map units apart. The alleles are Cy for curly wings and Pm for plum eye colour. The alternatives are normal wings (Cy^+) and red eyes (Pm^+). Determine the penotype ratio for a cross between two dihybrid curly-winged, red-eyed fruit flies. (Sounds like they've been to a party.) Assume that the Cy and Pm alleles are on the same chromosome.

PART V: The Gene Map

Using the information from crosses such as the one above, we can determine the percentage of cross-overs, and can then go back to determine the distances between loci on the chromosome and establish the genetic map, which show us not only the distance between, but also the order in which the loci occur. Loci on the same chromosome are said to belong to the same linkage group.

The common fruit fly, Drosophila melanogaster, has been the subject of many genetic studies and has had many of its alleles mapped on the four chromosomes that it possesses. We shall examine data that might have come from an experimental mating between two fruit flies.

First we'll consider a simple example involving two characteristics, eye colour and wing shape. In these flies, a red eye colour is normal, but there are many alternatives including the recessive colour ivory (i), wings can be normal or stunted (st). Let's begin by crossing ivory flies with stunted wing flies, then doing a testcross with the offspring of this first mating. In a testcross we cross our experimental flies with homozygous recessive flies, in this case ivory, stunted, as this will allow the recessive characteristic to be expressed each time it is inherited. This in turn tells us the genotype of the offspring of the first mating. Examining 1000 of the progeny gives the following results:

413 ivory   87 ivory stunted

391 stunted 109 wild type

Note that the recessive characteristics only are listed, the dominant characteristic is not shown; a fly having none of the recessive characters is said to be a "wild type", as this is the most common appearance of the fly in the natural population.

We can determine how the characteristics were linked in the parental generation by looking at the most frequently occurring genotype. Remember that only half of the alleles can be arranged in any given mieotic event. Looking at our data, we see that ivory types and stunted types occur most frequently, in fact (413+391)/1000x100%= 80.4% of the offspring are identical to the parents, telling us that the ivory gene was located on one chromosome of the pair, the stunted wing gene on the other chromosome.

The combinations occurring least frequently are the recombinant types. In this case the ivory stunted and the wild type. Again, from the data we see that (87+109)/1000x 100% = 19.6% of the flies were of the recombinant type. This is the number we are interested in as this tells us the distance between the alleles. Remember, the percentage of recombinants is the map distance. In this case the i and st genes are 19.6 map units apart.

12. A kidney-bean shaped eye is produced by a recessive gene k on the third chromosome of Drosophila. Orange eye colour, called "cardinal" is produced by the recessive gene cd on the same chromosome. A kidney, cardinal fly is crossed with a wild type fly and the offspring testcrossed with the following results for 500 flies:

kidney, cardinal	184	kidney	75
wild type	170	cardinal	71

Determine the map distance between these two alleles.

PART VI: A Gene Map

Now you've seen how you can go from the data resulting from an experiment to determine the distance between two alleles, let's take it one step further to see how we could determine the order and distance between several alleles on the same chromosome. Separate experiments such as the one we examined in the previous section are necessary, one to determine the distance between each pair of alleles. The map distances are individually calculated and can be shown in chart form. The map distances for six genes in the second linkage group of the silkworm Bombyx mori are shown in the table below.

	Gr	Rc	S	Y	P	oa
Gr	-	25	1	19	7	20
Rc		-	26	6	32	5
S			-	20	6	21
Y				-	26	1
P					-	27

Putting these together in the right sequence so that the map distances are all correct is a bit of a puzzle. I'll give you a hint which is to start with the longest distances and work down to the shortest, checking that they are all correct. I'll let you puzzle this out to see if you can come up with the correct map. (The answer is with the solutions.)

PART VII: THE HARDY WEINBERG LAW

This last part (whew!!) deals with predicting the frequency of genes in populations. To go back to one of our previous examples, that of haemophilia, the questions that we answered at that point were related to the chances of having affected offspring if you know of the existence of the gene in the parent. The other question you might ask is "What is the frequency of the gene in the entire population?"; in other words, how common is the condition? This is the type of problem that the Hardy-Weinberg law will answer.

The Hardy-Weinberg law says that if we can measure the frequency of a gene in a population, then we can determine the chances of a particular genotype occurring. There are certain conditions that apply. One is that we must be looking at a single allele and its alternative. For example, thalassemia is an anemia condition in man. The homozygous dominant genotype T^mT^m results in severe anemia (thalassemia major), heterozygous genotype T^mT^n results in mild anemia (thalassemia minor). Normal individuals are homozygous recessive T^nT^n. In population of Italians, the frequency of the T^m allele is 2%, the T^n accounting for the remaining 98%.

To apply the Hardy-Weinberg law we first let p be the frequency of the dominant T^m allele, p=.02 and q be the frequency of the recessive, normal allele, q=.98. The first condition of the Hardy-Weinberg law is that p+q=1; that is, there are no other alternatives, this condition is satisfied in this case. Now we can determine the frequency of each of the conditions. The frequency of the homozygous dominant is given by p^2, in this case $(.02)^2$=.0004 or .04%. The frequency of the homozygous recessive is given by q^2, $(.98)^2$=.9604 or 96.04% and the frequency of the heterozygote as 2pq=2(.02)(.98)=.0392 or 3.92%. Therefore, if we examine 10 000 Italian people at random, we would expect to find 4 that suffer from thalassemia major, 392 suffering from thalassemia minor and 9604 normal people.

Another condition of the Hardy-Weinberg law is that the alleles must be in equilibrium. The equilibrium condition means that the frequency of the gene is constant from generation to generation, in other words, this does not apply to populations which are rapidly changing. Whether the population is at equilibrium can be determined by summing the calculated frequencies of the three genotypes. The sum, p^2 must be one. Those mathematicians in the audience will recognize this as $(p+q)^2=1$. Check this result using the data from the previous example.

Let's look at another example, and work backwards from the population data to the gene frequencies. White wool is dependent on a dominant allele B and black wool upon its recessive allele b. Suppose that a sample of 900 sheep of the Rambouillet breed in Idaho gave the following data: 891 white and 9 black. Estimate the gene frequencies and determine how many of the sheep are hybrids.

We will let p be the frequency of the white gene B, as it is dominant, and q the frequency of the recessive b gene. The 9 black sheep are homozygous recessive, and their frequency is therefore given by q^2. The frequency of the black sheep is $9/900=.01$, $q^2=.01$ and q must be .1. If q is .1 then p must be .9 (remember $p+q=1$) and the frequency of the hybrid is $2pq=2(.9)(.1)=0.18$, so the number of hybrid sheep are $.18 \times 900=162$.

13. In shorthorn cattle, the genotype C^RC^R is red coat, C^RC^W is roan (amixture of white and red) and C^WC^W is white. If 108 red, 48 white and 144 roan animals are found in a sample of Shorthorns, calculate the estimated frequencies of the C^R and C^W alleles in the gene pool of the population. Determine if the population is at equilibrium. (Determine if the actual number of hybrids is approximately what is predicted by the Hardy-Weinberg law).

SBI5A1 Unit 4 GENETICS ASSIGNMENT

Show full solutions for all of the following questions. Draw Punnett's squares where needed.

1. In humans, the ability to taste a chemical called phenylthiocarbamide (PTC) is governed by a single locus. The allele for tasting is dominant to the non-tasting allele. Show the phenotype and genotype ratios that can result from a cross between two hybrid tasters.

2. Chickens with shortened wings and legs are called creepers. When creepers are mated to normal birds they produce normals and creepers with equal frequencies. When creepers are mated to creepers they produce off-spring in the ratio of 2 creepers to 1 normal bird. Crosses between normal birds produce only normal progeny. Given that this is governed by only one locus and a single pair of alleles, how can you explain these results?

3. In fruit flies, the gene for white eyes is a recessive sex-linked gene. (X^W white allele, X^+ wild type, red eye)
   a) Calculate the pheno- and genotypic ratios for a cross between a white-eyed female and a red-eyed male.
   b) Calculate the ratios for a cross between a white-eyed male and a hybrid red-eyed female.

4. A dominant allele L governs short hair in guinea pigs and its recessive allele l governs long hair. Codominant alleles at an independently assorting locus specify hair colour, such that C^YC^Y=yellow, C^YC^W=cream and C^WC^W=white. From matings between dihybrid short, cream pigs, predict the phenotypic ratio expected in the offspring.

5. The recessive mutation called "lemon" (le) produces a pale yellow body colour in the parasitic wasp Bracon hebetor. This locus exhibits 12% recombination with a recessive mutation called "long" (l), causing antennal and leg segments to elongate. The alternatives to these mutations are the wild type. Determine the phenotype ratios in a cross between two dihybrid wild type wasps.

6. The distances between 8 loci in the second chromosome of Drosophila are presented in the following table. Construct a genetic map showing the order and distance between these 8 loci.

	d	dp	net	J	ed	ft	cl	ho
d	-	10	31	10	20	19	14.5	27
dp		--	13	28	2	1	3.5	9
net			--	41	11	12	16.5	4
J				--	30	29	24.5	37
ed					--	1	5.5	7
ft						--	4.5	8
cl							--	12.5

7. One of the "breeds" of poultry has been largely built on a single gene locus, that for "frizzled" feathers. The frizzled phenotype is produced by the heterozygous genotype M^NM^F. One homozygote M^FM^F produces extremely frizzled birds called "woolies". The other homozygous genotype M^NM^N has normal plummage. A sample of 1000 individuals of the "breed" in the United States contained 800 frizzled, 150 normal and 50 wooly birds. Is this population in equilibrium?

ACTIVITY 5.1: A MODEL OF NATURAL SELECTION

INTRODUCTION:

The mechanism of evolution is natural selection. In nature, evolution proceeds at a rate that is so slow as to be impossible to measure. We can, however, illustrate the results of changes in environment, and the resulting change in gene frequencies mathematically, through the use of a model. Again, the model is useful in illustrating a situation, as well as compacting time to let us glimpse the future.

PART I: A POPULATION IN EQUILIBRIUM

Let's simulate the changes that would occur within a lab population of fruit flies. We'll start with a population that is not in equilibrium, then see how it will achieve equilibrium in succeeding generations. Suppose that we are dealing with fruit flies, looking at two alleles; a wild type allele for normal wing shape, and a recessive st allele for stunted wing. Suppose that we have 200 fruit flies to start with, 100 homozygous wild type males and 100 females with stunted wings. We can represent the gene pool of this P generation using beads. 200 red beads will represent the wild type alleles, 200 yellow beads the st alleles.

We can show a mating between these 200 flies by placing all of the red beads in one beaker and the yellow in another. By drawing a bead from each beaker we illustrate the union of gametes, forming a new diploid individual. Do this, and record the genotype and phenotype of each resulting individual. This produces the Fl generation.

Using the Hardy-Weinberg Law, determine the gene frequencies and if the P or Fl generations are at equilibrium, explaining your results.

We can now determine the F2 generation by placing all of the beads in one beaker and mixing them up. Randomly draw 2 beads out at a time (that means without looking) and record the genotype and phenotype of the offspring. Continue until all of the beads have been withdrawn. Determine if this F2 population is at equilibrium (or close to it), and once again determine the gene frequencies.

Explain why this population is at equilibrium, when the two previous populations were not.

Will the next generation also be at equilibrium? Why?

In this example, the gene frequencies were .50 for each allele. If the wild type allele had a frequency of .80 and the st allele a frequency of .20, how many generations would it take to achieve equilibrium, assuming we start with purebred flies?

What we have done to this point is to establish our model, and to illustrate how the results of matings can be predicted. The populations we started with were not at equilibrium, but quickly came to equilibrium as the result of random matings. The environmental pressure was constant, and no natural selection has been occurring, although we do see the increase in variation, (no heterozygous flies existed in our original sample).

PART II: NATURAL SELECTION

Let's add some additional complications, in that we will change the environmental conditions. Instead of each fly having equal opportunity to survive to mate as we assumed in our first example, let's be more realistic. A fruit fly with stunted wings is less able to survive to maturity due to its reduced ability to fly and obtain food. Let's see how our model can reflect this environmental change, and predict what will happen to the populations and the gene frequencies. Mix all the beads together in one beaker to represent the F1 gene pool again and draw out random pairs. Keep a tally of each genotype as it is withdrawn, and place the beads for each genotype in a separate beaker. (RR in one, Ry in another, yy in a third). Now we'll apply our selective pressure. Suppose that a homozygous stunted fly is 40% less likely to survive than a normal fly. Simulate this by removing 40% of the beads from the beaker containing only yellow beads (homozygous stunted). Remove only an even number of beads, because the selective pressure is removing whole individuals, each of which has two alleles.

Determine the new gene frequencies and check to see if this new population is at equilibrium.

Return the beads to one common beaker, except the beads you removed to simulate the death of the homozygous recessive individuals (you should have less than 400 beads in the beaker). Select the next generation randomly, and discard 40% of the homozygous alleles. Determine the gene frequencies and decide if the population is at equilibrium. Continue to simulate for three more generations.

What are the gene frequencies for each of these new populations? Will the stunted gene ever disappear completely from the population?

You probably predicted that, given enough time, this disadvantageous allele will disappear completely from the population. Here is where our model could lead us astray. An allele such as this would never disappear completely. Can you explain this? As a hint, notice what has happened to the total population size as you have gone through the successive generations. How could you correct the model to more accurately represent a real population?

PART III: EFFECT OF MIGRATION

Use the model to predict the results if every generation 10 homozygous wild type flies are added to the population, in addition to our selective pressure from Part II. Describe the effect of this on the change in the population. Will this population achieve equilibrium? Are there any modifications you might wish to make to your model to be more accurate?

ACTIVITY 6.1: A MODEL OF A CONTROL SYSTEM

INTRODUCTION:

You have had the opportunity to see how a model can be useful in explaining how a system may operate, and can be used to make predictions of how the system will actually operate in a given set of circumstances. The models you have used have been representational in the case of the molecular models used in Unit 1 and mathematical in the model used in the evolution unit just completed.

In this activity you are invited to design, and if you wish, construct your own model. The model you will design will demonstrate the essential components of a control system, such as those found in the body regulating the homeostatic environment. Your model can be representational or mathematical, but you must include the essential components which are a receptor, a conductor, a control centre, and effector and a response. Your model must include an explanation of how each of these components are represented and how the model illustrates the action of a control system. It must be able to predict reliably what is known about control systems in the body.

ACTIVITY 6.2: TONICITY AND CELLS

Adapted from "Investigations in Biology"

G. D. Benson, et al

INTRODUCTION:

When cells are placed in a hypotonic solution, water moves into the cell by the process of osmosis. In some animal cells this process continues until the cell membrane swells and ruptures. In the case of blood cells this is known as haemolysis. If the reverse process occurs (blood cells in a hypertonic solution), the cell loses water to the surrounding fluid and the cell shrinks. This is a process known as crenation.

Furthermore, if plant cells are placed in a hypotonic solution, water moves into the cell and the membrane swells until it reaches the elastic limit of the surrounding cell wall. At this point the plant cell is said to be turgid. This condition is known as deplasmolysis. If the reverse process occurs (plant cells in a hypertonic solution) water leaves the cell causing the cell membrane to shrink away from the cell wall. This condition is known as plasmolysis.

PURPOSE:

To observe the effects of osmosis in red blood cells and leaves of elodea.

MATERIALS:

0.015 M NaCl

0.034 M NaCl

ethanol

distilled water

elodes

microscope slides, cover slips

sterile blood lancets

cotton

toothpicks

PROCEDURE:

PART A: Haemolysis

Obtain three microscope slides and label them as follows: distilled water, 0.15 M NaCl, and 0.034 M NaCl. Sterilize your finger with cotton soaked in ethanol and prick your finger with the sterile lancet. CAUTION: disposable lancets are to be used only once. Do not exchange or reuse lancets. Add one drop of blood to each slide, cover with a coverslip and place on a microscope. On the corresponding slides add a drop of distilled water, 0.015 NaCl, and 0.034 M NaCl to the edge of the coverslips. Examine the slides immediately and then every three minutes for fifteen minutes. Record your results in a chart.

PART B: Plasmolysis and Deplasmolysis

Repeat the procedure from Part A using leaves from an elodea plant or other thin-leaved plant. Observe the distribution of chloroplasts within the cells when distilled water and 0.034 M NaCl are added.

OBSERVATIONS:

Record your observations in chart form, and describe fully the changes that occur in the cells.

QUESTIONS:

1. Define the terms: hypotonic, hypertonic and isotonic.
2. Using the terms in question 1, define osmosis.
3. What methods are used for maintaining isotonic extra-cellular fluid in the amoeba and the herring gull?
4. What is the osmotic relationship between human blood cells and plasma? What evidence indicates this?

ACTIVITY 6.3: OSMOSIS AND WATER BALANCE

In the previous experiment, you were able to see the effect of changes in the osmotic environment on plant and animal cells. In this experiment, we will expand our view to see what effect these changes can have on the entire organism. Again, you will determine the design of the experiment.

There are many examples of the effect of the osmotic environment in everyday situations. What I want you to do is to identify one of these situations, and design an experiment to show the effect of changes in the environment. Complete your design and show it to me before starting the experiment.

ACTIVITY 6.4: DISSECTION

INTRODUCTION:

The purpose of a dissection is to allow you to see the appearance and placement of the internal organs of a specimen. In this activity you will dissect a rat, and examine the respiratory, circulatory, digestive, and excretory systems.

PROCEDURE:

The instruments that you will use for your dissection are scissors, scalpel, probe and forceps. The scissors are the best cutting instrument as they allow you better control than the scalpel. The scalpel will only be used as a scraper or a probe as its use usually causes more damage than help.

Begin by giving your rat a bath in lots of running water to rinse most of the preservative from the fur. This improves the smell and reduces the irritation that the preservative may cause. After the bath is complete, lay the rat on its back in the dissecting tray. Observe the external anatomy carefully before beginning the cutting.

Begin the dissection by making a shallow cut with scissors from the anus to chin up the anterior surface of the animal. Cut just through the skin so that you do not disrupt the muscle found just below. Make two cuts from the middle of the chest up each foreleg, and two from the middle of the abdomen up each hind leg. This will form two flaps which can be folded and pinned back to allow you to examine the musculature of the chest and abdomen.

Make another shallow cut from anus to neck just through the muscle. When you come to the chest it will be necessary to cut through the ribcage. You may wish to make two cuts along each side of the ribcage so that you can expose the lungs more fully.

Now you are free to examine the internal organs. Do not remove any of the organs as it is important to see them in their normal arrangement.

THE RESPIRATORY SYSTEM:

Carefully dissect away the muscle on the front of the neck to expose the larynx and trachea. Follow the trachea until it branches into the lungs. Examine the lobes of the lungs, then dissect away some of the lung tissue to follow the branching of the bronchi. Examine the diaphragm.

THE CIRCULATORY SYSTEM:

Locate the heart and find the atria and ventricles. Trace the path of the major vessels entering and leaving the heart, the superior and inferior vena cava, aorta, and the pulmonary arteries and veins. Follow the aorta and identify the major branchings from it - the carotid arteries, the renal arteries and the arteries branching into the viscera.

THE DIGESTIVE SYSTEM:

Locate the esophagus behind the trachea and follow its path down through the diaphragm to the stomach. Make an incision in the stomach and examine the internal structure. Locate the duodenum where it leaves the stomach and look for the ducts connecting the liver and pancreas to the duodenum. Follow the small intestine to where it enters the caecum and determine the size of the caecum and appendix. Follow the large intestine to the anus.

THE EXCRETORY SYSTEM:

Find the kidneys which are located at the back of the abdominal cavity. Trace the renal vessels and the ureter to the bladder. Remove one of the kidneys and cut it in cross-section from top to bottom to enable you to see the renal cortex, medulla and pelvis.

OBSERVATIONS:

Describe the structures that you have encountered and make a sketch indicating their location in the animal.

Clean and wash all of the dissecting equipment. Wrap the specimen in a paper towel and place in the garbage.

ACTIVITY 7.1: A MODEL ECOSYSTEM

INTRODUCTION:

The purpose of this activity is to establish a model ecosystem. Our objective is to set up a closed system which will function without any outside intervention at all, once the initial conditions have settled down. You could, for example, set up an aquarium with a couple of goldfish, a few plants, and a food source for the goldfish. You must consider all of the biotic and abiotic components of your system, and analyse the expected relationships within the system.

Before setting up the system you must give me a complete and detailed plan for the model listing each and every component that will be a part of it, and describe its role within the system. Remember, the system will be completely closed and no outside interference will be permitted once the system is established.

ACTIVITY 7.2: INTERACTIONS IN ECOSYSTEMS

Adapted from "Biological Science, An Ecological Approach"

INTRODUCTION:

In this activity you will study the growth of a population using a mathematical model. Using a set of assumptions, you will be able to examine the rate of growth of the population and, by altering the assumptions, use the model to predict the outcome.

PROCEDURE:

Let us begin with real organisms--house sparrows. Now imagine an island. On that island, in the spring of 1972, is an imaginary (hypothetical) population of 10 house sparrows - 5 male/female pairs.

Here are our assumptions:

Assumption 1: Each breeding season (spring), each pair of sparrows produces 10 offspring, always 5 males and 5 females.

Assumption 2: Each year all the breeding (parent) birds die before the next spring.

Assumption 3: Each year all offspring live through the next breeding season. (In most real situations some parents would live and some offspring would die. But taken together, assumptions 2 and 3 tend to balance each other, reducing the difference between the model and a real situation.)

Assumption 4: During the study no other sparrows arrive on the island, and none leave.

How will the model work? You need to calculate the size of the hypothetical population at the beginning of each breeding season. According to assumption 1, in the spring of 1972 there are 10 birds. Each of the 10 pairs produces 10 offspring, a total of 50 offspring. According to assumption 2, the 10 breeding birds of 1972 die before the next spring. According to assumption 3, all of the 50 offspring live to the spring of 1973. Thus, at the start of the 1973 breeding season, there are 50 house sparrows on the island, and, again according to assumption 1, there are 25 males and 25 females - 25 pairs. Continue with this kind of reasoning to calculate the island's sparrow population at the beginning of the breeding season in 1974, 1975, 1976 and 1977.

You now have a series of numbers; you can get a clearer idea of the population change by plotting the numbers on a line graph. Construct the graph so that the years are shown along the horizontal axis and the number of birds along the vertical axis. Make the vertical scale large enough to show the 1977 population. Plot as many generations as you can.

No doubt you had difficulty plotting all the data on ordinary graph paper. This difficulty can be overcome with another tool--semi-logarithmic graph paper. It is not necessary to fully understand the mathematics of logarithms to use this tool. Ask your instructor to explain how to use this paper.

Construct your semi-log graph with the same data you used before.

ANALYZING THE DATA:

Look first at the arithmetic graph. How does the slope of the line connecting the plotted points change as you read from left to right? What does this mean in terms or rate of population change? Now compare the graphs. What kind of line shows the same thing on the semi-log graph? If you were to continue to use the same set of assumptions to calculate populations for an indefinite number of years and plot them on the graph, what would happen to the slope of the line on the arithmetic graph? What would happen to the slope on the semi-log graph?

FURTHER INVESTIGATION:

The model can reflect changes in conditions by changing the assumptions. Make each of the following changes successively and plot the growth of the population in each case.

1. Change assumption 2 as follows: each year 2/5 of the breeding birds (equally males and females) live to breed again a 2nd year and then die. All other assumptions remain unchanged.
2. Change assumption 3 as follows: each year 2/5 of the offspring (equally males and females) die before the beginning of the next breeding season. All other assumptions remain unchanged.
3. Change assumption 4 as follows: each year 40 house sparrows (equally males and females) leave the island None arrive. All other assumptions are unchanged.

INTERACTION BETWEEN SPECIES

A model such as described above can be expanded to include the interaction between two different species, usually in a predator-prey relationship. Make changes in the model to reflect this type of interaction. The other population could be a type of insect that would be prey to the sparrows. Run the model through at least 10 years to see if it adequately reflects a normal pattern. If it does not, make changes to the assumptions in order that it more accurately reflects the real world.

ACTIVITY 7.3: ECOLOGY AND ECOLOGY

INTRODUCTION:

On almost any day, the newspapers, television and radio will report on some incident involving the ecosystem. They may comment on chemical or radioactive waste disposal, leaks of hazardous material, or the efforts of biologists to monitor and protect a portion of the environment. Generally, these articles are accurate in their analysis of the ecological aspects of the problem, but occasionally their analysis is not the best.

For this activity, I would like you to watch for articles in the newspaper or shows on television which are concerned with ecological issues. Analyze carefully their content and particularly their conclusions and write a review of the show or article. Prepare reports on at least three articles, preferably on different topics and from different sources.

ACTIVITY 7.4: FIELD STUDY

INTRODUCTION:

This activity may be a part, or all of your report for this unit. Choose a community within the local ecosystem and analyze it. If this is to be the basis for your report, you must be thorough in your examination and study the ecosystem as fully as possible. This must include a description of the abiotic factors, an inventory of the plant and animal life found and a description of the niches occupied and the relationships within the system. There are many lab manuals and textbooks available within the room for your use.

If this is not to be your report, restrict your analysis to only one aspect of the community.

Design your study and have it approved before beginning.

REFERENCES

Albersheim, P., Dowling, J., and Hopkins, J., The Molecular Basis of Metabolism--A Laboratory Block, Biological Sciences Curriculum Study, Univ. of Colorado: D. C. Heath, 1968

Barrows, H. S. and Tamblyn, R.M., Problem-Based Learning--An Approach to Medical Education, New York: Springer, 1980.

Benson, G.D., Hunt, F.C., Lunn, D.T., and Shostal, E.J., Investigations in Biology, Don Mills Ont.: Addison-Wesley, 1977.

Carlock, J.R. and Moore, H.A., In the Laboratory--The Spectrum of Life, New York: Harper and Row, 1970

Engel, C.E., Problem Solving, Problem Based, Problem Centered and all that..., Centre for Medical Education Research and Development Newsletter, University of New South Wales

Freeman, W.H.(ed), The Living Cell, Readings from Scientific American, San Francisco, 1965

Galbraith, D.I. and Wilson, D.G., Biological Science, Principles and Patterns of Life, Toronto: Holt, Rinehart and Winston, 1966

Gonick, L. and Wheelis, M., A Cartoon Guide to Genetics New York: Barnes and Noble, 1983

Kimball, J.W., Biology, (4th edition), Don Mills Ont.: Addison Wesley, 1978.

--------, Biology, A Laboratory Introduction, Reading Mass: Addison-Wesley, 1967.

Lawson, C.A. and Paulson, R.E. (ed), Laboratory and Field Studies in Biology, New York: Holt, Rinehart and Winston, 1960.

--------, Biological Science, Molecules to Man (B.S.C.S. Blue, 3rd edition), Boston: Houghton Miffin, 1973

Lee, Addison E. (chairman), Biological Science, An Ecological Approach, (B.S.C.S. green version, 3rd edition), Univ. of Colorado: Rand McNally, 1973

McKusick, V.A., Human Genetics, (2nd edition), Englewood Cliffs, New Jersey: Prentice-Hall, 1969

Morholt, E., Experiences in Biology (6th edition), New York: Harcourt, Brace and World, 1967

Neufeld, V.R., Adventures of an Adolescent, Curriculum Changes at McMaster University, The New Biology and Medical Education, Ed., Friedman, C.P. and Purcell, E.s., Josiah Macy Jr. Foundation, 1983

--------, and Barrows, H.S., The 'McMaster Philosophy': An Approach to Medical Education, J. of Medical Education, 49, 1040-1050, 1974

Novak, J.D., A Theory of Education, Ithaca N.Y.: Cornell University Press, 1977

Otto, J.H. and Towle, A., Modern Biology, New York: Holt, Rinehart and Winston, 1965.

Problem Based Learning, Editorial, Medical Education, 15, 1-3, 1981

Schmidt, H.G., Problem-Based Learning: Rationale and Description, Medical Education, 1983

Stansfield, W.D., Theory and Problems of Genetics, New York: McGraw-Hill, 1969

Watson, J.D., The Double Helix, New York: McLelland and Stewart, 1968

--------, Molecular Biology of the Gene, (3rd edition), Menlo Park, California: W.A. Benjamine, 1977

Weinberg, S.L., Biology Laboratory Manual, Boston: Allyn and Bacon, 1968

APPENDIX

VALIDATION DRAFT SEPTEMBER, 1984

of

BIOLOGY: ONTARIO ACADEMIC COURSE

RATIONALE

The Ontario Academic Course in Biology is designed to prepare for biology programs in university. Much of the biology beyond the OAC level involves a biochemical approach, and this course will provide them with an introduction to this important aspect of the subject. Although the course is reasonably rigorous, it contains many applications and societal implications of the content covered that will be useful and of great interest to the students. They will, as a result of taking the course, gain new insights into some of the social issues that confront our society.

VALIDATION DRAFT September 1984

BIOLOGY

ONTARIO ACADEMIC COURSE

Unit Number	Time Allotment Hours	Unit Title
	CORE UNITS	
CU 1	16 h	Chemical Basis of Life
CU 2	16 h	Metabolism of Cells
CU 3	16 h	Plant Phsiology
CU 4	16 h	Genetics
CU 5	16 h	Evolution
CU 6	15 h	Vertebrate Physiology
	OPTIONAL UNITS: Select any one	
OU 1	15 h	Microbiology
OU 2	15 h	Animal Behaviours
OU 3	15 h	Ecology
OU 4	15 h	Local Unit
Total	110 h	

Note: The order of unit is suggested. The order of units may be rearranged or integrated with one another.

VALIDATION DRAFT September 1984

Biology - Ontario Academic Course

Core Unit #1

THE CHEMICAL BASIS OF LIFE Time: 16 h

100 RATIONALE

This unit has two main emphases: the basic biochemical concepts relating to the functioning of organisms; and scientific explanations of sub-organismic processes. The significance of the basic premises underlying scientific explanations are illustrated by the laws of thermodynamics.

110 OBJECTIVES

111 Attitudes: Students will be encouraged to develop:

a) a curiosity about the biochemistry of cellular processes (121, 141, 191, 193, 194);

b) an appreciation for the fact that scientific models are an aid to visualizing the shape and areas of chemical activity in molecules (121, 131, 193), 197).

112 Skills: Students will develop skill in:

a) building molecular models (122, 131, 196, 197);

b) identifying unknown substances (reducing sugars, proteins, fats) 124, 132);

c) making solutions of specific concentrations (123, 133);

d) observing temperatures at which enzyme activity is greatest (124, 133);

e) designing and performing experiments to investigate the factors affecting enzyme activity (123-24, 133, 198);

f) organizing in tabular form data from experiments on enzyme activity and chemical reactions (123-24, 133, 199);

g) isolating and identifying amino acids (124, 135);

h) making and interpreting a chromatograph of amino acids (124, 135).

113 Knowledge: Students will:

a) define or explain basic chemical terms: atom, ion, molecule, crystal, polar molecule, hydrogen bonding, covalent bond, nature of C-H bond, isomers, and simple carbon, hydrogen, and oxygen structures (121, 131);

b) recognize and draw important functional groups: alcohol, carbonyl (in the aldehyde and ketone positions), carboxyl, amino, sulfhydro, and illustrate the groups with specific reference to an organism's metabolism,

c) with reference to an organism's metabolism, illustrate four major types of chemical reaction, namely, neutralization, oxidation-reduction, condensation, and hydrolysis and state that in oxidation-reduction reactions, energy released in oxidation is greater than that required for reduction (123, 194);

d) recognize that oxidation-reduction reactions occur when electrons or hydrogen atoms are transferred from one substance to another (123);

e) explain specific chemical reactions in biology in terms of the first two laws of thermodynamics (121, 123, 195);

f) describe and recognize specific linkages, e.g., esters, glucosides (ether), and peptides (122, 131);

g) compare and contrast anabolic (endergonic) and catabolic (exergonic) reactions (123);

h) account for the process of polymerization in terms of condensation reactions (123, 194);

i) define the terms monosaccharide, disaccharide, fats, proteins, nucleic acids (124, 132);

j) explain the formation of important biological polymers, e.g., starch, glycogen, cellulose, proteins, fats, and nucleic acids (124, 132);

k) describe the significance of major organic molecules to the functioning of organisms (124, 141);

l) define the terms buffer and pH, and explain their role in maintaining homeostasis in and determining the habitat of organisms (124, 142);

m) explain in proposed mechanism for buffered solutions resisting pH changes (123, 133);

n) define the term enzyme (124);

o) account for the shapes of enzymes in terms of hydrogen bonding and sulphur bridges (124);

p) based on results of student experiments, explain the use of a scientific model by reference to the lock-and-key model of enzymatic specificity (124, 133, 199);

q) explain the effect of heat and pH changes on the shape and activity of enzymes (denaturation) (124, 133);

r) account for the effect of denatured enzymes on the activities of cells (124, 133);

s) explain the basis for identifying amino acids by paper chromatography (124, 135).

120 TOPICS

121 Basic chemical concepts

122 Functional groups and linkages

123 Chemical reactions

124 Biologically important organic molecules

130 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

131 build molecular models of functional groups, amino acids, polypeptides, and important linkages (196-97);

132 perform tests to identify the presence of glucose (Benedict's Reagent), proteins (Millon's Reagent), and fats (smear test) (171);

133 design and perform experiments to investigate the effects of the following on enzymatic activity: temperature, concentration on substrate and enzyme, pH changes (199);

134 analyse milk, saliva, urine for chemical composition such as sugar, fats, proteins;

135 isolate and identify amino acids using paper chromatography;

136 determine the pH of various substances, e.g., milk or saliva.

140 APPLICATIONS

141 The nutrition of organisms should be drawn from the three major chemical groups.

142 The life of an organism depends on its ability to maintain homeostasis, which in turn depends on the maintenance of the proper pH level.

150 SOCIETAL IMPLICATIONS

151 Research in the field of molecular biology, particularly that involving DNA, may result in the synthesis of beneficial products for commercial use e.g, synthetic insulin.

152 A balanced diet is very important in order to provide the fundamental organic groups (as they are assimilated by the body) for later synthesis into necessary tissues or energy reserves during metabolic processes.

153 The synthesis of complex organic molecules may provide the basis for consideration of theories concerning the origin of life forms during primitive earth conditions.

154 The organization of molecular processes is an underlying principle which may be applied to higher levels of biological

organization, e.g., cell, organism, ecosystem.

155 Greater knowledge of suborganismic biological processes has led to major breakthroughs in medicine, pest control, and environmental safety.

156 Greater knowledge of suborganismic biological processes has led to newer theories relating to longevity and the aging process.

160 <u>EVALUATION OF STUDENT ACHIEVEMENT</u>

At least 30 per cent of evaluation of student achievement for this unit is to be based on the following three components:

161 laboratory experiments and co-operative team work;

162 written and oral reports;

163 demonstrated ability to make logical predictions and draw inferences.

170 <u>SOME SAFETY CONSIDERATIONS</u> (See also p. 000.)

171 Warn students that some solutions are harmful if they are allowed to touch the skin (e.g., hydrochloric acid) or if inhaled (Millon's Reagent).

172 Wear safety goggles when using hazardous chemicals.

180 <u>POSSIBLE EXTENSIONS</u>

181 Discuss theories on the origin of life (e.g., Urey-Miller, Oparin).

190 SOME TEACHING SUGGESTIONS

191 Throughout, it is important to emphasize that the chemical concepts introduced in this unit are a means to an end; that is, they help explain sub-organismic biological phenomena.

192 Parts of this unit may be taught in succeeding units if the teacher believes this to be more appropriate.

193 Students who have had an advanced chemistry course may find some of the material in this unit a review. None the less, the material should be covered in sufficient depth so that students without a strong chemical background can understand chemical explanations.

194 Encourage students to make predictions of the possible products or reactants from chemical reactions involving condensation and hydrolytic reactions.

195 Emphasize the importance of the first two laws of thermodynamics as the underlying principle and/or need for writing balanced chemical equations. Students should also realize that although these laws cannot be empirically proven, their immense value lies in their predictive ability.

196 Encourage students to build ball-and-spring models of functional groups, and of molecules with ester, glucoside, and peptide linkages. Evaluate the models on the basis of their correctness (as indicated by written instructions) and also by students' responses to questions.

197 Emphasize to students the importance of using visual models to understand the structure of chemical substances.

198 When students are performing experiments, encourage them to

account for their observations in terms of the concepts presented in the unit.

199 Ask students to account for the "organized" synthesis of macromolecules. Relate this to enzyme specificity.

VALIDATION DRAFT -September 1984

Biology - Ontario Academic Course

Core Unit #2

METABOLISM OF CELLS Time: 16 h

200 RATIONALE

This unit has two main emphases: the biological principle that structure determines function; and the relationship between cellular respiration and the cell membrane. The fluid-mosaic model is introduced to explain the various interactions between a cell and its environment. Cellular respiration is examined both in terms of its importance to the functioning of an individual organism and to that of an ecosystem.

210 OBJECTIVES

211 Attitudes: Students will be encouraged to develop:

a) an appreciation of the principle of structure determining function as central to an understanding of biology (222, 291);

b) a curiosity about the use of scientific models which help to visualize biological structures and phenomena (222, 291).

212 Skills: Students will develop skill in:

a) interpreting electron-micrographs of cell membranes (222, 234);

b) preparing slides to observe mitochondria (222, 237);

c) performing experiments to investigate diffusion and osmosis (221, 232-32, 271);

d) performing experiments to investigate fermentation (223, 235, 244);

e) interpreting and graphing data from experiments on diffusion, osmosis, and fermentation (221, 223, 231-32, 235, 271).

213 Knowledge: Students will:

a) define or use the terms solution, solute, solvent, selectively permeable membrane, hypotonic, hypertonic, isotonic, diffusion, osmosis (221);

b) predict the direction of movement of solute and solvent particles through a selectively permeable membrane (221, 231);

c) state the composition and characteristics of a typical living membrane (phospholipids, cholesterol, proteins) (222);

d) explain how the fluid-mosaic model of the membrane accounts for phenomena associated with the membrane (222, 291);

e) account for the movement of solutes and solvents through a selectively permeable membrane on the basis of the fluid-mosaic model (221);

f) explain the effect of such factors as heat, pH, and organic solvents on membrane permeability (221, 236);

g) explain passive transport in terms of motion of particles (221);

h) define and state the importance of pinocytosis and phagocytosis (221);

i) state the characteristics of active transport (221);

j) use a scientific model to account for the apparent characteristics of active transport (e.g., the movement of solute particles against a concentration gradient) (221, 291);

k) define anaerobic respiration (223);

l) justify the reactions in anaerobic respiration on the basis of the first and second laws of thermodynamics (223, 292);

m) state the importance of anaerobic respiration to the ecosystem and to humans (223);

n) define aerobic respiration (223, 292);

o) relate the importance of aerobic respiration to the functioning organism and to the ecosystem (223);

p) justify selected steps in aerobic respiration on the basis of the first and second laws of thermodynamics (223, 292);

q) relate the production of ATP to active transport (223, 293);

r) relate the importance of aerobic respiration to the functioning organism and the ecosystem (223, 294);

s) explain how a cell's ability to obtain sufficient amounts of metabolites from the external environment and release waste products into the environment depends on the ratio of surface area to the volume of the cell (224);

t) describe how all membrane activity depends on the energy released by cellular respiration (223, 293).

220 TOPICS

221 Cell environment: selectively permeable membrane, active and passive transport

222 Structure and function of the cell membrane: the fluid-mosaic model

223 Aerobic and anaerobic respiration, fermentation, the first and second laws of thermodynamics

224 Relationship between surface area and volume of a cell

230 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

231 perform experiments to illustrate diffusion e.g., the diffusion of glucose and iodine through a dialysis membrane;

232 design and perform experiments to demonstrate and measure rates of osmosis;

233 synthesize coacervates;

234 interpret electron micrographs of membranes;

235 perform fermentation experiments (yogurt, baking);

236 perform experiments to demonstrate the effect of heat, pH, and organic solvents on membrane permeability;

237 observe mitochondria by preparing slides of celery.

240 APPLICATIONS

241 Discuss the importance of understanding membrane structure and function as it applies to the action of antibodies recognizing and attacking component parts of "different" cell membranes.

242 Respiration is the main source of heat liberated by organisms in silage and manure heaps.

243 Heat liberated during respiration has many implications for large ecosystems.

244 Several common foods and beverages are produced by fermentation, e.g., baked goods, wine, dairy products.

245 Greater public awareness of the importance of aerobic health helped create the current fitness boom.

246 Scientists' knowledge of cell membrane structure has been applied to cancer research and treatment.

250 SOCIETAL IMPLICATIONS

251 Countries in which people consume relatively little fat have a lower incidence of heart disease and hypertension than does North America.

252 Industries whose products are based on the fermentation process make an important contribution to the economy.

236 perform experiments to demonstrate the effect of heat, pH, and organic solvents on membrane permeability;

237 observe mitochondria by preparing slides of celery.

240 APPLICATIONS

241 Discuss the importance of understanding membrane structure and function as it applies to the action of antibodies recognizing and attacking component parts of "different" cell membranes.

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250 SOCIETAL IMPLICATIONS

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252 Industries whose products are based on the fermentation process make an important contribution to the economy.

260 EVALUATION OF STUDENT ACHIEVEMENT

At least 30% of the evaluation of student achievement for this unit is to be based on the following three components:

261 laboratory experiments and the demonstrations of proper techniques;

262 the ability to explain reactions on the basis of the first and second laws of thermodynamics;

263 written and oral reports.

270 SOME SAFETY CONSIDERATIONS (See also p. 000.)

271 Follow standard safety procedures in the laboratory, especially in experiments involving organic solvents. Use these solvents only in a fume hood.

280 POSSIBLE EXTENSIONS

281 Discuss the significance of different end-products in anaerobic respiration (fermentation) in yeast and in mammals.

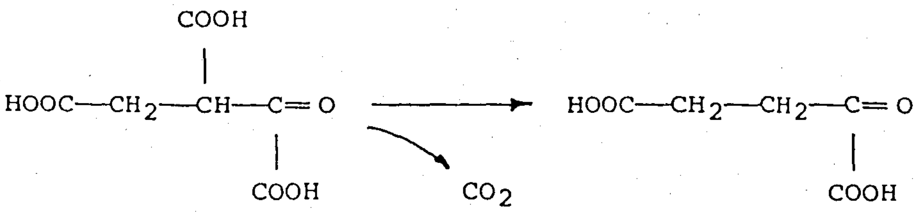
282 Explain why the Davson-Danielli model of the membrane has been modified to the fluid mosaic model.

283 Give explanations of muscle fatigue and muscle aches.

290 SOME TEACHING SUGGESTIONS

291 Emphasize the usefulness of such models as the fluid-mosaic model in visualizing both structure and function.

292 Students do not need to memorize chemical formulae and equations for respiration. From diagrams of the process of anaerobic and aerobic respiration, they should explain specific steps on the basis of the first and second laws of thermodynamics, for example;



oxalosuccinate ketoglutarate

Both laws are followed in that all the atoms can be accounted for, and entropy has increased in the generation of a gas.

293 Although this unit stresses the importance of ATP in active transport, it is important to point out that this molecule, along with other "energy-rich" molecules, is the energy source for numerous biological phenomena at the cellular level, e.g., muscle contraction, the synthesis of chemical compounds.

294 Discuss the relevance of respiration to such biological phenomena as decomposition, warm-bloodedness, and of the synthesis of useful products for humans.

295 Relate the concepts in this unit to the physiology units.

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Biology - Ontario Academic Course

Core Unit #3

PLANT PHYSIOLOGY Time: 16 h

300 RATIONALE

In this unit students will learn how plants convert energy into useful forms through the process of photosynthesis. Rather than memorizing the biochemistry involved, students should understand the mechanisms by which plants obtain the raw materials for photosynthesis and the importance of the end products to the biosphere. The laboratory activities will help students develop skill in growing and caring for plants.

310 Attitudes: Students should be encouraged to develop:

a) an appreciation for plants as living organisms that require care and preservation (325, 351, 353);
b) an appreciation for the fact that all living organisms depend on plants for their survival (325, 351);
c) an appreciation of green plants for their esthetic as well as economic value (325, 341-43);
d) a concern for the sensitive balances that regulate the life of plants and all other organisms (321-323);
e) a curiosity in the careers that are based on the germination and preservation of plants (325, 344, 394).

311 Skills: Students will develop skill in:

a) preparing and observing wet-mount slides of various plants and communicating their observations effectively either orally or in writing (322, 331);

b) analysing electron micrographs of plant structures (322, 335);

c) inferring the relationship between a plant structure and its function (322, 331, 334);

d) caring for living plants (325, 339n);

e) designing an experiment demonstrating how photosynthesis is affected by various changes in a plant's environment (324, 337);

f) interpreting graphs of data obtained from experiments with photosynthesis (321-23, 337);

g) researching topics related to plant physiology (321-323, 325, 338a, b).

313 Knowledge: Students will:

a) describe the process of converting energy from solar to chemical potential energy in the form of ATP, with the emphasis on the conversion of non-usable energy into usable energy forms (321, 339f);

b) explain the mechanisms by which ATP and reducing power (NADPH2) are produced by the light-dependent reaction (323);

c) explain the basic mechanisms by which CO_2 is reduced in the light reaction (321);

d) identify the site of photosynthesis in plants, chloroplast structure, and the location of photosynthetic cells in stems and leaves (322, 331, 334-35);

e) describe the basic structure of transport vessels (xylem--vessels and tracheids; rays--vertical and lateral), emphasizing that cells are living and are interconnected across their walls by extensions of the cytoplasm (plasmodesmata) (324, 332);

f) account for the sources, methods of entry, and transport of raw materials (gases, water, minerals, ions, and macromolecules) to the sites of photosynthesis, e.g., through leaf pull, capillarity, translocation (323);

g) explain the influence of the growth medium on the availability of raw materials, e.g., the effect of pH on nutrient availability (phosphates), the determination of habitat (sphagnum moss in acidic environments) (323);

h) based on evidence from experiments, describe how the rate of photosynthesis is affected by CO_2 concentration, temperature, light intensity and quality, light duration (photoperiod) (323, 337);

i) explain why plants are the earth's most important source of oxygen (325);

j) account for the interrelationship of photosynthesis and aerobic respiration (323);

k) explain how plants collect and concentrate raw materials to produce an end product (glucose) that can be used as the basis for the synthesis of other macromolecules, i.e., carbohydrates, fats, proteins, and others (e.g., poppy--opium, tobacco, coca--cocaine) (323);

l) explore the importance of plants to humans by selecting one of the following sections:

Food

i) explain why plants are the primary sources of food for all living organisms (i.e., they are the base of all food chains) (325, 339c-d);

ii) describe the advantages of a vegetarian diet in terms of cost, energy content, and nutrition (e.g., it has a low fat and salt content (325, 339a-b);

iii) outline the deficiencies of strict vegetarian diets (i.e., whether the proper balance of amino acids is maintained) (325, 339a-b);

iv) describe the importance of dietary fibre to the proper functioning of the human digestive system (325, 339c);

m) Fibre and Fossil Fuel

i) list the chemical and structural properties that make plants useful for fibres, building materials, and fuels, stressing that plants are renewable resources (325, 339f, 351, 353);

ii) describe the process by which plants were formed into fossil fuels (325, 339j);

iii) state the uses of fossil fuels for energy, stressing their non-renewability and the importance of their wise use (325, 339i);

Useful Chemicals

n) list specific compounds synthesized by plants that are used directly in or as bases for chemical substances and products, e.g., in medicines, pesticides, rubber (325, 339k);

General

o) i) state the esthetic value of plants, e.g., in landscaping, as interior decoration for homes, offices and restaurants include biological aspects (325);

ii) explain how plants are used to control soil erosion and to improve water drainage (325).

320 TOPICS

321 Photosynthesis: light and dark reactions

322 Plant structures and functions involved in photosynthesis

323 Raw materials of photosynthesis: source, methods of entry into the plant, transport to the site of photosynthesis

324 Conditions influencing the rate of photosynthesis

325 The uses and care of plants, their importance to human life

330 STUDENT ACTIVITIES

Activities, 331, 334-35, 337, and 339 are mandatory.

Students are to:

331 prepare and observe microscope slides of plant tissue and to describe their observations;

332 use paper chromatography to separate accessory pigments in chlorophyll;

333 observe the passage of ultraviolet light through chlorophyll extractions and explain observations in terms of

fluorescence;

334 examine thin-leafed aquatic plants to study chlorophyll structures and the presence and density per cell;

335 determine the size and shape of chloroplasts observed in electron micrographs;

336 measure the effects of water content on cell structure as related to osmotic pressure;

337 demonstrate the effects of CO_2 concentration, light quality and intensity, temperature, and photoperiod on the rate of photosynthesis by measuring O_2 bubble production;

338 a) research the historical development of the photosynthetic process, and current developments in vitro;

b) research the efficiency of energy conversion in crop species, e.g., leaf orientation on a plant, chlorophyll concentration in conifers;

339 investigate the importance of plants to human life by choosing <u>one</u> of the following sections to correspond to the appropriate knowledge objectives ;

<u>Food</u>

a) evaluate the reliability of advertising claims for health food;

b) visit a health food store and make a list of the products made from plants;

c) analyse the plant content of their daily diet and assess the fibre intake;

d) perform a library search on the role played by ruminant animals in the utilization of plants for human food;

e) research the history of the domestication of common food plants;

Fibre and Fossil Fuel

f) research the economic importance of a plant-related industry, (e.g., the contribution of crop plants, the pulp and paper industry) and the efficient use of the labour force in that industry to our standard of living (352);

g) examine various natural fibres (e.g., cotton, linen) to determine their unique properties;

h) research the importance of fossil fuels to industrialized nations (354);

i) examine coal and coke with the unaided eye and a hand lens;

Useful Chemicals

j) research the principles and treatment methods of holistic medicine;

k) demonstrate the ripening of green bananas by placing them into a plastic bag with apples (plastic bags emit ethylene to promote the ripening process);

l) demonstrate the use of onions as a natural herbicide in a sample garden.

340 APPLICATIONS

341 Plants make a wide range of contributions to daily life, from the practical (food and clothing) to the esthetic (house plants)

342 Better understanding of the principles of the photosynthetic

process has led to improved cultivation of plants for personal pleasure (e.g., in the house or garden) and for commercial/industrial uses.

343 Plants can be used as pollution indicators, e.g., petunias for ozone, gladiolas for fluorides.

344 Many careers are based on the maintenance and germination of plants, e.g., forestry, nursery management.

350 <u>SOCIETAL IMPLICATIONS</u>

351 Plants are a major source of the necessities of life (food, oxygen) and of such important products as lumber, paper fibre, and medicines.

352 Industries based on the production, maintenance, and processing of plants and plant products make an important contribution to Canada's economy.

353 Plants are a renewable resource. Prudent management of this resource is vital for future economic stability.

354 Industrialized nations need to reduce their dependence on fossil fuels as an energy resource.

360 <u>EVALUATION OF STUDENTS ACHIEVEMENT</u>

At least 30 per cent of the evaluation of student achievement for this unit is to be based on the following four components:

361 laboratory techniques and experiments;

362 written and oral reports;

363 project assigned in activity 339;

364 design of an experiment demonstrating the conditions influencing the rate of photosynthesis.

370 <u>SOME SAFETY CONSIDERATIONS</u> (See also p. 000.)

371 Follow basic laboratory safety procedures.

372 Caution must be exercised when using chromatography solvents.

380 <u>POSSIBLE EXTENSIONS</u>

381 Analyse the absorption spectra of various chlorophylls.

382 Investigate the role light plays in the synthesis and destruction of chlorophyll.

383 Compare the structural formulae of hemoglobin, cytochromes, and chlorophyll from an evolutionary point of view.

384 Examine chloroplasts in liverworts and mosses.

385 Compare the energy efficiency of long and short food chains.

386 Investigate plant adaptations to environmental conditions, e.g., the greater ability of C_4 plants to withstand high temperatures.

387 Demonstrate seed germination by fermenting the pulp of ripened tomatoes, drying the seeds, treating with hot water, and then planting (the inhibitor is blocked).

388 Investigate the effect of giberellins and auxins on plant growth.

389 a) Design an experiment to investigate the yield per acre of various plant crops, i.e., conduct test trials.

b) Research developments in acquaculture, e.g., the feasibility of harvesting the ocean as a means of increasing global food supplies.

390 SOME TEACHING SUGGESTIONS

391 The knowledge objectives of this unit should emphasize experimentation as much as possible.

392 Plan lessons carefully to ensure that the seedlings and plants required for experiments are available.

393 In activity 339, many of the options can be done concurrently if groups of students share experimental work.

394 Wherever possible, outline career opportunities relating to plant science.

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Biology - Ontario Academic Course

Core Unit #4

GENETICS Time: 16 h

400 RATIONALE

This unit has two emphases: a review of basic concepts from the Grade 11 unit on continuity and the development of genetic knowledge. Through analysis of experimental evidence, students will consider genetics as it relates to the cell, to individual organisms, and to populations.

410 OBJECTIVES

411 Attitudes: Students will be encouraged to develop:

a) critical-mindedness towards the tentative and changing nature of scientific ideas and theories relating to genetics (423);

b) a questioning attitude towards controversy among scientists concerning interpretations and applications of genetic knowledge (423);

c) an appreciation of social change and social problems that have resulted from scientific research in and technological applications of genetics (423, 442, 452);

d) an appreciation of the fact that many of the differences among humans are due to genetic variability (424).

412 Skills: Students will develop skill in:

a) crossing *Drosophila* to illustrate sex linkage, 9:3:3:1 ratios (424, 431, 471);

b) preparing and observing slides of the various stages of meiosis (422, 435);

c) using models to illustrate the Hardy-Weinberg principle and violations of it (424, 436);

d) performing a library search to obtain information relating to genetic research and societal concerns, e.g., cloning, amniocentesis (423, 434, 491);

e) using a punnet square to solve problems involving monohybrid and dihybrid crosses, probability, multiple alleles, sex-influenced and sex-limited inheritance, sex linkage, and population genetics (424, 432);

f) using probability laws to predict the results of crosses, e.g., the probability of two events occurring in a specific order such as having a boy, girl, girl, boy, in that order or having two boys and two girls in any order (424, 432-33);

g) making diagrams illustrating the stages of protein synthesis.

413 Knowledge: Students will:

a) state the chemical structure of a DNA molecule and an RNA molecule, their similarities and differences (421, 438-39);

b) list the four kinds of nucleotides in DNA, grouping them according to whether they are purines or pyrimidines (421, 438-39);

c) explain the role of DNA in the synthesis of proteins;

d) explain how a single strand of DNA constitutes a genetic message (421, 438-39);

e) explain why scientists think that DNA codes in triplets (421, 439);

f) describe how the experiments of G. Mendel, R. Feulgen, H. Muller, F. Griffith, A. Hersey, M. Chase, J. Watson, F. Crick, F. Stalh, M. Meselson, E. Chargaff, Sutton, and T. Morgan contributed to our understanding of genetics (423);

g) list at least two types of mutation at the DNA level (421);

h) describe the stages of meiosis and its role in diploid organisms (422, 435);

i) describe two ways in which meiosis increases genetic variability in gametes (422, 439 ii);

j) describe the special behaviour of homologous chromosomes during prophase of meiosis 1 (422,439 ii);

k) explain how crossing over occurs (422, 439 ii);

l) explain the term reduction division as applied to anaphase 1 of meiosis (422);

m) compare gametogenesis in male and female animals (422, 439 ii);

n) trace a given dihybrid genotype, e.g., AaBb, through gametogenesis and show all the possible genetic combinations (424, 433);

o) explain the relationship between blue eyes (phenotype), the "gene" for blue eyes (genotype), and the DNA molecule (424, 433);

p) explain how sex is determined in chickens, bees, fruit flies, and humans (424);

q) using a diagram, show how males determine the sex of their offspring in humans and why the probability of a male and female offspring is equal (424);

r) carry out a dihybrid cross such as AaBb x AaBh in three ways: (1) where the pairs of alleles are in different chromosomes; (2) where they are too closely linked on one chromosome for crossing over; and (3) where they are linked on the same chromosome but there are 90% non-recombinations and 10% recombinants (424, 433);

s) weigh the societal benefits and risks of such technological advances in genetics as cloning, amniocentesis, in vitro fertilization, sperm and egg banks, agricultural uses of genetic engineering, embryo transplants, gene therapy, recombinant DNA research (423, 434, 442, 452);

t) research genetic diseases in humans, e.g., Down's Syndrome, hemophilia, Klinefelter's Syndrome, Turner's Syndrome, Huntington's Chorea, muscular dystrophy (425, 434, 441, 444);

u) define the Hardy-Weinberg principle and illustrate by using a common trait such as tongue rolling T and t alleles in parent and student generation (424, 436).

v) construct a gene map, given test cross information (421, 437);

w) illustrate how factors such as selection, mutation, genetic drift and migration influence the Hardy-Weinberg equilibrium which has implications for speciation.

420 TOPICS

421 Biochemical genetics

422 Cellular genetics

423 Genetic research and technology: contributions of individual scientists, influences on society

424 Population genetics: inheritance of traits; probability laws, speciation

425 Genetic diseases in humans

430 STUDENT ACTIVITIES

Activities, 431-35 are mandatory. Students are to:

431 perform experiments involving monohybrid or dihybrid crosses of *Drosophila* (471);

432 determine the principles of probability and relate them to genetic crosses;

433 solve problems involving specific genetic crosses;

434 carry out a research project on the state of knowledge in a particular area of genetic research and its influence on the family and society, e.g., sperm and egg banks; cloning, in vitro embryos; embryo transplants; abortion; amniocentesis; genetic counselling; genetic screening; genetic diseases; recombinant DNA; animal and plant breeding (artificial selection); eugenics; industrial uses of genetic engineering (441-43, 451-52, 491);

435 observe prepared slides of the stages of meiosis;

436 use diagrams and models to illustrate the Hardy-Weinberg principle;

437 construct a gene map from test cross information;

438 Develop a model of a strand of DNA illustrating a specific sequence of nitrogen bases and the helical nature of the molecule;

439 i) using a model of a DNA molecule illustrate its role in protein synthesis and the transmission of genetic information;

ii) Draw chromosome diagrams for mitosis and meiosis to illustrate chromosome behaviour during specific stages and their respective end products;

iii) demonstrate chromosome crossing over using pipe cleaners or facsimile as a model.

440 APPLICATIONS

441 Thanks to genetic counselling, people are better able to make informed family planning decisions.

442 Technological advances in embryo formation and development, e.g., through sperm and egg banks and in vitro fertilization, have had a tremendous impact on agriculture and on family planning.

443 Genetic engineering has made possible the development of disease-resistant and high-yield crop species (451).

444 Through genetic counselling and gene mapping in the fetus, the incidence of genetic defects in a population may eventually be reduced.

450 SOCIETAL IMPLICATIONS

451 The development of new hybrid crosses in agricultural crops, poultry, and livestock has enhanced global food production and agriculture's contribution to Canada's national economy.

452 Greater public awareness of the aims and products of genetic engineering is needed because there are many difficult moral and ethical questions relating to this area of scientificresearch.

460 EVALUATION OF STUDENT ACHIEVEMENT

At least 30% of the evaluation of student achievement for this unit is to be based on the following two components:

461 laboratory work;

462 essay or research report from activity 434.

470 <u>SOME SAFETY CONSIDERATIONS</u> (See also p. 000.)

471 Stress the proper techniques for working with <u>Drosophila</u>.

480 <u>POSSIBLE EXTENSIONS</u>

481 Prepare slides of <u>Drosophila</u> chromosomes from the salivary gland of the larvae.

482 Breed mice to study a trait such as albinism.

483 Grow tomatoes or corn in order to observe the inheritance of specific traits in plants.

490 <u>SOME TEACHING SUGGESTIONS</u>

491 For activity 434, have students consider the value of genetic research by analysing the economic and social benefits in terms of the risks. They should also consider ethical implications.

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Biology - Ontario Academic Course

Core Unit #5

EVOLUTION Time: 16 h

500 RATIONALE

One of the greatest influences on modern biology has been the theory of evolution. This unit gives students opportunities to analyse the meaning and historical development of evolutionary theory, from Lamarck and Darwin/Wallace to the present. Through their research and investigations, students will be helped to understand its value in explaining evidence from various fields of biology as well as the general nature and role of theories in science. Students should also be reminded that the theory of evolution gives only one set of insights into the origin of life on earth. Other fields of study such as religion, philosophy and astronomy influence personal hypotheses on the origin of the universe and the life in it.

510 OBJECTIVES

511 Attitudes: Students will be encouraged to develop:

a) an open-mindedness towards scientific hypotheses and theories because they are tentative and continually changing (521, 551, 592);

b) an alert scepticism towards statements of authority in scientific discourse (523-24, 551, 595);

c) an appreciation of the fact that there is controversy among scientists concerning interpretations and applications of the theory of evolution (521, 523-24, 534, 591, 593);

d) a curiosity about the theory of evolution as a tool scientists use to explain natural phenomena of the past and present and to speculate about the future (523-24).

512 Skills: Students will develop skill in:

a) abstracting relevant information from reading selections on evolutionary theory and identifying the main ideas, the argument sequence, and the author's point of view (521-24, 533-34, 592);

b) using beads or other suitable material to construct models of populations in Hardy-Weinberg equilibrium and show how such factors as migration and genetic drift influence a gene pool (523, 532);

c) using the library and other sources to obtain information on the evidence in support of evolution (521, 523-24, 533-34).

513 Knowledge: Students will:

a) state Lamarck's theory of the inheritance of traits and give examples of applications, e.g., why giraffes have long necks (521, 533);

b) state the Darwin/Wallace theory and give examples of applications (521, 533);

c) use Darwin's theory of natural selection to explain the fourteen species of finches on the Galapagos Islands (521, 531);

d) define species and discuss variability within a species with reference to animals and humans (522, 533);

e) describe the colour change in the population of peppered moths and explain in terms of natural selection (521, 531);

f) list at least three isolating mechanisms, give examples of each, and explain why they are necessary for speciation (522, 533);

g) discuss the role of isolation in speciation with respect to the Galapagos finches (521, 533);

h) state the Hardy-Weinberg principle and explain it in terms of evolution (523);

i) explain how such factors as migration, mutation, and genetic drift violate the Hardy-Weinberg principle and lead to evolution (523, 532);

j) state the modern theory of evolution and compare it with Darwin's theory (521-23, 533);

k) use the modern theory of evolution to explain evidence from an area of biology, e.g., comparative embryology, paleontology (524, 533-34, 542, 594).

520 TOPICS

521 Origins and development of evolutionary theory: Lamarck, Darwin/Wallace

522 Speciation: the role of isolation and isolating mechanisms in evolution

523 Modern theory of evolution: the Hardy-Weinberg principle, the genetic basis of evolution

524 Applications of the theory of evolution to various fields of biology.

530 STUDENT ACTIVITIES

All of the following are mandatory. Students are to:

531 use a model to demonstrate natural selection and graph the results;

532 use a model to demonstrate the Hardy-Weinberg principle and the factors influencing equilibrium.

533 perform a literature search in one of the following areas of biology and write a paper showing how the theory of evolution helps explain evidence in that particular field:

a) paleontology: examine hominid fossils and analyse various interpretations of the data. By taking a hominin type such as the Neanderthals, explain how, from an examination of the same evidence, scientists can have different interpretations (542, 594);

b) comparative anatomy: compare the anatomy of various mammals;

c) comparative embryology: compare the embryos of various vertebrates;

d) comparative biochemistry: compare biochemical similarities among living organisms, e.g., the presence of cytochrome enzymes in almost all living organisms or amino acid sequences in the hemoglobin of mammals;

e) chromosome structure: compare karyotypes of closely related species, e.g., chimpanzees, orangutans, and humans (542);

f) geographical distribution: compare the distribution of plants and animals in the oceanic islands, e.g., the Galapagos finches;

g) domestication: select a plant or animal species, e.g., corn or the dog, to show how a species can be altered by selective breeding (541);

534 read the evidence in support of human evolution and show how the same evidence or facts can be used to support different interpretations (592).

540 APPLICATIONS

541 The mechanisms of speciation and genetic mutation to create change within species provide the potential of selective breeding for domestic agricultural and livestock species.

542 Possible evolutionary paths of organisms are used to establish ancestral links using a variety of evidence e.g., fossils, comparative embryology.

550 SOCIETAL IMPLICATIONS

551 By developing the ability to distinguish among facts, theories, and opinions--not only in scientific writings but also in the popular press-people can make better decisions on matters relating to the influence of science and technology on their lives.

552 Some areas of science are not clear-cut, resolvable issues and regardless how detailed the analysis may get, a definitive answer may not be possible at present.

553 The study of science is dynamic and currently held beliefs must adapt and often be modified in light of new data.

554 The theory of evolution gives only one set of insights into the origin of life on earth. Other fields of study such as religion, philosophy and astronomy influence personal hypotheses on the origin of the universe and the life in it.

560 EVALUATION OF STUDENT ACHIEVEMENT

At least 30% of the evaluation of student achievement for this unit is to be based on the following two components:

561 research papers

562 laboratory experiments and reports

570 SOME SAFETY CONSIDERATIONS (See also p. 000.)

571 Observe standard safety procedures when working in the laboratory.

580 POSSIBLE EXTENSIONS

581 Use the evidence for the origin of life to illustrate evolution, e.g., Oparin's hypothesis, Urey-Miller's contributions.

582 Research theories on the origin of races and discuss the reasons for racial similarities and differences.

583 Describe chronometric and relative dating techniques, e.g., C_{14}, the potassium-argon method.

584 Show how the behavioural, biochemical, and anatomical similarities among primates support the theory of evolution.

590 <u>SOME TEACHING SUGGESTIONS</u>

591 This unit should be taught after the unit on Genetics in order to deal with the genetic basis of evolution.

592 In this unit the emphasis is on the role of theories in science; therefore, it is important to ensure that students can distinguish among and use properly such terms as fact, theory, and hypothesis.

593 Discussion on various aspects of and points of view on evolution must be handled sensitively and with tact.

594 If possible, arrange a class visit to a museum so that students can observe fossils, e.g., hominids, dinosaurs, the various types of plant and animal fossils.

595 Emphasize to students that personal beliefs are formed and strengthened by listening to, reading, and evaluating evidence contrary to one's opinions.

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Biology - Ontario Academic Course

Core Unit #6

VERTEBRATE PHYSIOLOGY Time: 15 h

600 RATIONALE

Nothing is more relevant to students than their own bodies. With this continuation of the analysis of vertebrate systems studied in the Grade 11 Advanced - Level Biology course, students will be helped to understand the body's biochemistry and the metabolic functions performed by cells. The focus of the unit is homeostasis--the processes and mechanisms that maintain it and its application to all living things.

610 OBJECTIVES

611 Attitudes: Students will be encouraged to develop:

a) an appreciation for the need of organisms to maintain a stable internal environment to sustain life (621);

b) an awareness of the significance of the extracellular fluid on the internal composition of a cell (622, 634, 642);

c) an appreciation of the role of feedback systems in the maintenance of homeostasis within a cell or organism (623, 692-93);

d) a respect for narrow tolerance limits in metabolic functions, deviations from which may have serious consequences, e.g. shock or death (625);

e) a respect for the concept of homeostasis and its application at all levels of biological organization.

612 Skills: Students will develop skill in:

a) designing models to illustrate the concept of a feedback system (623, 632-33, 646, 692-93);

b) recording and graphing data from investigations involving the relationship of cells to their environment and interpreting the results (622, 634-35, 639, 672);

c) making solutions of various concentrations to simulate hypo-, hyper-, and isotonic ECF environments (622, 634, 672);

d) dissecting a mammalian organ directly involved in maintaining homeostasis, e.g., kidney or brain (624, 636, 671);

e) making inferences about the nature of large-scale systems from principles applicable to a small scale, e.g., the need for homeostasis in the biosphere can be inferred from its importance to the cell (621, 647);

f) designing experiments demonstrating the effect of various stimuli on homeostatic mechanisms, e.g., alcohol and caffeine depress ADH concentration, thus diminishing the capacity of nephrons to reabsorb H_2O (624, 635);

g) performing experiments to demonstrate the effects of hyper-, hypo-, and isotonic solutions on plant and animal cells (622, 624, 634);

h) labelling diagrams of mammalian excretory and nervous systems (624, 636).

613 Knowledge: Students will:

a) define the term homeostasis and explain its significance to a state of dynamic equilibrium (621);

b) explain the importance of controlling the internal and external environments in both unicellular and multicellular organisms (621, 631);

c) give the tolerance ranges for various metabolic states, e.g., normal blood pH is 7.4, while a pH of 7.3 or 7.5 may result in a coma (625, 638);

d) explain the homeostatic control of at least four metabolic conditions, e.g., H_2O balance, pH, body temperature, blood glucose, ions (Ca^{++}, K^+, and Na^+) (624, 632, 692-93);

e) distinguish between positive and negative feedback systems, comparing methods of operation and end results (623, 633, 646, 693);

f) describe several mechanisms, both physical and behavioural, that allow multicellular organisms to adapt to environmental conditions, e.g., body temperature-homeothermic and poikilothermic species, H_2O and salt balance - marine and freshwater species (624, 644-45);

g) explain how cellular processes such as active transport and osmosis help regulate an organism's internal environment (624, 641, 691);

h) outline the process of nephron filtration and the necessary conditions for the reabsorption of essential solutes, e.g., glucose, vitamins, sodium, H_2O, and amino acids (624, 636-37, 643, 651-52);

i) define the terms endocrine gland and exocrine gland and give an example of each (623);

j) explain the significance of the pituitary and hypothalamus glands to the regulation of hormonal feedback systems, e.g., ADH (anti-diuretic hormone), TSH (thyroid stimulating hormone), adrenalin in menstrual and ovarian cycles, and their role in H_2O reabsorption (623, 633, 646);

k) list the instruments and tests commonly used to measure and monitor levels of metabolic products, e.g., the thermometer, urinalysis, blood analysis (625, 638);

l) describe the processes that regulate the supply of ATP within a cell and the importance of ATP to active transport, e.g., the relationship of the sodium pump to proper muscle fiber and nerve impulse transmission (624);

m) describe how the nervous system allows animals to receive, interpret, and respond to environmental stimuli (624, 636);

n) describe various disorders that result from malfunctions of homeostatic control systems and methods of treatment, e.g., diabetes mellitus is the result of a pancreatic malfunction and is treated with insulin; nephron malfunction is treated by dialysis; constipation, by laxatives; hyperacidity of blood, by such buffering agents as bicarbonates (625, 639, 641, 643, 651-52).

620 TOPICS

621 Homeostasis: definition and significance to all levels of biological organization

622 External environment of cells

623 Feedback systems: positive and negative

624 Maintenance and control of homeostasis: osmosis and active transport, the endocrine and nervous systems

625 Malfunctions of homeostatic mechanisms

630 STUDENT ACTIVITIES

Activities 632-36 are mandatory. Students are to:

631 write a research report on the scientists who postulated and proved the existence of the homeostatic principle, e.g., Claude Bernard, Walter Cannon;

632 design a model demonstrating the essential components of a control system (receptor, conductor, control centre, effector, and response);

633 demonstrate a positive or negative hormonal feedback system by modifying the control system model (662);

634 perform experiments to demonstrate the effects of hyper-, hypo-, and isotonic environments on both plant and animal cells (RBC) (672);

635 design an experiment to illustrate conditions affecting the osmotic process in the control of the water balance in a cell (641, 691);

636 dissect a mammalian kidney and/or brain (671);

637 compare the excretory systems of a variety of vertebrate classes, e.g., fish, birds, desert rodents;

638 perform a urinalysis to test for the presence of substances, e.g., glucose, amino acids, that may indicate a metabolic malfunction;

639 design an experiment to test the effectiveness of various commercial buffers in neutralizing the acidity of a solution, i.e., excess HCl in gastric secretions during stress conditions (672).

640 <u>APPLICATIONS</u>

641 Osmotic principles may be used to prevent plants from wilting, to preserve foods, and to treat wounds and digestive disorders, e.g., constipation or diarrhea.

642 The behaviour of cells in hypertonic environments may account for the sensation of thirst after salty foods have been eaten.

643 The technology for kidney dialysis was developed from knowledge of the process of selective reabsorption in the nephron (651-52).

644 Techniques for combatting hypothermia are based on knowledge of the body's physiological responses to cold water or air temperatures.

645 Air trapped by body surface hair can have an insulating effect. Application of this principle can be seen in clothing designed for extremely cold climates, e.g., goose down is used for jackets and coats.

646 Menstrual feedback systems can be artificially manipulated either to decrease or increase the possibility of conception. By altering estrogen and progesterone levels, ovulation can be prevented, while altering FSH and LH levels increases the number of eggs released, thus improving the chances for fertilization.

647 Homeostatic principles can be seen in the cycling of organic matter in an ecosystem, i.e., in C, N, and P cycles

648 An understanding of homeostatic controls allowed scientists to develop effective treatment methods for malfunctions of control mechanisms, e.g., the blood sugar levels of diabetics could be controlled with insulin

650 <u>SOCIETAL IMPLICATIONS</u>

651 Physicians' increased knowledge of renal disorders and the public's greater awareness of the funding needed for such treatment has made dialysis techniques more effective and treatment accessible to more people.

652 Recent advances in medical research have allowed people with diabetes and kidney disease to lead normal, productive lives.

660 EVALUATION OF STUDENT ACHIEVEMENT

At least 30 per cent of the evaluation of student achievement for this unit is to be based on the following two components:

661 laboratory experiments and reports;

662 development of a working model of a feedback system.

670 SOME SAFETY CONSIDERATIONS (See also p.000.)

671 Wear disposable gloves and protective goggles during dissections.

672 Exercise caution when handling acid solutions.

673 Follow appropriate sanitary procedures in performing urinalysis.

680 POSSIBLE EXTENSIONS

681 Research A. B. MacCallum's hypothesis that the resemblance of body fluids to the composition of seawater suggests that life may have originated in the oceans.

682 Explain the concept of the countercurrent model in Henle's loop.

683 Perform an experiment to demonstrate glycogen conversion to glucose using diastase.

684 Discuss the conversion of lactic acid to pyruvic acid during muscle fatigue.

685 Relate the importance of the skin (vitamin D), thyroid, and parathyroid in maintaining adequate levels of calcium and

phosphorus in bones and blood.

686 Research Banting and Best's contributions to the treatment of diabetes.

687 Explain the significance of proper diet and eating habits to the efficient operation of homeostatic mechanisms.

688 Discuss the importance of Ringer's solution in fresh dissections.

690 SOME TEACHING STRATEGIES

691 Emphasize to students the relevance that cellular processes such as osmosis and diffusion have to their daily lives.

692 Using a model may be an effective means to demonstrate the operation of a control system and the comparison between positive and negative feedback.

693 The concept of a feedback system that can be applied to many metabolic processes may be further enhanced by the theory of biofeedback, e.g., used in coping with stress.

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Biology - Ontario Academic Course

Optional Unit #1

MICROBIOLOGY Time: 15 h

100 RATIONALE

This unit emphasizes laboratory activities as a means of helping students understand the relationship of micro-organisms to an ecosystem and their effects on human life.

110 OBJECTIVES

111 Attitudes: Students will be encouraged to develop:

a) a respect for the place of beneficial species of bacteria in the world (124, 142, 152-53, 191-92);

b) a commitment to help control contagious diseases caused by microorganisms by good personal hygiene (125, 143, 151).

112 Skills: Students will develop skill in:

a) preparing and examining slides of the various classes of microorganisms (yeast, moulds, protists, blue-green algae, and bacteria) (123, 131, 171-72);

b) using aseptic techniques to prepare culture media and to sterilize equipment (122, 131, 133, 138);

c) preparing culture plates and transferring and incubating bacteria (122, 133, 136);

d) determining the bacteria count in a water sample (122, 138, 192);

e) isolating and culturing bacteria in food such as dairy products (122, 131);

f) isolating and culturing yeast and moulds (122, 131);

g) identifying the types of protists in a sample of pond water (122, 132);

h) making a fermented food product, e.g., yoghurt (122, 134);

i) performing experiments to determine the factors affecting bacteria growth and using appropriate counting techniques to analyse the results (122, 133);

j) performing experiments to test the effectiveness of antibiotics and antiseptics on bacteria (125, 135).

113 Knowledge: Students will:

a) describe the different aspects of microbiology and the functions performed by microbiologists in such fields as food, soil and sanitation (121, 191);

b) review the characteristics of monerans, fungi, protists, and viruses, and give examples of their function within an ecosystem (124);

c) relate the results of their experiments to the functions of microorganisms in an ecosystem (124);

d) describe the conditions affecting bacterial growth, methods of identification (gram positive and gram negative), and practical applications (e.g., in the food industry) (123, 133);

e) research the beneficial uses of microorganisms (in fermentation--alcohol and acid production; in milk products; in decomposition; nitrogen fixation; genetic research) (124, 139b, 141-42, 144, 152-53);

f) research communicable diseases--sources of infection, effectiveness of antibiotics, antiseptics, and disinfectants (mouthwashes, toothpaste), and chemotherapy (125, 137);

g) describe the epidemiology of a viral disease such as typhoid fever, gonorrhea, syphilis, influenza, herpes, rabies and AIDS (125, 139a);

h) describe the production, mode of action, and effectiveness of antibodies (125);

i) describe the mode of action, effectiveness, and harmful side effects of antibiotics (sulfonilamides, penicillins, actinomycins, tetracyclines) (125, 137).

120 <u>TOPICS</u>

121 Microbiology as a field of study

122 Microbiology techniques

123 Monerans, viruses, fungi, and protists: general characteristics

124 Harmful and beneficial effects of microorganisms on the ecosystem and on humans

125 Communicable diseases spread by microorganisms, treatment methods

130 STUDENT ACTIVITIES

Activities 131-36 are mandatory. Students are to:

Laboratory activities (191)

131 culture microorganisms (e.g., yeast or bread mould) and observe under the microscope (171-72);

132 use the microscope to observe and identify the species of microorganisms in a sample of pond water (192);

133 culture *E. coli* and design experiments to determine the factors affecting growth (171);

134 make yoghurt or another fermented product;

135 test the effectiveness of various mouthwashes, disinfectants, antiseptics, and antibiotics on bacteria;

136 test the bacteria in water, soil, and food samples (192);

137 use the proper staining techniques to prepare slides of E. coli (171);

138 determine the sources of bacteria in the school by culturing bacteria from various locations, e.g. cafeteria, pool, locker area;

Library search activities

139 a) investigate the epidemiology of a communicable disease (143);

b) investigate the beneficial effects of microorganisms (141-42, 144).

140 APPLICATIONS

141 Microorganisms have great economic importance in agriculture,

medicine, the pharmaceutical industry, and the food industry.

142 Many products in daily use are produced with bacteria, e.g., beer and wine, compost for use in home gardens, certain dairy foods.

143 The spread of contagious diseases can be prevented by proper hygiene.

144 Microorganisms, particularly E. coli bacteria, have important uses in genetic research.

150 SOCIETAL IMPLICATIONS

151 Knowledge of proper hygiene and the treatment of contagious diseases may help to reduce the cost of medical treatment.

152 The role of bacteria in the decomposition of organic material is significant in the operation of nutrient cycles.

153 Genetic manipulation in microorganisms, e.g. E. coli, has made possible the production of chemicals used to treat ailments, e.g. human insulin for the treatment of diabetes.

160 EVALUATION OF STUDENT ACHIEVEMENT

The evaluation of student achievement for this unit is to be based on the following three components:

161 laboratory experiments and demonstration of proper techniques;

162 laboratory reports;

163 library search reports and oral presentations.

170 SOME SAFETY CONSIDERATIONS (See also p. 000.)

171 Ensure that students use the proper techniques for handling and disposing of microorganisms and for handling chemicals and stains.

172 Use only non-pathogenic varieties of microbes for experiments.

180 POSSIBLE EXTENSIONS

181 Do a science fair project that is an extension of the laboratory investigations.

182 Review the literature on the current uses of microorganisms in genetic research.

190 SOME TEACHING SUGGESTIONS

191 Have students tour a sewage treatment plant to observe the use of microorganisms to control pollution.

192 For the experiments involving analysis of soil and water samples, take students on a field trip in the community to collect the samples.

191 Emphasize to students the importance of performing laboratory activities as a means of understanding the uses and functions of microorganisms.

192 Through discussion and research activities, students should develop an understanding of the influence of microorganisms on ecosystems and on their lives.

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Biology - Ontario Academic Course

Optional Unit #2

ANIMAL BEHAVIOUR Time: 15 h

200 RATIONALE

This unit takes two approaches to the study of animal behaviour: ethological and behavioural. Students are introduced to the basic premises of both approaches, in particular the importance of understanding an animal's behaviour in terms of its environment and with respect to its evolutionary development.

For each phylogenetic level, from the simplest to the most complex, students are given opportunities to observe and describe animal behaviour, to analyse the significance of the behaviour in terms of the animal's environment, and to infer the physiological basis of a behaviour pattern.

Their investigation with a variety of living organisms should help students develop an active concern for the conservation of the natural and a humane attitude towards all living things.

210 OBJECTIVES

211 Attitudes: Students will be encouraged to develop:

a) an attitude of care and respect towards living organisms (221);

b) an objectivity in viewing living organisms in terms of their own behaviour patterns rather than from an anthropomorphic point of view (221);

c) a questioning attitude towards experiments that cannot be replicated in order to confirm results (221-24, 231-36, 291).

212 Skills: Students will develop skill in:

a) caring for living organisms used in the laboratory (221, 223-24);

b) designing experiments to test hypotheses about animal behaviour, e.g., reaction to light, sound, smell, taste (222, 234);

c) designing and carrying out an experiment that uses positive reinforcement to condition a vertebrate (221, 223, 232, 273, 292-94);

d) setting up and using appropriate laboratory equipment (221-24, 231-36);

e) establishing appropriate variables in an experimental set-up (221-24, 232-36);

f) making careful observations of phenomena being investigated (221-24, 231-36, 291);

g) recording data accurately, summarizing the data, and making valid interpretations (221-24, 231-36);

h) writing formal reports of laboratory experiments with animal behaviour (221-24, 231-36);

i) dissecting and labelling the parts of a vertebrate nervous system, with emphasis on the brain (222, 236);

j) using the library to research the nervous system of a vertebrate and describe the relationship between the complexity of behaviour and the complexity of the nervous system (222, 237);

k) observing and describing the behaviour of vertebrates (e.g., the gerbil, guppy, ring dove) and inferring the adaptive value (223, 233, 271-72, 274, 291-94);

l) observing the response of various invertebrates, e.g., the paramecium, hydra, planaria, sow bugs, to chemicals (weak acid, saline solution) and electricity (224, 235).

213 <u>Knowledge</u>: Students will:

a) distinguish between ethological and behaviourist experimental techniques and advocates, e.g., imprinting vs. conditioning (221, 231-32, 239, 241-42);

b) describe different types of behaviour, e.g., taxis, reflex, habituation, instinct, imprinting, conditioning, learning, and give examples of each (223-24);

c) use ethological concepts, e.g., sign stimuli and a fixed action pattern, to describe the instinctive behaviour of an organisms in the laboratory (221, 223-24, 233);

d) list the parts of the human nervous system (222);

e) contrast the structure and function of a sensory neuron and a motor neuron (222);

f) explain the electrochemical changes that occur during nerve impulse transmission (222);

g) using a diagram, illustrate an action potential and show the resulting changes in polarity as measured by an oscilloscope (222);

h) diagram and describe a simple reflex arc (222);

i) compare vertebrate nervous systems, emphasizing brain structure (222, 236);

j) relate the complexity of the nervous system in such invertebrates as paramecium, hydra, planaria, insects, and lower vertebrates to the complexity of behaviour observed in the laboratory (222, 235, 237);

k) describe the adaptive value of the behaviour of organisms observed in the laboratory (221, 231);

l) compare the senses of lower vertebrates and humans and their role in the organism's behaviour (223, 234);

m) describe the relationship of hormones (estrogen, progesterone, and testosterone) to instinctive behaviour (222);

n) describe the contributions of ethologists and behaviourists such as K. Lorenz, N. Tinberger, von Frisch, and B. F. Skinner to our knowledge and understanding of animal behaviour (221, 238).

220 TOPICS

221 Animal behaviour: ethological and behavioural approaches, contributions of individual scientists

222 Physiological basis of behaviour: senses, central nervous system, nerve impulses, hormones

223 Characteristic vertebrate behaviours: reflex, habituation, instinct, imprinting, conditioning

224 Characteristic invertebrate behaviours: taxis, reflex, habituation, instinct, learning

230 STUDENT ACTIVITIES

Laboratory Activities

Activities 231-32 and 237 are mandatory. Students are to:

231 perform an experiment based on ethological research by imprinting a newly hatched duck or chick in a certain behaviour and doing an ethological study for one week (271-72, 274, 292-94);

232 perform an experiment based on behavioural research by conditioning the behaviour of a vertebrate, e.g., a gerbil, mouse, or rat (272-74, 292-94);

233 observe the reproductive and courtship behaviour of a vertebrate (e.g., ring doves) and describe the behaviour in terms of instinct (fixed action pattern) (294);

234 perform experiments demonstrating the human senses (sight, sound, smell, taste, and touch), e.g., determine the location of the sense (taste) receptor, or demonstrate touch by

testing the receptor density in various parts of the body;

235 observe the behaviour of various invertebrates such as paramecium, planaria, hydra, or sow bugs and relate the behaviour to the organism's physiology (291);

236 dissect the nervous system of a preserved vertebrate, e.g., a fetal pig, with particular attention to the brain;

Research activities

237 research the nervous system of a vertebrate and describe the relationship between the complexity of behaviour and the complexity of the nervous system;

238 research the contributions of Nobel Prize winners in ethology and behaviour;

239 compare the approach taken by human learning theorists, e.g., Piaget, and that of animal behaviourists, e.g., Skinner.

240 APPLICATIONS

241 Ethological techniques have been used to promote the learning process in children.

242 Positive and negative reinforcement techniques have been used by child behaviourists and psychologists.

243 Basic conditioning techniques used by ethologists in their research have also been adopted by humans to teach animals specific tasks or "tricks", e.g. teaching a dog to sit up and "beg".

244 Animals have been trained to perform high risk tasks, thus reducing the danger to human lives, e.g. dolphins are sometimes used to locate oceanic mines.

245 Ethological principles are used in the training of animals used to assist disabled people, e.g. seeing eye dogs, dogs for the deaf, rhesus or capuchin monkeys for quadriplegics.

250 SOCIETAL IMPLICATIONS

251 The behaviour an organism exhibits, whether it be learned or instinctive, has survival value to the individual species.

252 Some ethological principles provide a reference base for child rearing, e.g. reward as positive reinforcement for a desired behaviour such as telling the truth.

253 Ethological studies have assisted psychologists and educators in understanding and treating abnormal human behaviours and learning disabilities in children.

254 Animal behaviour studies have helped to improve populations of endangered species, e.g. peregrine falcons.

260 EVALUATION OF STUDENT ACHIEVEMENT

This unit places a major emphasis on laboratory work, which should be considered in the evaluation of students' work. At least 50% of the evaluation of student achievement for this unit should be based on major reports consisting of the results of two of the following:

261 an ethological study;

262 a conditioning experiment;

263 a research component dealing with a vertebrate nervous system.

270 SOME SAFETY CONSIDERATIONS (See also p. 000.)

271 Consult the Animals for Research Act and board documents on the care and keeping of animals. If newly hatched chicks or ducks are used, ensure that proper facilities are set up in the classroom and that a proper home can be obtained for these animals after one week.

272 All animals used in the classroom should have adequate food, water, and cage facilities at all times. Students must not perform any experiments that cause pain to the animals or that deprive them of sufficient food and water.

273 Conditioning experiments should demonstrate only positive reinforcement. Emphasize to students the importance of handling animals with care.

274 Wild animals should not be brought into the classroom. Obtain the animals for experiments from a science supply store or a pet store.

275 Avoid the use of animals that may cause allergic reactions to students in your class.

280. POSSIBLE EXTENSIONS

281 Read the Scientific American article by Lehrman, The Reproductive Behaviour of the Ring Doves[1], and describe the relationship between behaviour and hormones.

282 Raise stickleback fish and observe instinctive behaviour. Use the Scientific American article by N. Tinbergen, The Curious Behaviour of the Stickleback[2], to explain ethological

concepts, e.g., stimuli.

283 Research the influence of drugs on the nervous system.

284 Report on recent findings in brain research.

285 Read the Scientific American articles by Skinner, How to Teach Animals[3], and Hess, Imprinting in Animals[4], and compare the parameters of ethological and behaviourist research.

286 a) Investigate the application of ethological research to the study of humans, e.g., work with autistic children.

b) Investigate the relationship between genes and behaviour, e.g., the influence of an extra sex chromosome on deviant behaviour.

c) Investigate the relationship between learning and memory (retention span) in humans.

287 Raise crayfish to observe the effects of slight variations of temperature on behaviour, or raise guppies to observe ritual courtship behaviour and record observations.

288 Where possible, investigate the effect of electrical stimuli of varying strengths on the action potential in a frog neuron and gastroanemius muscle tissue.

289 Use statistical tests(e.g., the chi-square test) to analyse data from experiments. The microcomputer could be used here to analyse data.

290 SOME TEACHING SUGGESTIONS

291 The major emphasis in this unit should be on laboratory activities. Encourage students to make careful, detailed observations and to record all observations accurately. For example, the conditioning experiment should stress the design

and method of the experiment rather than the results. The role of experimentation and observation in developing theories should be stressed. Students should also be encouraged to develop a humane attitude toward all living organisms.

292 Because of the length of time needed to observe animal behaviour, the experimental and research work in the unit could be ongoing. For example, if this unit were taught in conjunction with the animal physiology unit, students would have more time to spend in studying and conditioning their animal and completing their research paper. The vertebrate ethological studies can be done as out-of-class work.

293 Encourage students to be responsible for the daily care and feeding of their animals. Giving students this task encourages the development of a responsible attitude and concern for living organisms.

294 If lack of facilities and board restrictions make the experiments with larger vertebrates impractical, use films and film loops to illustrate a variety of species in a wide range of behaviours.

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1. The Reproductive Behaviour of Ring Doves, D. S. Lehrman; Scientific American Volume 211, No. 5, November 1984, pp. 48-54
2. Imprinting Animals, E. H. Hess, Scientific American Volume 198, No. 3, March 1958, pp. 81-90
3. How to Teach Animals, B. F. Skinner, Scientific American Volume 185, No. 6, December 1951
4. The Curious Behaviour of the Stickleback, N. Tinberger, Scientific American Volume 187, No. 6, December 1952, pp. 22-26

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Biology - Ontario Academic Course

Optional Unit #3

ECOLOGY Time: 15 h

300 RATIONALE

In this unit the emphasis is on the contributions of ecological research to our understanding of the environment. Students are introduced to the kinds of questions ecologists ask, the techniques used to answer these questions, and the value and limitations of research data in predicting the effects of both natural and artificial alterations to the environment.

Various approaches may be taken to the study of ecology, for example, teachers could stress either field studies and experiments, or case studies involving data description of main concepts, or analysis of ecological issues. This unit defines the key concepts which would be uniform across the province but at the same time allows teachers the flexibility to choose the approach best suited to their resources.

310 OBJECTIVES

311 Attitudes: Students will be encouraged to develop:

a) a questioning attitude toward research on ecological issues with respect to its predictive value and limitations (321-22, 335, 392-93);

b) an appreciation of the ecosystem model, as a useful tool in the study of the environment (321, 331, 341);

c) a commitment to acquire enough scientific knowledge to make informed decisions about societal issues relating to ecology (321-22, 333, 342);

d) a respect for the limitations on the amount of energy and natural resources of the biosphere (321);

e) a respect for the conflicting interests and concerns of commerical interests and environmentalists (321-22, 351-52);

f) an appreciation of the sensitive balances that regulate the life of an ecosystem (321-22, 331, 341);

g) a responsible attitude toward the effects of their actions (e.g., littering) that directly or indirectly affect the environment (321-22, 341-42).

312 Skills: Students will develop skill in:

a) performing experiments in the field and in the laboratory (321-22, 331, 334);

b) using the library to obtain information relating to ecological concerns (321-22, 336);

c) interpreting the data obtained from a field or research study, describing the techniques used to obtain the data, and explaining the limitations of the data (321-22, 335);

d) evaluating knowledge claims about ecological issues (321-22, 333, 342).

313 Knowledge: Students will:

a) describe an ecosystem in terms of biotic and abiotic factors (321, 331);

b) using a description, illustrations, or a model ecosystem such as an aquarium or terrarium, explain the interactions among organisms, energy flow, and biogeochemical cycles within an ecosystem (321, 331);

c) describe problems that are studied by ecologists (321-22, 336);

d) collect data on ecological concerns from government, industry, and individuals, e.g., conduct a local survey on toxic waste disposal (321-22, 332, 335);

e) make a field, pond, or stream profile (321-22, 334);

f) use diagrams or illustrations to describe succession in one or two environments, e.g., in sand dunes, a pioneer field, bare rock (322);

g) describe succession in a particular ecosystem, e.g., the Great Lakes, and distinguish between the changes that are a result of natural phenomena and those caused by human intervention (322).

320 TOPICS

321 Concept of an ecosystem: populations and communities, energy flow, biogeochemical cycles, interdependence

322 Concept of succession: natural changes, human changes

330 STUDENT ACTIVITIES

Activities 331-333 are mandatory. Students are to:

331 set up and study a model ecosystem;

332 analyse research results, e.g., predator-prey relationships, population curves, water-soil analysis (392;

333 critically analyse media articles on ecological topics;

334 take field trips to ponds or woods to collect data (371);

335 interpret data from a field or research study (392-93);

336 perform a library search on ecological issues, e.g., acid rain.

340 APPLICATIONS

341 Research in ecology has increased our understanding of the effects of human intervention in the biosphere.

342 Knowledge of ecology is the basis for evaluating environmental issues and for a respectful attitude towards nature.

350 SOCIETAL IMPLICATIONS

351 Government has had to set controls and limits on the acceptable level of various air, soil, and water pollutions.

352 Many ecological problems, e.g., acid rain, can be solved only through the co-operation of government and industry.

360 EVALUATION OF STUDENT ACHIEVEMENT

Evaluation of student achievement should be consistent with the approach used. For example, if the teacher chooses a field studies approach, then at least 35 per cent of the evaluation should be based on experimental work. If a case study or critical issues approach is taken, then 35 per cent of the evaluation should be based on an analysis of knowledge claims and research skills. This could be in the form of a seminar or formal research paper.

370 SOME SAFETY CONSIDERATIONS (See also p. 000.)

371 The necessary safety precautions should be observed on field trips. Follow board policy, where applicable.

380 POSSIBLE EXTENSIONS

381 Extensions would be dependent on the selection of the ecological issue or community chosen as the main focus to develop basic ecological concepts.

390 SOME TEACHING SUGGESTIONS

391 This unit may be taught as an interdisciplinary unit with the geography or history department.

392 As stated in the rationale, a major aim of this unit is to emphasize some of the contributions of ecological research to our understanding of the environment. The terminology of ecology, which is extensive, should be limited to only those terms necessary for describing main concepts.

393 Teachers are encouraged to adopt an approach that is most suitable to their situation. A field studies approach is recommended. However, if a field studies approach is not feasible because of time limitations or because equipment is unavailable, the teacher can use data from ecological research in order to show the relationship between data and interpretations of the data. If an issues-oriented approach is taken, the teaching strategy suggested in the Grade 11 unit, Impact of Science on Society, could be adopted.

394 A detailed expansion of specific skills, knowledge, and activities will need to be done by a school or group of schools once the approach that meets the local needs is selected.