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Scope and Method of Study: This report has been developed with the intended purpose of presenting a foundation for the development of a high school advanced biology program. The procedure employed in writing this report involved library research of: laboratory manuals of appropriate biological areas, magazine articles and reference texts.

Findings and Conclusions: Within the scope of a library research report there are few findings which can be credited as being original in nature. However, in conclusion to this report it should be remembered that other authors will desire to research other areas which have not been touched upon by this author, but the form of research will have been presented. Many different advanced biology programs are possible and must be developed with individual needs and abilities as guides.

ADVISOR'S APPROVAL ______________________

A HIGH SCHOOL ADVANCED BIOLOGY PROGRAM

By

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A HIGH SCHOOL ADVANCED BIOLOGY PROGRAM

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PREFACE

A majority of high schools do not at the present time offer advanced work in biology. With the basic belief that an advanced biology program is necessary, this report is designed to stimulate the development of more advanced biology programs.

Indebtedness is acknowledged to Dr. L. Herbert Bruneau for his assistance in the procurement of reference material; to Dr. Robert C. Fite as Director of the National Science Foundation Academic Year Institute; and to my wife for her assistance in the preparation of this report.

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PART I. INTRODUCTION

High school biology is at present being taught as a one year course at the freshman or sophomore level in most public schools. The material which is presented in the classroom situation is primarily a brief introductory insight into the world of plant and animal life; with little or no provision for a follow-up or continuing investigation. It is the opinion of the author that a second year of more advanced and specialized work for qualified students in biology is not only of merit, but of essential importance in our public school curriculum. This report has been formulated to present a sample advanced biology program for consideration when a second or advanced study of biology becomes practical to include in the school curriculum.

It is desired that this report will be informative to both the author and reader, should they share a common interest in establishing an advanced high school biology program. Included in the following report will be: probable subject areas, materials to exploit, preparation and developmental factors to consider, and some procedural techniques. It is to be understood that this report will reflect the personal preferences of the author.

A high school education has the basic responsibility of preparing its recipients for successful living in and contribution to their society. The high school, along with the church and home is therefore responsible for developing the whole individual not just a small facet of that individual. It is with regard to the last statement, that I have chosen this topic for my report because it is impossible to completely develop an individual by only presenting generalities in the classroom.

To be sure, a school is not expected to spoon-feed information to its students, but rather is entitled to expect that with some directional interest applied, the student will be able to apply some basic knowledge in obtaining more advanced knowledge. However, it is the responsibility of the school and society to provide the best possible education for its students and therefore, where possible to provide advanced work in specific fields of interest. Biology, dealing with themselves and their environment provides an excellent chance for the school to better equip its graduates with information of applied value, which will be useful in future education and for life experiences.

Having stated why I think an advanced biology program is necessary, it now becomes important to investigate the factors which will greatly affect the type of program which will be developed. The influencing factors can be primarily divided into the areas of: the school, the teacher and the student. In discussing these factors it will be advisable to consider the teacher as a connection between the school resources and students quest for understanding. Considering the influencing areas of the school, the teacher and the student, let us discuss them in chronological order as arranged.

The school and community are placed in the initial position because it will be the decision of the community representatives in the school system, the school board and taxpayers, to decide whether or not the advanced level of work will be offered. In proposing a second year of biology, the teacher must be prepared to illustrate reasons why this additional material is necessary and of value to the community. It would be most advisable to influence the thinking of the school principal and superintendent so that their support may be applied in convincing the school board of the validity of the advanced program. If properly presented, an advanced biology program can probably be developed in most progressive schools of moderate financial means. The teacher presenting this proposed curriculum addition will need to be somewhat of a politician because the ideas of change and expense will be seriously considered by the school board and may need an extra push to be accepted.

As I have mentioned, the teacher must take the lead in formulating this new advanced biology program, but at the same time must be capable of functioning as the connection between the community represented by the school, and the students. The teacher will need to sell this change in past procedures and to do this, must be able to first sell himself. It is not sufficient to ascertain that a change should occur but rather it is necessary to properly equip yourself to successfully administer the proposed change. It therefore becomes the function of the teacher to become properly trained in the proposed field so that the program can be reasonably certain of functioning well if developed.

The aspects of teacher preparation for an advanced biology program will include: an ability to stimulate interest in students, so that qualified students will seek to pursue a deeper study of biology; course work preparation to facilitate higher level teaching; the ability to show good judgment in purchasing of equipment and supplies; and, an ability to sell the need for the program. The teacher who wishes to establish an advanced biology course on the high school level must recognize the amount of work involved and be willing to adapt to the requirements. It would be very desirable for the teacher to have some extra preparation time for laboratories and with cooperation from the administration this can probably be realized. A consideration here would be student laboratory assistants to help with preparations, thus relieving some of the teacher's load as well as providing some good experience for the participating students. With a discussion of the school and the teacher completed, I now direct the attention of this report to the most important aspect of the problem--the student and his or her needs.

I earlier stated that the entire individual could not be developed by a general education. With this firmly in mind, I shall investigate the function of the student and his or her affect on the development of an advanced biology program.

Education is for the advancement of society as determined by the advancement of the individuals within that society. It therefore, becomes necessary to more completely develop each individual's capabilities in order to facilitate the advancement of the entire group in the society. An advanced biology course in itself will not advance the development of the individual unless the participants become mature enough to participate in advancement of themselves by applying those ideas that were set forth in basic and advanced course work in education. The needs of the individual students will tend to determine and limit the scope of the offerings of the advanced biology course. Regardless of the basic orientation of the advanced biology course work, the goal will be student advancement by doing rather than by telling and will be based upon teacher stimulation and student application.

Having extablished the functions of the school, teacher, and student in determining the type of an advanced biology program, the problem now becomes that of developing an advanced program which will be usable. The items of consideration here will be: selection of the students, determination of class size limitation, selection of appropriate areas of study, and the requirements for the course. These four items will be discussed in chronological order in the following paragraphs.

The selection of students will primarily be based on an expressed interest, need and achievement competancy levels based on past educational records. The advanced biology course will be strictly an elective subject which may be elected by students who are interested and qualified. Students who are in the junior or senior class, and have successfully completed general biology and chemistry with average or above records and are interested in some phase of the biological sciences at a post high school level, will be given careful consideration. The most important aspect of selection will be the students expressed purpose in enrolling in the subject as compared with the probability of using what will be learned in advanced biology. Even though this is an elective course, it is possible that through guidance, certain students may be encouraged to enroll in an advanced biology program.

The second factor in developing an advanced biology program for a secondary school will be the determination of a workable class size. In the selection of a maximum number of students per class of advanced biology, the teacher must consider: available space, available materials and equipment, activities to be included in the program and the preparation time alloted for the advanced biology class or classes. In an advanced biology class it will be desirable to have students working in pairs on the laboratory level, therefore, an even number of students should be planned for. Students should have adequate space for microscope work and other laboratory procedures without the necessity for crowding two groups together. Each pair of students should have access to dissecting equipment and specimens as well as a binocular microscope and a standard microscope. The type of activity will affect class size as indicated in the case of work area, but also in the case of planned field trips. The size must be kept to a limit which can efficiently be taken through a field trip situation as a learning process not an entertainment session. Another consideration will be the size of class which can function in a two hour laboratory class if they can be successfully programmed into the advanced biology program. Individual conference periods will be valuable in an advanced program and this will also determine class size by comparing the time per conference with the preparation time of the teacher so that all students will periodically be able to have a conference session. Considering all of the above factors in class size determination, it seems practical to set a workable limit at 16-20 students.

The third factor in the development of an advanced biology program becomes that of the selection of the topics or areas to be covered within the course. This will vary greatly and could be expected to change for each group of students. The areas offered for study in an advanced biology program will be influenced by the future expectations and needs of the students, however, it will not be practical to alter the entire program from year to year because of one or two student's interests. Also influencing the areas of advanced study will be the degree of competency obtained by the teacher in the various fields of study. This does not imply that an area can't be discussed if the teacher is not expert in that area. Areas should be selected which will have the greatest practical importance to the students and which can also be supplemented by community resources. Assuming that this advanced program will be a two semester program, the selection of included areas of study might also be influenced by equatable time allotments for particular areas. With these considerations, it becomes a matter for the individual teacher in the particular community to establish the inclusions and exclusions of the advanced biology program. A consideration here might be that advanced can mean a continuation from basic work as well as the investigation of entirely new material.

The fourth major factor in the development of an advanced biology program will be the included requirements of the classwork. It should be understood that an advanced biology course infers laboratory activities as well as lecture and discussion activities. The requirements for an advanced course in biology will by necessity vary, however, some basic requirements should be: individual project work, individual conference reports, assigned reference readings, oral class reports, and assorted examinations.

Having stated what affects the establishment of an advanced biology program on a secondary level and also what affects the development of an advanced biology program, I am now ready to formulate a sample advanced biology program. It is again to be understood that the following reflects the preferences of the author.

The sample advanced biology program prepared in this report is designed as a two semester course to be taught at the junior and senior level to students with a background in basic biology and chemistry. There are four major approaches to an advanced biology program: (1) experimental courses - research, (2) special fields of study, (3) seminar courses, (4) college level courses. I have selected the second type, special fields of study, because I feel that it has more flexibility and application.

PART II. COURSE OF STUDY OUTLINES

FIRST SEMESTER

I. Cytology - 6 weeks

A. Introduction
1. Parts of cells
2. Functions

B. Cellular inclusions and functions
1. Granules and vacuoles
2. Plastids
3. Photosynthesis
4. Respiration

C. Cellular replication
1. Mitosis
2. Protein synthesis
3. DNA
4. RNA

D. Summary
1. Importance of understanding
2. New ideas

II. Anatomy and Physiology - 13 weeks

A. Introduction
1. Transition from cells to organisms
2. Updating of laboratory techniques

B. Comparative anatomy
1. Anatomy of dogfish shark
2. Anatomy of the frog
3. Anatomy of simple mammal (rat-cat-rabbit)
4. Anatomy of man

C. Comparative Physiology
1. Physiology of the frog
2. Physiology of simple mammal (rat-cat-rabbit)
3. Physiology of man

D. Summary
1. Conclusion of all areas up to this point
2. A look beyond

SECOND SEMESTER

I. Genetics - 8 weeks

A. Introduction
1. Terms and activities
2. Inheritance versus environment

B. Genetics and evolution
1. Origin of life
2. Why changes occur
3. Mutations

C. Genetic principles
1. Dominance and recessiveness
2. Ploidy
3. Chromosome mapping, crossing over and linkage
4. Sex determination
5. Population studies
6. Human inheritance, blood type, sex linkage
7. Radiation affects

D. Summary
1. Conclusion and projection into future

II. Ecology - 11 weeks

A. Introduction
1. From genetics to individual interrelationships
2. Environment types and factors

B. Contributing areas to study
1. Limnology and ichthyology
2. Taxonomy

C. Specific ecological studies
1. Niche
2. Ecotone and ecosystem
3. Population studies

D. Summary
1. Associate all factors
2. Interplay of cells with organisms, heredity, and environment

PART III. FIELDS OF STUDY

SECTION 1. THE FIELD OF CYTOLOGY

In the study of cytology it must be remembered that the point of concentration will be on microscopic or submicroscopic detail. With this in mind, it will also be necessary to be able to present most of the outlined material for this area in the form of discussion and lecture sessions. The represented areas for consideration should be supplemented with laboratory work where possible.

The purpose of the area of cytology will be to familiarize the students with the minute aspects of cells--why and how they function. Once the understanding is grasped, the transition to a more workable macroscopic level is more easily made.

This report will not attempt to provide lecture notes or even a complete laboratory program for the teaching of cytology. This report will provide sample laboratory exercises and references which can be drawn upon for individual modification.

An introduction to cytology will vary with personal preference but I would suggest a general discussion based upon past experience and supplemented with projection of photographs from _Scientific American_ magazines. With the discussion of cells underway, it will be rather continuous to consider the functions of cells as a unit and then the discussion of cell parts and what their functions contribute to the cell as a unit. As a unifying process, I would suggest that the students be given an opportunity to solidify their thoughts by constructing a sample plant and/or animal cell based upon their present knowledge.

EXERCISE 1: Construction of a Typical Cell

MATERIALS:
- Small cardboard boxes
- Cellophane
- Toothpicks
- Polystyrene strips and balls
- Tape and glue

PROCEDURE: A suggestion would be to ask the students to construct a cell, which if provided with the substance of life, would function and have its parts in proper proportion. Once the students have worked with this problem, they will be more ready to consider the internal complications within a cell.

In considering the problem of cellular inclusions and functions, it will be necessary to depend rather heavily on discussion and audio-visual aid presentations. Projection of electro-micrographs obtainable from Scientific American articles will again be valuable aids in pointing out the internal parts of cells. As each particular structure is identified it would be well to consider its probable function and research which has been done with it. Some parts to consider would be: vacuoles, plastids, membranes, nucleus, nucleolus, Golgi apparatus, mitochondria, endoplasmic reticulum and generalized cytoplasm.

EXERCISE 2: Examination of Elodea Leaves

MATERIALS:

Microscope
Elodea leaves

PROCEDURE:

The students could again be familiarized with the space and size concept by observing cells of Anacharis (Elodea) to note the vacuole, its size and the space which it leaves for the other structures mentioned.

A concept to begin to formulate at this time would be-- are these discrete structures, or are they in a state of flux within the cell boundaries.

In discussing plastids and their functions, it will perhaps be desirable to observe and test for these structures.

EXERCISE 3: Examination of Elodea Leaves

MATERIALS:

Living green leaves (may be frozen)
Hot plate
Two 600 ml. beakers
One 8 oz. capped medicine bottle
One 250 ml. graduated cylinder
Medicine dropper
One 100 ml. flask
Carbon tetrachloride
200 cc. of 95% ethyl alcohol
Forceps and hot dish holder

PROCEDURE:

1. Obtain some Anacharis (Elodea) leaves and observe the green structures which are mobile in the cytoplasm--what is the probable identity of these structures? Now using either these same leaves or some larger plant leaves, prepare to study the process of chlorophyll extraction. (Exercise 84-BSCS Revised Yellow Version.)

2. Warm hot plate.

3. Fill 600 ml. beaker with water and heat. Add 200 cc. of 95% ethyl alcohol to other 600 ml. beaker--cover this one with a glass plate and heat.

4. Place the green leaves in the hot water just long enough to blanch. Do not over heat.

5. Transfer wilted leaves into alcohol. Boil five minutes and stir.

6. Cool alcohol and pour 100 cc. of extract into 8 oz. medicine bottle and the rest pour into flask, cover and store in refrigerator. (Note the extract color)

7. Not all things are soluble in the same solvent--principle of differential solubility. Check this principle in the following way:

a. Add 130 cc. of carbon tetrachloride to 100 cc. of extract in the 8 oz. medicine bottle.
b. Shake and check for layer separation. If no separation occurs, add 2 or 3 medicine droppers of water and shake again. You should note a cloudy appearance.

With some knowledge of plastids and cellular structure, the focus of attention can be directed to the topic of photosynthesis. This topic of cellular activity can well be augmented with laboratory work at the discretion of the instructor. Using (Weisz, 1959) as a reference, go through the basic chemical discussion of photosynthesis and how the transfer of energy occurs. (Abramoff and Thomson, 1963).

EXERCISE 4: Investigating Photosynthetic Reactions

MATERIALS:

Live green plants - Geranium or Elodea
Dark box
Light source
Bell jars
Potassium hydroxide or sodium hydroxide
.25% sodium bicarbonate solution

PROCEDURE:

1. Several days before the experiment place some Geranium plants in a dark room.

2. Place light shields over some of the leaves, then illuminate for 3 days.

3. Pick off some of the covered and uncovered leaves and test for starch content as follows:

a. Kill leaves by boiling in water.
b. Remove pigment by placing in hot alcohol.
c. Flow iodine over the leaf in a petri dish to check for starch.

4. Check the affect of light intensity on oxygen production using Elodea as the plant source.

a. Cut sprigs of Elodea and place them in test tubes of $NaHCO_3$ at .25% concentration.
b. Place the test tubes at various distances from the light source.
c. Count the number of bubbles produced every five minutes once they begin to be emitted.

5. Again use the Geranium leaves and determine the influence of CO_2 on photosynthesis. (These plants should have been in the dark and represent a negative starch test.)

a. Place plants under separate bell jars.
b. Add a container of KOH or NaOH to one bell jar--this removes CO_2.
c. Add a container of $CaCO_3$ to the other bell jar.
d. Provide an equal light source for each jar.
e. After a 24 hour period check both plants for the presence of starch.

Cellular respiration can now more readily be discussed once the students have had a brief chemical introduction to cellular photosynthesis. Again use (Weisz, 1959) as a reference source if not being used as a text. The discussion in this area will dwell upon adenosine triphosphate (ATP), adenosine diphosphate (ADP), energy transfer and energy utilization. It will be primarily a discussion area but a laboratory exercise in cellular respiration might be applicable. (Wald, Albersheim, Dowling, Hopkins, Lacks, 1962).

EXERCISE 5: An Experiment with Cellular Respiration

MATERIALS:

Volumeter
Three day old pea seedlings
Cotton
Soda lime
Rubber stoppers
Kerosene
Eye dropper

PROCEDURE:

1. Set up volumeter.
2. Fill one test tube to within two inches of the top with pea seedlings--insert cotton plug over seedlings and then add a 1" layer of soda lime (solid NaOH and $Ca(OH)_2$) over cotton plug.

3. Fill second tube to within 2 or 3 inches of the top with water.

4. Insert rubber stoppers.

5. Add kerosene drop to ends of each side arm. (Adjust it so it is at the distil end of each tube).

6. Clamp escape tubes and wait five minutes for equilibrium.

7. Take reading in each graduated tube until the difference between them is constant--this difference equals rate of O_2 consumption. (Remember that one molecule of CO_2 produces one molecule of O_2 in photosynthesis.)

8. The rate of CO_2 production divided by the rate of O_2 consumption is the respiratory quotient.

With the developed understanding of cell structure and some basic physiological occurances, we may now look more closely into the cell and pay particular attention to the cellular proteins. A review of basic cellular division can best be done with the aid of models and colored pipe cleaners to show the activity of chromosomes from a gross view. Some prepared onion root tip slides would also be valuable in explanation of the process of mitosis. Once the students are familiarized with chromosomes and cell division the topic very nicely turns to how, where and when does this building of proteins occur.

Cellular proteins have been identified, isolated and called desoxyribose nucleic acid (DNA) and ribose nucleic acid (RNA). At this point the students are ready for a discussion of protein synthesis as it involves the cellular proteins. The methods of presentation of this topic are many, however, most primarily involve discussion and audio-visual aid presentation. Electron micrographs of a very recent date may be of value, however, this topic will need to be presented not as a fact, but as a theory based upon experiments and speculations. A Watson-Crick model of DNA will be useful and perhaps the students could make some template pieces of heavy cardboard or light wood to be worked with in formulating ideas about how synthesis occurs. Scientific American articles will prove to be of great value in this particular phase of cytology. It is possible that some slides could be made to analyze the protein content using the Feulgen reaction (Swanson, 1957) to show cellular DNA.

With the designated time allotment of six weeks for the discussion of cytology, it becomes obvious that the discussion will need to be somewhat limited. Students could more completely grasp the involved concepts if some reference reading was done and brought to class for discussion. It will therefore be important that the school's library be kept up to date both in reference books and periodical literature. The final time should be alloted for a summation of acquired information and as a stimulus for future student investigations into the field of cytology.

SECTION 2. THE FIELD OF ANATOMY AND PHYSIOLOGY

In concerning ourselves with anatomy and physiology, we must realize that we are dependent upon an understanding of microscopic details in order to understand these areas of a more macroscopic nature. This area of study will be greatly supplemented with laboratory work and some emphasis will be placed upon the development of laboratory technique.

The introduction to this area can be accomplished rather easily by reviewing what the students acquired from basic biology course work. With some background information on gross specimens and some knowledge of cellular composition, the students will be able to make some valid predictions of further complications of organisms to be studied in this area of anatomy and physiology. In introducing this area of laboratory study it will be necessary to ascertain the level of developed technique among the students and to acquaint the students with terminology which will be used in dissection procedures. Once you know how involved the students were in laboratory investigation in the basic course, you can determine the rate at which to proceed. Very probably the basic course prepared the students with a brief insight into the anatomy of the fish, frog and man with lesser time spent on intermediate specimens. With these items in mind the topic of comparative anatomy may begin.

Assuming that the students have had some experience with dissection, this area of study may begin and continue in the laboratory. The primary goal must be understanding rather than simply inquisition. With a review of past experience completed the students can be presented the task of a new investigation with the subject presented being a doubly injected dogfish shark. It will be advisable to have the students work in pairs during these laboratory exercises.

Suggested areas of investigation are: 1. external anatomy, 2. digestive system, 3. respiratory system, 4. urogenital system, 5. circulatory system, 6. skeletal system, and 7. nervous system.

Because this report is not intended to limit the presentation, I will not set down the patterns of study for these areas. However, I will list references to be drawn upon and I would suggest that the students be given typed instructions to be followed at their own pace as long as that pace meets established time allotments. In doing their laboratory work, the students should be given as much assistance as needed, but emphasis should be on individual interpretation and exploration.

With the dogfish shark well in mind, a quick review of the frog would perhaps be of value. Whether or not this is done in class, the students should be able to interpret the similarities and differences between the dogfish shark and the frog.

If time permits, it would be advisable to dissect an intermediate specimen between the frog or dogfish shark and the discussion of man. This intermediate could be the cat, rat or rabbit with preference given to the rat. If this intermediate is dissected, the following areas of concentration are recommended: 1. digestive system, 2. respiratory system, 3. urogenital system, 4. circulatory system, and 5. nervous system.

With a developed understanding of lower animals, the consideration may now be shifted to a discussion of man. This particular area of concentration will by necessity be largely a discussion session with audio-visual aid supplementation and possibly some guest lecturers from the medical sciences. This will be a point of comparative anatomy with emphasis placed upon similarities and differences between man and the other specimens which have been studied. With a background in anatomy, we shall now focus our attention on the physiology of the systems we have been concerned with.

In the area of physiology much will be done as a discussion or demonstration, however, the amount of laboratory work could increase markedly, with very adequate equipment. Recommended laboratory equipment would include: a kymograph, a syringe and various needle types, standard dissection and observation equipment.

The frog, Rana pipiens, becomes a good laboratory specimen when studying physiology because of background knowledge, ease of acquiring and produced reactions. A rat may equally successfully be used as a demonstration or experimental laboratory animal.

EXERCISE 6: Physiology of a Leopard Frog (Rana pipiens)

MATERIALS:
Leopard frog (live)
Dissecting kit
Saline solution
Inductorium
Acetic acid
Hydrochloric acid

PROCEDURE:

1. Pith a leopard frog--do not damage the spinal cord.
2. Open body cavity by a shallow midventral incision.
3. Observe heart action. Remove the heart and place it in Ringer's solution. (Youmans, 1962).
4. Stimulate the dorsal abdominal nerves with the inductorium.
5. Stimulate muscles directly with the inductorium.
6. Discuss all observations and determine whether or not they coincide with anticipated results.
7. Pith another frog or use the musculature from the previous frog.
8. Suspend frog by the lower jaw.
   a. Test for reflex by pinching its toes. (Record time factors).
   b. Stimulate chemically with various concentrations of HCl--wash thoroughly with water after each dose.
   c. Electrical stimulus--attach two fine wires to the frog's ankle and connect to the inductorium.
   d. Stimulate with acetic acid on filter paper by placing it on the thigh and chest.
9. Discuss all data and observations made.

Some other possible experiments or demonstrations would be: determining the heart beat of a turtle or frog and the affect of injecting adrenalin and acetylcholine into the system. All mentioned experiments can also be carried out on the rat with a similar degree of success. The rat also is a good specimen to use in showing the effect of insulin shock and hyperthyroidism or hypothyroidism. The physiology of man can best be discussed, but certain phases can be checked such as: light stimulated eye pupil constriction or dilation, respiratory rate--affect of hyperventilation, and circulatory vessel pressure.

In conclusion, it will be necessary to attempt to associate all areas of concentration in anatomy and physiology, so the student is left with the idea that these areas are inseparably involved in the explanation of advancement in the systemics of the animal kingdom. Finally, in concluding this first semester's work, it will again be desirable to project what is now known into present research and what scientific milestones may be uncovered in the future.

SECTION 3. THE FIELD OF GENETICS

Up to this point, the student has become acquainted with the cytological, anatomical and physiological aspects of the specimens we have worked with. It is now time to acquaint the student with the application of cellular structures and how they show a greater or lesser degree of expression in the individuals which contain these structures. This then is the topic of genetics.

In studying genetics it will be well to develop a complete understanding of basic terminology and activities which have been and are to be studied. An introduction to genetics will therefore include a review as well as an insight into things to come. Again, it is necessary to state that the author does not intend to write lecture notes or set laboratory procedures, but rather the purpose is to illustrate what could be incorporated into a sample unit of genetics.

An introductory discussion of genetics will profitably include the contributory aspects of genetics and environment as they affect the involved individual. Many theoretical problems can be introduced to stimulate thought patterns that will be of importance further into the course. By necessity, a liberal discussion of the origin of life will be an important part of this unit on genetics and this must be taught in a realistic manner. The origin of life can be presented in an acceptable manner with the assistance of a basic knowledge of chemistry and time. The religious accounts of the beginning of life are not to be discounted, rather they are to be constructively incorporated and will tend to fit nicely into the evolutionary sequence. With a firm foundation established for the origin of life you will be ready to move into the realm of change and why it occurs.

Gene configuration is not fixed. A given gene can exist in different forms and the change from one form to another is called a mutation. (Bonner, 1961). The discussion of mutations can be augmented by the study of *Drosophila* and the subsequent checking for new transmissible characteristics which are considered to be mutations. (Abramoff and Thomson, 1963). Before *Drosophila* can be effectively studied for genetic principles, you must know what you are looking for which will necessitate a study of the fruit fly and its identifying features.

EXERCISE 7: *Drosophila* Genetics (Abromoff and Thomson, 1963).

MATERIALS:
Live *Drosophila* cultures
Magnifying device

PROCEDURE:
1. Have healthy cultures of wild type *Drosophila* available.
2. Note characteristics of wild type: dark red eyes, tan-bristle covered body, long straight wings.
3. Note sexes of *Drosophila*.

a. Pointed abdomen, several dark abdominal stripes, terminal tuft of bristles on abdominal tip.
b. Smaller, rounded, pigmented abdomen, tuft of bristles on forelegs.

4. Examine other fruit flies and determine differences and or similarities. (Suggested cultures--vestigial winged, dumpy, white-eyed and bar-eyed and wild type.)

5. Discuss the cause of these different fly types.

With this general introduction to genetics we can now turn to a more detailed study of genetics, beginning with the principles of genetics and how they may be studied. Certain assumptions will need to be made about the basic background in genetics of the participating students and the students will need to have available references to fill in their background where necessary.

Some traditional cases of dominance and recessiveness have undoubtedly been studied but it will be wise to review them briefly along with the principles of hybrid crosses. The major concept to re-establish at this point, is that not all characteristic traits express themselves in each situation but under certain situations each trait will find expression. Some exercises with monohybrid and dihybrid crosses would help express the ideas of dominance and recessiveness as well as introducing the factors of phenotypes and genotypes. Having done some work with monohybrid and dihybrid crosses, we can now consider poly ploidy in genetic characteristics if time is permissive. A general discussion will review the affect of haploidy and diploidy and with this understanding the transition to triploidy etc., can be made if desirable.

A suggestion at this time would be to discuss meiosis and show the involved steps with colored pipe cleaners. The discussion of basic genetics can be continued at this point into the topics of chromosome mapping and crossing over with some work again with pipe cleaners and the addition of audio-visual projection of filmed crossing over and mapping results.

In discussing crossing over, it will be valuable to also study linkage to more completely fit the pieces together where the number of known genes exceed the haploid number of chromosomes, some of the genes will show linkage and tend to be inherited as a group. (Swanson, 1957). Whereas linkage involves unit groups of genes, crossing over involves incomplete linkage of genes along a chromosome. Electron micrographs of chromosomes at various meiotic stages will help to show this as represented by the chiasma in the field of view. If facilities are available, prepared slides from the shoots of germinating grain seeds will also show the phenomena of crossing over. Chromosome recombination is known to occur and is called crossing over. (Crow, 1963). A suggestion here would be to work some exercises with chromosomes to show how crossing over could occur. Having some background in linkage and crossing over, a brief discussion of chromosome mapping would be in order.

Chromosome mapping is a method of plotting the probable location of particular genes on a chromosome. The chromosome map distances are measured in units of 1% crossing over, so if two genes are 15 units apart there is 15% recombination between them. (Crow, 1963). The study of chromosome mapping will best be accomplished at this level of study with sample problems or situations.

EXERCISE 8: Working Problems with Chromosome Mapping

MATERIALS:
Paper

PROCEDURE:
Arrange the genes on a chromosome so that they will meet the following situation:
In chickens there is 10% recombination between the genes for brown eyes (Br) and light down (Li). There is 26% between brown eyes and silver plumage (S) and 16% between silver plumage and light down. Another gene, slow feathering (K) is found to have 11% cross overs with (S) and 27% with (Li). All of these genes are on the same chromosome but what is their order of arrangement? (Crow, 1963).

Many other problems of this type could be performed if time permits.

A discussion of genetics could not be complete without a venture into the topic of sex determination and sex differentiation. Assuming a basic background in this area, the discussion can move toward the sex chromosomes, their patterns and influence. Here again it is suggested that audio-visual materials might be employed to show the probability of the offspring being a male or female. The discussion may include a consideration of the (XO) condition in male grasshoppers and some other animals. At this same time, the topic of sex linkage might be investigated in brief detail. Such cases as the crossing of a homozygous red-eyed female with a white-eyed male in Drosophila, produced offspring with all red eyes. (Crow, 1963). The reverse is true if the parental types are reversed, therefore, with further investigation you can determine that eye color is carried on the X chromosome. With this type of problem in mind you can now profitably turn to population genetics with the fruit fly as the involved specimen.

The area of population study will probably be the most fascinating area in genetics. The immediate problems will be to obtain pure cultures of Drosophila, cultivate a desirable food media for them, provide a healthy habitat for them and learn how to handle and work with the fruit flies. Since we earlier mentioned fruit flies of wild, vestigial, dumpy, bar-eyed and white-eyed types, it might be wise to use these as our pure cultures. A review of how to tell male from female will be of value before starting with this laboratory work. I would suggest that the students again work in groups of not more than three in a group and that their first work with the fruit flies be a designated cross of two types of flies. Part of their project should be to predict what the offspring will be during the time the offspring are developing. After this initial cross is studied, the students should be given the opportunity to make other crosses of their own choosing.

EXERCISE 9: Experimental Crosses with Drosophila

MATERIALS:
Live Drosophila cultures

PROCEDURE:
1. Obtain the desired parents.
2. Permit the cross.

3. Note two of the F_1 generation.
4. Cross an F_1 with a wild type.
5. Cross an F_1 with a bar-eyed type.
6. Record all observations and interpret them.

It will be necessary to promote extreme care in the work with fruit flies so that pure strain cultures may be kept on hand.

With some knowledge of genetic factors in fruit flies, it will now be more practical to discuss human genetics. Undoubtedly the students have discussed eugenics in some detail but a more sophisticated study can now be undertaken. Some areas of suggested discussion are: twins, blood type, hemophilia, thalassemia minor, and perhaps some visual traits such as eye color, hair color and skin texture. A study of human heredity will need to be concerned also with the affect of the environment as was mentioned earlier.

In concluding this unit on genetics it will be important to associate all factors previously discussed and attempt to use this as a format for a look into the future. The problem of fallout might well be considered at this time and if possible some normal fruit flies could be irradiated at a doctor's office to allow students to see the possibility of induced changes. With this conclusion of genetics we will now focus our attention on the field of ecology and its many facets.

SECTION 4. THE FIELD OF ECOLOGY

In our earlier discussions we mentioned that it would be necessary to consider environmental factors in order to completely understand the expression of genetics, cytology and other more gross aspects of individual characteristics. The study of particular environments and the relationship among environments is ecology. In the study of ecology it will be essential to establish a working vocabulary which will permit the students to express themselves in discussions of environmental factors and classification. Having discussed some of the involved terminology, it will now be possible to introduce the students to ecology. A suggested introductory exercise would be to develop a descriptive essay of a particular geographical area and ask the students to consider the information and determine how many separate environments are involved and what factors determine each separate one. Now, with a brief insight into what is involved in ecology, the topic may be turned to more specific areas.

Limnology will be an area of particular interest in ecology and like all phases of ecological study, will best be studied on a field trip--laboratory follow-up basis. In considering limnology, it will be valuable to develop an understanding of the following areas: 1. ichthyology, 2. lake succession, 3. food and energy pyramid relationships,

4. taxonomy of flora and fauna, 5. lake overturn phenomena, 6. watershed factors.

The topic of ichthyology can be introduced in many ways, however, a suggestion would be a study involving the determination of native fish species in a given area. The conservation department would be a good source of information and perhaps would demonstrate a lake or stream shocking procedure.

In discussing lake succession, the major concern is the realization that lakes are in a state of change and that this can be indicated by particular factors or characteristics of the body of water. Some of these characterizing factors that might well be investigated are: depth of water, temperature of water, type of supported plant and animal growth, oxygen content, amount of organic debris accumulation at the bottom, presence of insect larva in bottom debris, amount of shore line development and the pH of the water.

SUGGESTED STUDY IN LAKE SUCCESSION (Field Trip)

1. Visit a lake and collect water, bottom debris, flora and fauna samples. Also note the depth, temperature at various depths and the amount of shore line.
2. Return to the laboratory and compute or correlate the information collected in the field. This will require some ability in the taxonomy of collected specimens.
3. With this information, discuss the characteristics oligotrophic, eutrophic and dystrophic bodies of water and attempt to ascertain the type which has been studied.
4. Visitation by students to other bodies of water would be desirable if time permits.
5. Follow-up this study with a detailed discussion of lake succession and lake overturn.

SUGGESTED STUDY IN ECOLOGICAL PYRAMIDS

1. Using information collected in earlier work--discuss the relationship of plants, minerals and animals in lake productivity and classification.
2. Set up some theoretical situation and determine what the producers, consumers and decomposers would be and what their effect would be on the lakes classification.

In concluding the discussion of limnology, it will be advantageous to discuss the influence of watershed conditions and how they affect the lake. If any time is available at this point, it would be valuable to take a second review field trip to solidfy this total discussion before moving into a more detailed consideration of ecology.

With some recent field trip experience it will now become possible to continue the study of ecology as it should be--as a field course. It is suggested that the remaining time alloted to ecology be spent developing the concepts of a niche, ecotone, ecosystem, population ecology and a summary.

In discussing a niche, it will be necessary to develop critical thought processes to determine what a niche is and if it actually exists. It is suggested that a particular plant or animal be considered separately from other competing members in its environment. This can best be done by first considering all the members of the environment and then determining the role of the one particular member. The concern will now be to determine whether another organism could successfully function in this same situation or whether the organism under consideration is in fact the only one capable of adapting to the particular niche.

SUGGESTED DISCUSSION TOPICS

1. Consider the case of the sea lamprey in the Great Lakes.
2. Consider the case of the Trillium. (Odum, 1960).

Having acquired a general understanding of a niche, let us now consider the situation of an ecotone. This can, perhaps, best be done after some consideration or review of the preceeding discussion if necessary.

SUGGESTED DISCUSSION TOPICS

1. Consider the situation of a lake edge as an overlap between aquatic and terrestrial environments.
2. Consider the situation of a forest edge as an overlap between dense woods and open prairie.

After discussing an ecological niche and the concept of ecotone, we may now consider the more inclusive discussion of an ecosystem.

Living organisms and their nonliving environment are inseparably related and interact with each other. Any area of nature that includes living organisms and nonliving interacting substances is an ecological system or ecosystem. (Odum, 1960). Ecosystems may be divided into terrestrial and aquatic and then subdivided within each group. I will suggest several subdivisions and recommend that each be observed in a field trip situation preceeded by a discussion and possibly supplemented by color slides. A follow-up laboratory session to analyze any collected specimens will be very advantageous. The follow-up can also be used to terminate the discussion of that particular ecosystem type.

The suggested subdivisions of a terrestrial ecosystem are: 1. sand dunes, 2. prairie, 3. forest edge, 4. coniferous forests, and 5. deciduous forests.

The suggested subdivisions of an aquatic ecosystem are: 1. lentic water (standing water), 2. lotic water (running water), 3. shore line, and 4. artificial bodies of water.

Ecosystems may be studied very nicely with a classroom terrarium setup in one of the above mentioned ecosystem subdivisions. It will probably be more practical to set up a terrarium in the form of a terrestrial ecosystem subdivision. It might be desirable to study micro-ecosystems rather than macro-ecosystems and the following exercise will give an example of a micro-ecosystem.

EXERCISE 10: A Micro-ecosystem

MATERIALS:

Test tubes
Bunsen burner
Elodea (live) or other fresh water plants
Pond water
Snail (live)

PROCEDURE:

1. Obtain a clean medium sized soft glass test tube.
2. Rotate it in a Bunsen burner flame heating at a point just above the half way mark on the tube.
3. Remove from flame and pull it into an hourglass form.
4. Cool the tube.
5. Add to lower half of the tube: one small snail, one filamentous algae or Elodea, fill ½ of bottom half of tube with clear pond water.
6. Dry inside and outside of constricted portion of the tube.
7. Heat constricted portion of the tube and pull until the constriction is sealed.
8. Make observations and record changes that are observed in the plant, snail or water.
9. Interpret the contribution and/or function of each part of the closed micro-ecosystem.

The next consideration in ecology will be perhaps the most important--population studies. This area has been touched upon when dealing with the edge affect or ecotone, but now must be considered in more detail. The students have been on several field trips up to this point and have made several observations that will perhaps be of value in this area of study. This particular area will be more valuable after several classes have collected data which can be used as a comparison in future studies. The procedures to be used in this area of consideration are many and I will only suggest a few.

SUGGESTED SAMPLING TECHNIQUES

1. Insect sampling.
   a. Sweeping of plants with insect nets.
   b. Pitfall traps. (Lemon, 1962).
   c. Wind vane samplers.
2. Small mammal census.
   a. Equidistant grid pattern.
   b. Closed octagon. (Lemon, 1962).
3. Surface sectioning of plants.
   a. Counting.
   b. Identification.
4. Bird study by observation.
   a. Feeding habits.
   b. Nesting habits.
   c. Movement patterns.

The details involved with these sampling techniques may effectively be developed by the individual. It is suggested that where possible, the students be the investigators which will require that they set up their own research gathering problem. After the sampling has proceeded for an appropriate time, as determined by collected samples, the students should be able to present their information to the class perhaps as a symposium or seminar.

Since it is recognized that ecology is a vast field of study, this work must not be considered as a closed subject. Suggested references should be available to further promote interest and investigation. Any time which is remaining could be spent in summarizing all the discussed factors in ecology and the projection of present information into future studies and possible results.

PART IV. CONCLUSION

With the proposed areas of study investigated and the time for further work short, it will be advisable to summarize the year's achievements and what they may mean to future work in biology. Since this program stipulated that only interested and capable students would be enrolled in it, the problem of motivation throughout the year may not have been a very large one. Never-the-less, it is essential that the study be evaluated to facilitate the advancement of the program by making necessary revisions which will make advanced biology even more valuable to its participants in future years. In conclusion, it must be remembered that cooperation between the school administration, the students and the teacher is essential for the functioning of this advanced program. To insure future cooperation, the proposed program must not be fixed but rather adaptable to necessary changes so that the presentation is totally vital and current in scope.

BIBLIOGRAPHY

CYTOLOGICAL REFERENCES

Abramoff, Peter, and Robert G. Thomson. Laboratory Outlines in Biology. San Francisco: W. M. Freeman and Company, 1963.

Allfrey, V. G., and A. E. Mirsky. "How Cells Make Molecules." The Scientific American, Volume 205, Number 3 (September, 1961), 74-82.

Bassham, J. A. "The Path of Carbon in Photosynthesis." The Scientific American, Volume 206, Number 6 (June, 1962), 88-100.

Bearn, A. G. and J. L. German III. "Chromosomes and Disease." The Scientific American, Volume 205, Number 5 (November, 1961), 66-76.

Benzer, Seymour. "The Fine Structure of the Gene." The Scientific American, Volume 206, Number 1 (January, 1962), 70-84.

Biological Sciences Curriculum Study. Revised Yellow Version. Boulder: Johnson Publishing Company, 1961.

Brachet, Jean. "The Living Cell." The Scientific American, Volume 205, Number 3 (September, 1961), 50-62.

Crick, F. H. C. "The Genetic Code." The Scientific American, Volume 207, Number 4 (October, 1962), 66-74.

DeRobertis, E. D. P., W. W. Nowinski, Franciso A. Saez. General Cytology. Philadelphia and London: W. B. Saunders and Company, 1960.

Fischberg, Michail and A. W. Blackler. "How Cells Specialize." The Scientific American, Volume 205, Number 3 (September, 1961), 124-140.

Gerard, R. W. Unresting Cells. New York: Harper and Brothers Publishers, 1949.

Geise, Arthur C. Cell Physiology. Philadelpha and London: W. B. Saunders and Company, 1960.

Hadorn, Ernst. "Fractionating the Fruit Fly." The Scientific American, Volume 206, Number 4 (April, 1962), 100-110.

Hayashi, Teru. "How Cells Move." The Scientific American, Volume 205, Number 3 (September, 1961), 184-204.

Holter, Heinz. "How Things Get into Cells." The Scientific American, Volume 205, Number 3 (September, 1961), 167-180.

Hurwitz, Jerard and J. J. Furth. "Messenger RNA." The Scientific American, Volume 206, Number 2 (February, 1962), 41-49.

Katz, Bernhard. "How Cells Communicate." The Scientific American, Volume 205, Number 3 (September, 1961), 209-220.

Lehninger, Albert L. "How Cells Transform Energy." The Scientific American, Volume 205, Number 3 (September, 1961), 62-73.

Mazia, Daniel. "How Cells Divide." The Scientific American, Volume 205, Number 3 (September, 1961), 100-120.

Miller, William H. "How Cells Receive Stimuli." The Scientific American, Volume 205, Number 3 (September, 1961), 222-238.

Morowitz, H. J. and M. E. Tourtellotte. "The Smallest Cells." The Scientific American, Volume 206, Number 3 (March, 1962), 117-126.

Moscona, A. A. "How Cells Associate." The Scientific American, Volume 205, Number 3 (September, 1961), 142-162.

Robertson, J. David. "The Membrane of the Living Cell." The Scientific American, Volume 206, Number 4 (April, 1962), 64-72.

Sharp, Lester W. Fundamentals of Cytology. New York and London: McGraw-Hill Book Company, 1943.

Swanson, Carl P. Cytology and Cytogenetics. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1957.

Wald, George, Peter Albersheim, John Dowling, John Hopkins III, and Sanford Lacks. Twenty-Six Afternoons of Biology: An Introductory Laboratory Manual. Reading, Massachusetts: Addison-Wesley Publishing Company, 1962.

Weisz, Paul B. The Science of Biology. New York: McGraw-Hill Book Company, 1959.

ANATOMY AND PHYSIOLOGY REFERENCES

Abramoff, Peter, and Robert G. Thomson. Laboratory Outlines in Biology. San Francisco: W. M. Freeman and Company, 1963.

Berman, William. How to Dissect. New York: Sentinel Book Publishers, 1961.

Hyman, Libbie Henrietta. Comparative Vertebrate Anatomy. Chicago: University of Chicago Press, 1942.

McKean, Irene. Anatomy and Physiology: Laboratory Manual and Study Guide. Philadelphia and London: W. B. Saunders and Company, 1958.

Romer, Alfred Sherwood. The Vertebrate Body. Philadelphia and London: W. B. Saunders and Company, 1956.

Steen, Edwin B. Laboratory Manual and Study Guide For: Anatomy and Physiology. Dubuque, Iowa: Wm. C. Brown Company, 1962.

Wald, George, Peter Albersheim, John Dowling, John Hopkins III, and Sanford Lacks. Twenty-Six Afternoons of Biology: An Introductory Laboratory Manual. Reading, Massachusetts: Addison-Wesley Publishing Company, 1962.

Weichert, Charles K. Elements of Chordate Anatomy. New York: McGraw-Hill Book Company, 1959.

Youmans, W. B. Human Physiology. New York: The MacMillan Company, 1962.

GENETICS REFERENCES

Bonner, David M. Heredity. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1961.

Caspari, E. W. and J. M. Thoday. Advances in Genetics. (10th Volume) New York and London: Academic Press, 1961.

Crow, James F. Genetics Notes (5th Edition) Minneapolis: Burgess Publishing Company, 1963.

Ducrocq, Albert. The Origins of Life. London: Elek Books Limited, 1957.

Sinnott, E. W., L. C. Dunn and Th. Dobzhansky. Principles of Genetics. New York: McGraw-Hill Book Company, 1950.

Srb, Adrian M. and Ray D. Owen. General Genetics. San Francisco: W. H. Freeman and Company, 1952.

Sturtevant, A. H. Genetics and Evolution. San Francisco: W. H. Freeman and Company, 1961.

Swanson, Carl P. Cytology and Cytogenetics. Englewood Cliffs, N.J.: Prentice-Hall Inc., 1957.

ECOLOGICAL REFERENCES

Benton, Allen H. and William E. Werner Jr. Principles of Field Biology and Ecology. New York: McGraw-Hill Book Company, 1958.

Biological Sciences Curriculum Study. Revised Green Version. Boulder: Johnson Publishing Company, 1961.

Cragg, J. B. Advances in Ecological Research. New York and London: Academic Press, 1962.

Lemon, Paul C. Field and Laboratory Guide for Ecology. Minneapolis: Burgess Publishing Company, 1962.

Muenscher, Walter Conrad. Aquatic Plants of the United States. Ithaca, N.Y.: Comstock Publishing Company, 1944.

Odum, Eugene P. Fundamentals of Ecology. Philadelphia and London: W. B. Saunders and Company, 1960.

Palmer, E. L. Field Book of Natural History. New York: McGraw-Hill Publishing Company, 1949.

Storer, John H. The Web of Life. New York: The Devin-Adair Company, 1956.

Welch, P. S. Limnology. New York: McGraw-Hill Book Company, 1952.

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