A UNIT PROGRAM FOR HIGH SCHOOL BIOLOGY

by

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B. S., Ottawa University, 1932

A. B., Ottawa University, 1933

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Education

KANSAS STATE COLLEGE

OF AGRICULTURE AND APPLIED SCIENCE

1939

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INTRODUCTION

The history of biology as shown by Preston (23, p. 86-87) has been one of ever-changing development. Previous to the merger of botany and zoology into biology, each of these courses passed through a number of stages, with much consequent addition of material. There had been a natural history trend, type studies, morphology, and finally an ecological trend. With the combination of the two subjects, a study of human physiology was also added.

The result of these changes was creation of much confusion among science teachers as to what they should teach. Many tried to include all the work covered in zoology and botany by condensing the material. Others tried to cover the work by making type studies of a few important plants and animals. A New York course of study divided the year into thirds, giving the first term to plants, the second to animals, and the third to human biology. Many of the text books of the period from 1920-1925 followed this syllabus and, as a rule, presented condensed outlines of work which required more than a year's work for the average high school biology student and made considerable selection of the material taught a necessity on the part of the teacher.

During the time following 1925 came another change in biology teaching, due to the realization that the teachings of botany and

zoology were based on the same fundamental principles, and should be taught on the basis of these common principles. Preston (23, p. 68) states this viewpoint clearly as follows:

> After all, it was reasoned, biology is the study of life, and life is much the same thing in plant, animal, and human being. There is the same sort of cellular organization, the same general type of constructive and destructive metabolism throughout, including digestion, transfer, osmosis, assimilation, and oxidation with its accompanying energy release, the same union of sperm and egg in reproduction, the same influence of heredity, the same need of modification in response to environment, and the same principle of geographical or ecological distribution in case of failure to modify or adapt. It was thought that a course based on these and other similarities, teaching each course or principle once instead of several times in different organisms, would go farther toward a real interpretation of what life means than anything then attempted; in addition it would give a much better opportunity to create an understanding of the interrelations of living things, for the teaching of which there has been little place in courses confined to a single field whose boundaries might not safely be overstepped.

On this new basis of teaching biology through fundamental biological principles, and with the needs of the pupils in the forefront in place of the purpose to cover the science fully, a much more satisfactory course was set up. But in the last few years the same old problem of overloading the course has arisen, through the practice of teaching biology as "Civic Biology" to the exclusion of other material which is essential to an understanding of the real principles of biology, material which is either omitted or hastily taught and which is just as essential to an understanding of life principles and of much more interest to the average high school pupil than the teachings

of civic biology. Varrelman (30, p. 273) says of these recent trends:

> There should be a "back to nature" movement among biologists. By cutting out fads and fancies, a single biology course could be given which should contain more old fashioned natural history or ecology, more knowledge of plants and animals and less of their detailed insides.

Kinsey (18, p. 384) criticizes severly the teaching of the morphological type course, civic biology, applied science, human health, and other similar courses in biology and insists that teachers must get back to the teaching of biological principles and their application. Brownell and Wade (5, p. 237-238) maintain that there is as much need for a thoroughly unified as well as a general knowledge of biological science in high school as there is in college, and that high school studies should be made of plants and animals primarily to arouse, foster, and establish abiding interests in the living things found in the natural environment of those taught, these studies being based on biological principles.

The writer contends that biology should not have the extra load of civic biology or other extra-biological materials thrown onto an already full program, except as it fits into the teaching of the great essential principles involved in biology. Civic biology should be taught as a separate course or in some other related course which is not carrying so great an informational load. Kansas elementary schools in the third class cities or rural communities teach very little natural science, so that the course in biology must give these essentials before it attempts work in other fields.

Biology as taught in high schools should present the basic biological principles, an understanding of which are essential and which if properly learned the student will apply to his own life. This statement that these principles are essential is true because the functioning of all forms of society is based upon them; the principle of cellular growth, of metabolism and the processes and organs involved in metabolism, the principles of distribution, of behaviorism, of reproduction, the effect of heredity and environment on all living organisms, the interdependence and interrelationships which exist among living forms, and the balance of nature which exists as a result of these interrelationships. An understanding of the general classification of living organisms is also necessary for an understanding and proper organization of the facts of biology as based on these principles. Today, also, it has become increasingly important that there be developed an understanding of the biological principles involved in the conservation of wild life.

The need for teaching conservation principles is becoming more apparent, and a trend in this direction is seen in the more recent biology texts, which give definite treatment to conservation problems.

The teaching of conservation might be objected to on the grounds that it is just another fad which is being thrown into the biology course or that it should be classified as applied biology, but the

principles involved in conservation are essentially biological principles which can be emphasized best by teaching them under the name of conservation. Leopold (19, p. 480) brings out the idea that the teachings of biology will become meaningless history or will be supplanted by other sciences if these principles are not soon taught and used.

Weaver (31, p. 680) shows that there is a definite trend toward required teaching of conservation in the public schools. Florida, Wisconsin, and Oklahoma have laws requiring the teaching of conservation in all schools of the state. Other states, notably Vermont and Massachusetts, have discussed it. A bill was introduced in the last regular session of congress for enactment of a law concerning teaching of conservation, but it failed to pass. The Wisconsin office of Education issued a bulletin in 1937 for use in the public schools as an aid in the teaching of conservation.

A report by the conservation committee of the Central Association of Science and Mathematics Teachers in 1933 stressed the need for thorough-going instruction in the subject of conservation of natural resources, as aspects of other subjects until better plans could be worked out. They recommended that teacher's conventions stress the necessity of conservation education, that textbook reviewers and publishers emphasize conservation topics wherever feasible in academic subjects; that lists of available bulletins, texts, agencies, and other means suitable for instructional use be made available for teachers;

that courses in teacher training schools be provided for teacher training and that definite courses of study and supplementary materials be made available to teachers for biology, general science, or other subjects, as they would fit into these subjects.

It is apparent that the organization of a program of instruction based on biological principles and adapted to the needs of the high school pupil is a task of no small proportions. It is a task over which the opinions of authorities have been changing as different techniques have been tried. The writer's attack on this problem is an attempt to set up a program of units based on the fundamental biological principles as given by Preston (23, p. 30) which will combine the best teachings of the present day material available for biology into a program best bringing out known biological principles.

ORGANIZATION

The work was planned for a one-year course for sophomores and juniors of a four year high school with class and laboratory periods covering a total of three hundred minutes per week.

The organization is based on the unit-problem plan and each unit is built around one or more of the major principles of biology with subordinate principles taken up in the problems and centering around the larger principle or principles. The attention of the pupil is centered on these principles rather than on a large number of facts taken up in consideration of a large number of plants and animals.

The principles used as a basis for the unit studies were based on the major principles of biology as outlined by Preston (23, p. 90). These principles as set up in the unit topics by the writer are:

1. The Classification of Plant and Animal Life.
2. The Changing Forms of Life on the Earth. (organic evolution, geographical distribution, and adaptations)
3. The Interrelationships Existing Among Living Things.
4. Metabolism and the Body Structures Involved in Metabolism.
5. Nature's Plan for the Continuation of Life.
6. The Effects of the Laws of Heredity on Plant and Animal Life.
7. Plant and Animal Behavior.
8. The Conservation of Life.

Each unit is prefaced by a short lecture and discussion of the problems to be taken up as based on a suggested approach to be given with each unit. Also at the beginning of the school year there is to be a discussion of the year's work as a whole, with a presentation of study methods based on the scientific method of problem solving. Pupil problems and interests are to be used in so far as possible for development of each unit, and they are to be used in every case for the unit approach.

CRITERIA FOR SELECTION OF UNIT MATERIAL

1. Reference material is to be material which is easily read

and understood by pupils of high school age.

2. The materials and activities are to be closely related to the natural interests of the pupils.

3. The references are to be well illustrated both by examples and pictures.

4. Textbooks used for references are to be comparatively recent texts which consider new developments in the field covered by the units.

5. The content material and activities are to be built up only after consultation with related high school and college departments.

6. New vocabulary requirements are to be only of terms essential to the understanding and development of the principles involved.

METHOD OF STUDY

1. Oral discussion and preview of the unit in class with development from a definite approach.

2. General reading over the field covered by the unit.

3. Outline of the chief ideas or principles involved in developing the major principles of the unit on the basis of problem questions.

4. Study chiefly for the purpose of memory and understanding

of the chief ideas of the unit; information is to be secured mainly for illustrating the principles involved in the unit.

5. Test on completion of the unit for the purpose of diagnosis and for grading students on the work of the unit.

6. Review of the work of the unit based on the test results.

The objectives used for this course are those set up by Baker and Mills (2, p. vii-viii) which are based on the general objectives of secondary education.

1. To provide the student with a fundamental knowledge of life processes.
2. To present the basis in fact upon which the individual may proceed intelligently to develop attitudes, dispositions, and standards for healthy living.
3. To provide many situations that challenge the intellectual interests of adolescent youth.
4. To present many situations that have a direct bearing upon problems of life in the home.
5. To offer opportunities for the development of hobbies and recreational opportunities.
6. To present situations for the development of vocational interests.
7. To aid in the solution of community problems, thereby developing scientific attitudes, dispositions, and standards in civic life.
8. To aid in some measure in developing a respect for the contributions of men known the world over for biological research and service.

UNIT I. THE CLASSIFICATION OF PLANT AND ANIMAL LIFE

The purpose of this unit is to introduce the pupil to the plant and animal kingdoms. The purpose is primarily to show the relationship and kinship existing among all the forms of life, and to give a background of knowledge of plants and animals which will lead into the succeeding units. The unit is placed first for this reason. It is also placed here because the autumn months give good seasonal opportunities for collecting and for field work. Collection work on all forms of life should be started during the first weeks of school.

This unit is not to be considered as supplying detailed training in taxonomy. It is to be considered only as an introduction to taxonomy which will develop in the pupil an intelligent attitude toward the system of classification used by biologists. It should give him a general knowledge of the use of our taxonomic system and of the principles involved in its use.

Seven weeks time is to be used in teaching this unit.

Pupil objectives:

1. To understand the principles used by biologists in classifying plants and animals.
2. To learn to identify some of the more important local plants and animals.
3. To correct mistaken ideas in regard to common names and common groupings.

4. To appreciate the work biologists of the past have done in regard to development of a system of classification.
5. To develop interest in natural history with the specific purpose of finding new interests or hobbies.

Generalizations to be developed:

1. A taxonomist is an explorer.
2. Taxonomy is based on likenesses and differences in structure.
3. The use of Latin or Latinized names gives a uniform language for classification.
4. Each group in a classification scheme is based on some definite structural relationship.
5. Taxonomy shows us a part of the story of the development of life.
6. Likenesses in structure among organisms, either in adult or embryonic stages, show relationship.

Approach:

Collect a large variety of plants and smaller animals on a field trip. Ask the class as a group to set up a system for naming or classifying them. Following this activity, bring out through questions some of the likenesses and differences in the various specimens collected, and group the plants and animals as they should be, calling attention to the characteristics which place each in its category.

From this approach, go directly into the work of problem I.

Problem I. How are plants and animals classified?

1. What was the part of Linnaeus in working out a system of classification? Give a brief summary of his work.
2. What are the divisions now used in classification?
3. What are some of the general characteristics used in classification?
4. What part does a study of structures have in showing relationships? Define and illustrate the meaning of "homologous" and "analagous" structures.
5. What part does a study of embryos have in showing relationships?
6. What is meant by: "a natural system of classification"; "an artificial system of classification"?
7. Why are scientific names used in classifying or naming plants and animals? What language is used? What endings are used for the various divisions?
8. What are some of the ways by which plants or animals get their common names?
9. What disadvantage is there to the use of common names? Of what use are common names to you? Do you think it would be easier to study biology if we used only common names?

10. What are the characteristics common to both plants and animals? How do plants and animals differ from each other?
11. What is a key? Construct a key for classification of the four great plant divisions.

Problem II. How are plants classified?

1. What are the four great divisions of the plant kingdom?
2. List the plant forms belonging to the Thallophytes. Give the chief characteristics of these as a group.
3. What are diatoms? Where are many of them found?
4. What are the three general types of bacteria?
5. What are algae? Where are they generally found?
6. What are fungi? Where and how do they live?
7. What is the chief difference between fungi and algae?
8. What are lichens? Where are they generally found?
9. Make sketches of the following in order that you may become better acquainted with them: (Label parts as well as you can.) a. the three types of bacteria. b. spirogyra or other algae. c. yeast cells. d. bread molds. e. diatoms. f. black stem rust of wheat. g. mushrooms. h. corn smut. i. lichens.
10. What are the chief characteristics of the Bryophytes? What forms belong to this group?

11. Make a sketch of the moss plant, showing the two types or generations.

12. How would you distinguish between the mosses and lichens?

13. What are the chief characteristics of the Pteridophytes? Where would you look for wild ferns?

14. Make a sketch of a fern plant, showing the two types or generations.

15. What are the chief characteristics of the Spermatophytes? What are the two subdivisions of this group?

16. Compare the gymnosperms with the angiosperms as to their distinguishing characteristics. Name some of the plants belonging to each group.

17. What are the two important divisions of the angiosperms? Contrast the two as to their differences. Collect specimens of each group, and make sketches illustrating the stem and leaf structures of each.

18. List some of the outstanding families of the monocotyledonous plants. Give the chief characteristics by which you might identify family groups.

19. List some of the outstanding families of the dicotyledonous plants. Give the chief characteristics of each family.

Problem III. How are some of the primitive forms of animals classified?

1. What are the characteristics of the protozoa? Where are they usually found? Using the microscope, find as many forms as you can. Identify these and make sketches.
2. Make a list of some of the parasitic forms of protozoa.
3. What are the characteristics of the Porifera or sponges?
4. What forms belong to the Coelenterates? Where are most of them found? What form may be found in our locality?
5. Make sketches showing the life history of the jellyfish.
6. What are the characteristics of the Nemathelminthes, or roundworms? What forms belong to this group?
7. Make a brief writeup on the life history of the hookworm and of trichina.
8. What are the characteristics of the Echinoderms? Where are most of the species found?
9. What are the characteristics of the Platyhelminthes or flatworms? List some of the species.
10. Make a brief writeup on the life history of one of the liver-flukes or of one of the flatworms.
11. What are the characteristics of the Annelids? Are they structurally similar to the Arthropods?

12. Make sketches showing the stages in the life history of the earthworm.
13. What are the characteristics of the molluscs?
14. Name the three classes of the molluscs and give an identifying characteristic for each.

Problem IV. How are insects and their relatives classified?

1. What are the chief characteristics of the Arthropods?
2. List the classes of the Arthropods and give identifying characteristics for each group.
3. How do the grasshopper and the crayfish compare with each other in regard to body organs and external appearance? Make sketches of each. In what ways do they show relationship?
4. How would you distinguish between the millipedes and the centipedes? Do centipedes have a hundred legs, or millipedes a thousand?
5. How do insects differ from the arachnids?
6. Find out how many important orders of insects there are and learn the identifying characteristics for each order. Be able to classify our common insects into their proper order.
7. Describe the methods used in pinning or mounting insects. Make sketches showing these methods.
8. How do insects differ from most animals in regard to their

life histories? Name and describe the two types of life histories.

9. Collect insects and prepare some representative group of insects or prepare a life history group. Pin these in boxes or prepare them in "Riker" mounts.

10. Prepare accounts of the life history of at least one insect of each order for your notebook.

11. What is peculiar about the eyes of insects? How many do they have, as a rule?

12. What types of mouthparts are found in insects?

13. Where are the sense organs of touch, smell, and hearing located on the grasshopper?

14. Prepare a list of the insects we have studied, showing whether they are harmful or helpful to man. (an artificial classification)

Problem V. How are the Chordates classified?

1. What animals show the beginning of a vertebral column, but do not have a true backbone?

2. What are the chief classes of the vertebrates? Make a table listing these, and give the chief characteristics of each of the classes.

3. List the chief orders of the mammals, and give the characteristics used in fixing each of these orders.
4. How do birds differ from the mammals? How do they differ from the reptiles?
5. What are the chief characteristics of the reptiles? List the orders of reptiles, using common names.
6. What four families of turtles are found in our locality?
7. What are the chief characteristics of the snakes? What two families are found in Kansas? About how many species of snakes do we have in our locality?
8. List some of the common snakes found in our locality and give some characteristics which would enable you to identify them.
9. How can the poisonous snakes be identified? How would you treat the bite of a poison snake?
10. How do lizards generally differ from snakes? What lizard does not have legs?
11. What are the chief characteristics of the Amphibians? Name the three orders.
12. How do the salamanders differ from frogs and toads? How does the salamander differ from the "mud-puppy"?
13. How do frogs differ from toads? Name some of our common species of frogs and toads, and give an identifying characteristic for each.

14. What are the chief characteristics of the fishes? Read about the fishes. Collect members of the most important families: the sunfish and bass family, the minnows, the catfishes, and the suckers. Make a list of some differences which would aid you in identifying each of these families.

Essential Vocabulary for this Unit:

principles	taxonomy	segmented	grub
classification	biology	antennae	maggot
kingdom	zoology	spiracles	caterpillar
phyla	entomology	larva	dorsal
class	botany	nymph	ventral
order	homologous	pupa	anterior
family	analogous	adult	posterior
genus	sperm	cocoon	thorax
species	spore	chrysalis	abdomen
ungulates	omnivorous	chitin	organism
rodents	marsupials	chordates	gymnosperm
carnivores	vertebrae	monocotyledon dicotyledon	angiosperm

Reference Outline:

I. Early systems of classification: based on the use of color, external appearance, size, shape, habits, etc.

II. Present system of classification: based on the Linnaean system.

A. A natural system is based on homologous structures. Separations are made on the basis of differences.

B. Naming or nomenclature is simplified and made uniform by rules for naming organisms by the use of Latin or

Latinized names.

C. Divisions used in the present classification system: Dynamic Biology, p. 685.

D. The classification of plants and definitions of the various groups: Dynamic Biology, pp. 685-688.

E. The classification of animals and definitions of the various groups: Dynamic Biology, pp. 688-693.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 294-297. pp. 406-475.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 118-342.

Heiss, Obourn, and Hunsor, Our World of Living Things. pp. 19-51.

Hunter, Problems in Biology. pp. 179-180. pp. 217-278.

Kinsey, New Introduction to Biology. pp. 13-102.

Smith, Exploring Biology. pp. 87-122.

Pieper, Beauchamp, and Frank, Everyday Problems in Biology. pp. 406-444.

UNIT II. THE CHANGING FORMS OF LIFE ON THE EARTH

This unit deals with a study of the distribution of life as it is found today and of the principles back of this distribution. A study is made of life as it began and of the subsequent dispersal of life over the earth. The study includes one of the most interesting phases of biology for the high school pupil, the story of the evolution of

life, of the proofs which show that evolution has taken place, and the theories as to how these changes have occured. A very comprehensive outline of the work is given each pupil, an outline based on the references given in the summary outline at the end of this unit.

Five weeks time is to be used in teaching this unit.

Pupil objectives:

1. To know some of the causes of the distribution of life.
2. To understand something of the means by which this distribution took place.
3. To understand why some forms of life are restricted to a given area and to learn what some of these restricting factors are.
4. To know the plants and animals of our local habitats in relation to their environment.
5. To understand that all life must adapt itself to the conditions of its environment if it is to live in that environment.
6. To understand something of the means by which life has developed on the earth.

Generalizations to be developed:

1. Life tends to adapt itself to the conditions it must withstand.
2. Barriers serve as the limiting factors of dispersal of living things.

3. Animal or plant life is not always found in all the regions to which it is adapted.
4. Highly specialized organisms are more apt to become extinct under changing conditions than less highly specialized ones.
5. No species of plant or animal can exist in an area to which it is not adapted.
6. Life under natural conditions is a continual struggle for existence for all living things.
7. Isolated regions have forms of life peculiar to themselves.
8. The range of any form of life is dependent on its adaptations.
9. Many forms of life have perished in the struggle for existence.
10. The development of life from its first simple beginnings has covered tremendous periods of time.

Approach:

Class discussion is developed as to the origin and development of life. "Where was the 'garden of Eden'?" "How was man able to get to the other continents?" "How did other forms of life become dispersed from their place of creation?" "Was all life created in one place?" Following this discussion, general reading which gives authoritative answers for some of the questions is assigned.

Problem I. What are the evidences which show that life has changed on the earth?

1. What are the evidences as to the beginning of life? Was life created on each of the continents?
2. Have there been any great changes in the earth's surface in the past which aided dispersal of life?
3. Why do many of the North American plants and animals resemble Eurasian forms while those of Australia belong distinctly to that one realm?
4. How do we know that forms of life on the earth have changed over long periods of time? List the five proofs given by Baker and Mills which show that life has changed.
5. What is the law of recapitulation?
6. What do geological records show about the early forms of life? What do they show about its dispersal over the earth in the following ages?
7. In what other ways than in the rocks have ancient forms of life been preserved?
8. Make a short report on the evolution of the horse as shown by geological records.
9. Find out all you can about the geological history of Kansas. What were the higher types of plants and animals found in Kansas at the time the Osage county coal beds were formed?

10. Make a geological time scale showing the approximate time at which the various forms of life appeared on the earth.

11. What is the importance in the study of the development of life of such animals as the trilobites, the lancelets, the lungfish, and the archaeopteryx?

12. Notice the steps in the development of life forms as shown in your geological time scale. Which steps took the longest period of time? How have scientists computed this time?

Problem II. What does the geographical distribution of our present forms of life show about the dispersal of life?

1. What are realms? What determines their boundaries?

2. List the eight life realms. Make a chart showing those found in each. Underline any life forms which have been transported to the realm by man. What are some conclusions concerning the distribution of life which can be drawn from these facts?

3. What are barriers? What forms may barriers take? Why does not all of Asia or all of Africa belong to one realm?

4. What are life regions? What determines their boundaries?

5. What are the three life regions of North America? List some of the principal forms of life found in each as you did in question 2.

6. On what basis are regions divided into zones?

7. In what zone or zones is Kansas? Animals and plants vary considerably in different zones; what would you expect to find near the boundaries or at the boundaries of different zones? Does Kansas have any of these "transition" zones?

8. What is meant by the "range" of an animal or plant? What effect do barriers have on an animal's range? How can man increase or decrease the range of an animal or plant?

9. How can an animal or plant increase its natural range? What may happen if it does?

10. What are some of the more frequent retarding factors which limit the range of an animal or plant?

11. What are some factors which may cause an animal to leave its natural range?

12. What is meant by the "habitat" of an animal or plant?

13. Visit some of our local plant and animal habitats. List some of the plants and animals you see in at least five definite habitats.

14. Would you find more than one natural habitat in a pond or stream? Explain.

15. How does life in each of the following habitats differ from life elsewhere?: (Answer this question by listing the chief environmental factors found in each habitat.) desert life,

life of the tropical jungles, life at the north pole, life in the antarctic, life on the mountain tops.

16. Your answer to question 15 gave some differences in needs of plants and animals of different habitats. What similar needs or conditions were necessary for life in any of these habitats?

Problem III. How have organisms become adapted to life in their environment?

1. What is meant by "adaptation"?
2. What adaptations have the following types of organisms made for food getting: saprophytes, carnivorous animals, rodents, the ungulates, green plants, birds of prey, seed-eating birds?
3. Make some sketches from pictures or from museum animals showing some of the types of mouthparts used in food getting, and label as to their use.
4. What adaptation or adaptations have been necessary for each of the following methods of locomotion: swimming, running, jumping, burrowing, climbing, gliding, flying?
5. What are some adaptations which aid or insure preservation of the species? (as a race rather than as individuals)
6. What are some animals or plants which have an offensive or defensive armor for protection?
7. Name some animals which protect themselves by feigning death.

8. Name some other animals which protect themselves by some special means.

9. What is meant by "protective coloration"? Give some examples of protective coloration. Distinguish between "protective coloration" and "protective mimicry".

10. What are some of the means by which animals are protected against changing or disagreeable temperatures?

11. What might happen to plants or animals if they are taken out of their local range to another? Under what conditions should they survive? Notice your answer to question 2, problem II. Why have some transplanted organisms survived, while many others have died out?

Problem IV. How has the evolution of life occurred?

1. Read about the theories of early workers in the field of biology as to how life forms have developed and changed through the ages.

2. Who was Lamarck? What were his ideas as to the way in which life had changed? Does his theory seem reasonable today?

3. Who was Charles Darwin? What were his ideas as to the way in which life had changed? Summarize his theory. Do his ideas seem more reasonable than those of Lamarck? What were the weak points in his theory?

4. What is meant by "natural selection"? What is meant by "the

struggle for existence and the survival of the fittest"? Is it impossible to eliminate this struggle for existence? Explain.

5. What important discovery did Weismann make? Describe the experiment which he used to disprove Lamarck's theory of "evolution".

6. Who was De Vries? What did his discoveries in regard to mutations show in regard to Darwin's findings? What did he show in regard to our changing forms of life?

7. Read about the use of the x-ray in producing mutations.

8. Which of the above mentioned theories as to the way in which life has changed is more generally accepted today?

Essential vocabulary:

realm	geology	migration
region	paleontology	protective coloration
zone	adaptation	mimicry
range	natural selection	barrier
habitat	environment	ecology
diurnal	arctic	organism
nocturnal	antarctic	tropism
crepuscular	hibernation	theory

Reference outline for the unit:

I. How did life become distributed over the earth?

A. Factors causing the dispersal of life were: changes in weather, changes in the surface of the earth, the presence of too many enemies, lack of food, overpopulation, or inadaptation for a particular environment.

B. Factors limiting the dispersal of life: racial stability, a stable or unchanging environment, a well-adjusted balance of nature, or barriers such as mountains, rivers, lakes, forests, oceans, prairies, deserts, enemies, unsuitable temperatures or other adverse weather conditions.

C. Forms of distribution: continuous or discontinuous.

D. Effects of ecological factors or organisms: the effects of light, temperature, water, gravity, pressure, air, and food as outlined from "Dynamic Biology".

E. Evidences as to the beginning of life and its distribution: Dynamic Biology, pp. 670-671.

F. Conditions during the early ages:

1. Simple forms of life developed through long periods of time into a large number of more complex forms.
2. Land bridges or shallow water existed between the continents so that life forms were more nearly similar over the earth than they are today.
3. Breaking up of the land bridges isolated the forms of life into the eight great realms.
4. Changing conditions in each of the realms have since caused changes in the forms of life in each realm.

G. Steps in the development of life forms through the early ages: Dynamic Biology, pp. 670-671.

II. Organization of the geographic distribution of organisms with classification of the divisions down to the local habitats: outlined from Dynamic Biology, pp. 9-20.

III. Adaptation to environment.

A. General adaptations of water forms: stream-line form, absence of external coats, concealing coloration.

B. Adaptations of land animals:

1. Limbs under the body for locomotion: sharp claws and short, well muscled limbs for climbing; long, slender legs and a light body for running; strong, short, heavily muscled legs and a cylindrical body for burrowing; front limbs modified as wings and body structures light for flying; front and hind limbs connected by membranes for gliding.

2. Respiratory system for taking in oxygen and giving off carbon dioxide: the higher animals breathe through nostrils to lungs; insects through spiracles in the abdomen.

3. Adaptations for caring for eggs to prevent drying: laying in water; protective shell; burying in moist soil; laying in nests and hatching with body heat; carrying in the body until ready to hatch, or while the embryo develops.

4. Protection of body from changing temperatures: scaly coverings; coat of armor; thickened skin; coat of hair, fur, scales, or feathers.

5. Protection from enemies or adaptations for defense: stings or stinging cells; sharp claws and teeth; spines, quills, or horny projections; poison glands; scent glands; slimy or offensive discharges; warning or sounding apparatus; ability for rapid flight; horns or antlers; powerful legs for kicking; cutting hooves; feigning death; protective coloration.

6. Adaptations for perpetuation of the species: distribution; migration; hibernation; complex metamorphosis; spore formation; reproduction.

7. Adaptations for food getting: teeth adapted for gnawing, grinding food, or tearing flesh; sharp claws; mouth parts adapted for piercing and sucking; beaks of birds for tearing flesh, crushing seeds, or adapted for the taking of insects; protective coloration; speed; keen sense of smell, hearing, or sight.

C. Evidences showing that plants and animals have changed to meet new environmental conditions: Dynamic Biology, p. 669.

D. Theories as to the means by which changes in plants and animals have occurred: Dynamic Biology, pp. 679-681.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 2-84. pp. 602-618. pp. 661-681.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 269-290. pp. 639-650.

Heiss, Obourn, and Hanser, Our World of Living Things. pp. 255-265.

Hunter, Problems in Biology. pp. 280-311.

Kinsey, New Introduction to Biology. pp. 109-171.

Smith, Exploring Biology. pp. 503-578.

Pieper, Beauchamp, and Frank, Everyday Problems in Biology. pp. 291-348.

Robbins and Isenberger, Practical Problems in Botany. pp. 304-339.

UNIT III. THE INTERRELATIONSHIPS EXISTING AMONG LIVING THINGS

This unit naturally follows unit II in that in increases the pupil's understanding of "natural selection". The primary purpose of the unit is to show that all life is dependent on other forms of life for existence. This interdependence is first considered through a study of the food cycle, the carbon cycle, and the nitrogen cycle and development of the idea of the balance which results through these cycles. Following this study, examples of some of the more interesting interspecific and intraspecific relationships existing among organisms are considered.

Four weeks time is to be used in teaching this unit.

Pupil objectives:

1. To understand some typical life cycles which illustrate the interdependence of organisms.
2. To know some of the adaptations by which life forms are associated with each other.
3. To learn how living forms depend on other living forms or their remains for food and other life-giving activities.
4. To appreciate the forces which operate in producing or tending to produce a balance of nature.
5. To understand something of the causes of epidemics.
6. To learn that the plants of the world form the foundation or important key to life for all animals.
7. To learn how man may help in keeping a proper balance among the various forms of life.

Generalizations to be developed:

1. Plants are the ultimate source of food for all life.
2. There are many varying degrees of helpfulness between organisms.
3. The amount of energy in the universe remains constant and can neither be created nor destroyed.
4. The natural rate of reproduction of all life is such that without proper controls the earth would be overpopulated in a short time.

5. The result of having many kinds of plants and animals on the earth with varied feeding habits is a balance of nature.

6. Man is the greatest disturber of the balance of life.

Approach:

Read and discuss pages 490-491 in "Dynamic Biology". The authors discuss the cycle of life and the necessity of death in order that there may be life, as based on a quotation from William Cullen Bryant's poem, Thanatopsis.

Problem I. How are plants and animals dependent on each other?

1. What is a food cycle? Make notebook sketches to illustrate.
2. What are elements? What are atoms? How are compounds formed from elements?
3. Can elements be destroyed? Could they be manufactured in the laboratory?
4. What happens normally to the elements taken up by food plants in compounds? What happens to them after they are used as food?
5. What is meant by the "nitrogen cycle"? Illustrate the use of nitrogen by plants and animals in this cycle.
6. What is meant by the carbon cycle? Illustrate the uses made of carbon in a typical carbon cycle.
7. Do the other elements used in the body have similar cycles? List some elements which are used.

8. What elements are always present in carbohydrates and fats? What additional elements are present in protein foods?
9. What is the process by which plants manufacture food from carbon dioxide and water? How does the plant gather raw materials? Make a sketch of a typical plant, showing the parts involved in the process of food manufacture.

Problem II. What are the relations existing between animals or plants of the same species? (intraspecific relations)

1. What animals are found which belong to the solitary (non-mating) types? How do their numbers, variety, and range compare with the mating types?
2. What are some of the variations in regard to mating which are found among the mating types?
3. What are some of the variations which exist among monogamous animals?
4. Outline the life history of the following colonial insects: ants, the social wasps, bumblebees, and the honeybees.
5. What variations are found among members of a colony as to their duties?
6. What is slavery as referring to animal associations? Is slavery common among animals?
7. What is meant by a society in reference to animal associations? Make a list of some gregarious animals.

8. What seems to be the purpose or the advantages of animal societies? Do any of the animal societies "choose" group leaders?

9. Do you think man could learn anything of personal value from a study of animal societies? Is there any comparison possible of the social or everyday life of man and that of the colonial insects?

Problem III. What are the relations existing among different species of living things? (interspecific relations)

1. What is commensalism? Read about or discover for yourself good examples of commensalism. Describe the following examples of commensalism: the pilot fish and its relations with the shark; barnacles on the whale; climbing plants on trees; seeds on the coats of animals; animals using plants or trees for shelter.

2. What is meant by mutualism? Look up the following examples of mutualism: man and domestic animals; man and the song birds; insects on flowers; squirrels as storers of seeds; ants and their cows; bacteria as organisms causing decay.

3. What is symbiosis? Give the story of the symbiotic relationships existing among the following: nitrifying bacteria on legumes, lichens; the hermit crab and the sea anemone; the protozoan which lives in the alimentary tract of the termite;

the yucca and the pronuba moth.

4. What is meant by parasitism? Make a list of some of the common parasites. Name their host and the type of harm done.

5. What happens eventually to any animal or plant as it develops parasitic habits?

6. Summarize the life history of the following parasites: tapeworm in man; hookworm; trichina; fleas; sucking lice on hogs; mistletoe; corn smut.

7. Do parasites ever prey on other parasites?

8. Who was Louis Pasteur? Write the story of his life and achievements in the field of biological science.

9. Write a short report on Koch's work in the field of bacteriology. What did he do for this science?

10. Make a list of some of the bacteria which are parasites on or in man and name the disease they cause.

11. What are some of the conditions which prevent bacterial disease? What are some means used in controlling disease?

12. Obtain bacteria from various sources and grow them in petri dishes. On prepared culture media, isolate into culture tubes. Stain and examine these bacteria under the microscope.

13. Read about some of the protozoa which parasitize man.

14. What is predatism? List several examples of predatism.

15. What is the difference between parasitism and predatism? Could parasitism become predatism?

16. What are some other ways in which living things might hinder other living things other than through parasitism and predatism?

Problem IV. What effect has the "balance of nature" on plant and animal life?

1. What further light has this unit thrown on the idea of "the struggle for existence and the survival of the fittest"? Do you think those which should survive always do? In "nature's" scheme, it is necessary that life should be a continual struggle for existence. Explain.
2. What principles have been made clear by this study in regard to the relative numbers of parasites and predators as compared with their hosts? What happens to a group of predators if they become too numerous? Why is a protected animal which produces many young, as the house cat, apt to produce an epidemic?
3. What is meant by "the balance of nature"? Explain and illustrate by examples of established balances.
4. Why is the maintaining of a balance in nature important? Is it easy to upset this balance? Is the balance ever a perfect one? Explain.

5. Why do pests often become epidemic? What method does nature use in pest control?

6. What is the biological definition for an epidemic? What are the causes of epidemics? What are the general characteristics of an epidemic?

7. Is it safe to say that man is the greatest disturber of the balance of nature? Why does man have so much trouble even when he tries to aid nature in maintaining a balance of life? Should man be more careful in killing animals he considers as pests? Explain.

8. Can animal predators or parasites upset the balance of nature? What may happen if they do?

Essential vocabulary:

cycle	carbon dioxide	commensalism	monogamy
element	photosynthesis	mutualism	promiscous
atom	saprophyte	symbiosis	polygamy
compound	parasite	society	polyandry
carbon	predatism	gregarious	prey
oxygen	delayed predatism	epidemic	host
nitrogen	slavery		

Reference outline for the unit:

I. Food cycle, nitrogen cycle, carbon cycle: Our World of Living Things, pp. 87-90.

II. Intraspecific relationships:

A. Solitary types: forms that do not mate, but reproduce by budding, fission, spore formation, or other simple means.

B. Mating types: polyandrous; polygamous; promiscous; and monogamous. Monogamous types include life matings, seasonal matings, mating until the young are able to care for themselves, or mating for only a short period.

C. Colonial types: groups living together for the mutual benefit of all and for the care of the young, and with a division of labor among the various members.

1. Honeybees: queen, drones, workers or undeveloped females.

2. Ants: winged females or queens, unwinged and undeveloped females or workers, large undeveloped females or soldiers, and drones.

3. Social wasps: queens, worker. Males in fall only.

4. Bumblebees: similar to the social wasps.

D. Societies: groups banded together for company or for protection.

E. Slavery: members of another group of the same species are captured and made to do the work of the colony.

III. Interspecific relationships:

A. Commensalism: an association in which a member of one species is benefited and the other is not injured.

B. Mutualism: an association in which both members are benefited.

C. Symbiosis: an association similar to mutualism but differing in that each member involved cannot live without the other.

D. Parasitism: an association in which one individual is benefited but gives nothing in return, the host being injured. (parasitism implies degeneracy because the parasite eventually loses the use of certain body parts and certain body functions).

E. Predatism: an association in which one organism preys on another, killing it directly. The organism killed is called the prey. Parasitism which kills the host may be called "delayed predatism".

F. Means by which living things may hinder other living things:

1. Overpopulation, causing scarcity of room, food, etc.

2. Through protective devices: poisons, stings, teeth, etc.

IV. Ecological relationships:

A. Balanced conditions in nature: New Int. to Biology, pp. 471-472.

B. The causes of epidemics: New Int. to Biology, pp. 478-479.

C. Description of an epidemic: New Int. to Biology, pp. 495-498.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 489-520.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 17-43.

Hess, Osburn, and Hanser, Our World of Living Things. pp. 87-104.

Kinsey, New Introduction to Biology. pp. 435-727.

Smith, Exploring Biology. pp. 203-267. pp. 326-360.

Pieper, Beauchamp, and Frank, Everyday Problems in Biology. pp. 223-290.

Robbins and Isenberger, Practical Problems in Botany. pp. 236-248.

UNIT IV. METABOLISM AND THE BODY STRUCTURES INVOLVED IN METABOLISM

This unit is based on the principle of metabolism--the constant building up and tearing down which goes on in the body of every organism. It deals with the fundamental life processes carried on by organisms, from the simple celled forms up through the more complex ones.

In studying the unit the pupil should learn how plants manufacture and use food, and how this food forms the fuel from which both plants and animals derive their energy. They should learn something of the nature of the various foods, their purpose, and how the various body organs function in assimilation, use, and excretion.

Six weeks time is to be used in teaching this unit.

Pupil objectives:

1. To understand the means by which plants manufacture food.
2. To understand the means by which food is transformed into energy.
3. To understand the means by which food energy is used by the organism, food is assimilated, and waste products given off.
4. To compare various organisms in the scale of life as to the division of labor and specialization shown in body organs.

Generalizations to be developed:

1. A well-balanced diet must contain all the classes of foods.
2. The cell is the unit of structure of all life.
3. Protoplasm is the essential material of all cells.
4. The digestive organs of an animal are closely related to the kind of food it uses.
5. Oxygen is required by all living cells.
6. In simple animals digested food is carried to the body cells by diffusion. In higher animals the individual cells obtain food by diffusion, but the food is carried to the cells by the blood.
7. The excretory system removes waste materials from the blood.
8. The nervous system and the endocrine glands control the rate of metabolism.

Approach:

The work of the unit begins with a discussion of foods and the part played by each kind of food in furnishing heat, energy, body building materials, and in maintaining health. The functions of each of the types of food, carbohydrates, fats, proteins, minerals, and vitamins are discussed. Next the question of how we might know these foods is brought up and the tests are described for each. Then the pupils are asked to bring some common foods to school and to make their own tests on these foods. This work leads directly into the work of the first problem. A detailed study of body organs is not intended--merely a general understanding of principles involved in the various types.

Problem I. What are the kinds of food used in the body and how is each used?

1. What are the fuel or heat foods?
2. What are the foods which furnish both heat and energy?
3. What is the measure used for fuel foods? What is the daily amount needed by a boy in the teens? A girl? An adult?
4. List your average meals for a day and check the approximate amount of calories you are getting. Is your diet well-balanced?
5. What are some of the factors which cause the fuel need to vary in various organisms or in man?

6. Do cold blooded animals use carbohydrates or fats to the extent that the mammals do? Explain.
7. About what is the average proportion of caloric requirements of carbohydrates, proteins, and fats, for man?
8. What are the foods needed for growth and repair?
9. Can proteins furnish heat and energy? Explain.
10. Is water an essential material for all forms of life?
11. Why is oxygen an essential material for all forms of life?
12. What are vitamins? What is their function in the body? Study the list given in the outline. Know some of the foods which contain each. Know the purpose of each vitamin.
13. What are some of the minerals used in the body? Make a list of minerals commonly used and find out how they are used.
14. What are some of the "acid-forming" foods? What are some of the effects of acidosis?
15. What animals live on a strictly plant food diet? What animals live on a strictly meat diet? Why cannot man live on a strictly plant food diet?
16. What are the general purposes of a food? Must a food fulfill all of these general purposes to be classed as a food?
17. Find out all you can about diseases due to diet or to improper nutrition, lack of vitamins or minerals, and glands and keep a list of these as you study the work of the unit.

18. What are some of the evidences of lack of proper nutrition in man?

19. Carry out experiments to determine the kind of food materials present in various kinds of foods.

Problem II. What are the structures involved in the carrying out of metabolism, and how do they function?

1. Draw and describe the typical cell which is the unit of all plant and animal structure. What are its parts?
2. What forms of life are one-celled?
3. What is it that determines the size of an organism, the size of the cells, or their number?
4. What is protoplasm? Where is it found?
5. What are the five principal functions of cells? How do these functions differ in forms like the amoeba as compared with the higher forms of life?
6. What is a tissue? What is an organ? What is the general importance of body organs to an animal?
7. How do the organs with special functions give an animal or plant an advantage over those with less specialized functions?
8. What is the purpose of the digestive system? Make a sketch of the digestive system of man, labeling the important parts. Make sketches of the digestive system of one form of protozoa, of the sponge, clam, earthworm, crayfish, frog, and a reptile.

Note the specialization in higher forms.

9. Make a careful outline of digestion in the human body, tracing the steps in digestion from the mouth to the small intestine. Name each of the digestive juices and enzymes having a part in digestion and give the function of each.

10. What is the function of the blood? What part has the circulatory system in carrying on metabolism?

11. Make a drawing of the circulatory systems of various animals in the scale of life as you did in question 9. Are these systems similar? How do they differ?

12. What is the composition of the blood? What are the functions of the materials composing the blood?

13. Read about Harvey's work in discovering the way in which the blood circulates. Read about Metchnikoff's discovery of the way in which the white corpuscles kill germs.

14. What is lymph? What is the purpose of the lymphatic system?

15. What is the purpose of the respiratory system in animals? Make sketches to show the different types of respiratory systems, as found in various animals in the scale of life.

16. How is oxygen taken into the blood stream from the lungs? How does waste carbon dioxide get back to the lungs?

17. What is the purpose of the excretory system? What organs have a part in excretion in man?

18. Find out about some of the other types of excretory systems possessed by the lower animals.

19. How are waste products produced in the body?

20. How does the skin serve as an organ of excretion?

21. How do the kidneys aid in removing waste materials? What wastes are removed by the kidneys?

22. What is the purpose of the nervous system? What are some of the ways in which it may affect metabolism? Make a series of sketches showing the development of the nervous system in animals.

23. What are some of the functions of the endocrine system in regard to metabolism? How are the endocrine secretions transported to the place where they are used?

24. Make diagrams or sketches of the plant, showing the means by which it gets food and other materials. Compare the plant with animal life in regard to respiration, circulation, and methods of securing food.

25. What enzymes do plants have? Why do they need enzymes? From where are these enzymes secreted?

Essential vocabulary:

metabolism	endocrine	osmosis	proteins
assimilation	hormone	ventricle	cambium
respiration	peristalsis	ptyalin	rennin
excretion	villi	amylopsin	phloem
enzyme	lymph	trypsin	xylem
digestion	plasma	capillary action	pepsin
arteries	calory	photosynthesis	lipase
veins	stoma	urea	diastase
capillaries	auricle	carbohydrates	malpighian tubes

Reference outline for the unit:

I. The composition and uses of the five classes of foods; tests for these foods: Our World of Living Things, pp. 68-70.

II. Characteristics of poor nutrition: Our World of Living Things, p. 72.

III. The composition of blood; functions: Dynamic Biology, pp. 253-254.

IV. The agencies acting of food to cause digestion: Dynamic Biology, p. 248.

V. Organs of the excretory system and their functions: Dynamic Biology, p. 271.

VI. Glands of the endocrine system, location, and purpose: Dynamic Biology, pp. 256-257.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 209-291.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 261-366.

Heiss, Obourn, and Hanzer, Our World of Living Things. pp. 62-86.

Hunter, Problems in Biology. pp. 313-350.

Kinsey, New Introduction to Biology. pp. 250-255.

Williams, Healthful Living. pp. 24-73. pp. 192-213.

UNIT V. NATURE'S PLAN FOR THE CONTINUATION OF LIFE

Previous units have given the pupil some idea of the reproduction of life through a study of life histories. This unit is intended primarily to show the principles involved in the stages through which all life must pass before birth. A study of the biological processes which occur shows the pupils something of the wonderful way in which life unfolds and develops and should serve as an additional stimulus to study in the biological field. This unit is the answer in so far as possible to the pupil's question of "how does life develop?" and "where does life come from?"

Three weeks time is to be used in teaching this unit.

Pupil objectives:

1. To understand and appreciate the definite means by which nature has provided for the reproduction of life.
2. To learn that all life comes from a similar source.
3. To learn that life as we know it can come from life only.
4. To understand something of the causes for differences in size of animals and of the causes of differences in the length of their life cycles.

Generalizations to be developed:

1. All life comes from life.
2. The creation of new life is the great purpose of all life.
3. The care which animals give their young increases proportionately as they bear a lesser number of young.
4. In asexual reproduction a cell or group of cells separates from the parent organism and develops into a new organism.
5. In sexual reproduction the new organism begins as the result of the union of two cells.
6. The "higher" animals care for their young carefully, feeding and protecting them until they are able to care for themselves.

Approach:

A class discussion of the origin of life is started. The pupils are asked to find out something of the old ideas in regard to the means by which life developed--flies from filth, frogs and toads from slime, and other ideas of spontaneous development.

Problem I. What do we know about the source of life?

1. Do all living things have parents? What are some of the early ideas concerning this? Read about the experiments of Redi, Spallanzani, and Pasteur.
2. What was the early idea concerning the homunculus, or little man in the head of a sperm?

Problem II. How do plants reproduce and develop?

1. Read to find out how plants reproduce, and how they grow. List the methods of plant reproduction, and study each so that you understand it.
2. Make sketches or drawings illustrating the method of reproduction in flowering plants.
3. Study carefully the methods of pollination of the higher plants and make sketches showing the general methods of pollination.
4. What are some of the adaptations which plants possess for the care of the seed and its dispersal?
5. How do plants grow? What limits the growth of the monocotyledonous plants? What limits the growth of most of the dicotyledonous plants?
6. Check carefully all definitions given in the vocabulary outline which deal with plants or plant reproduction.

Problem III. How do animals reproduce and how do their young develop?

1. List the methods of animal reproduction and study each so that you thoroughly understand the general principles of each.
2. How do the methods of reproduction of animals compare with those in plants? Is there any close similarity? Use

specific examples for comparison.

3. Study and outline your findings in regard to the mating habits of the phyla of animals.

4. Make a list of the animals which build nests for their eggs. Make another list of the animals which maintain homes for themselves or their young.

5. Study the outline on care of the young as shown for the various phyla. Do further reading on this subject.

6. Notice throughout your study the lack of care for the young among the lower forms of life. Notice the increasing care for the young among the higher forms, and the correlation of this with the decreasing number of eggs and sperms which is possible because of this. List some of our common forms of life, and the number of eggs or young.

7. How does conjugation occur among the lower forms of animals? Make a sketch illustrating conjugation.

8. How does the hydra reproduce? Are there male and female hydra?

9. How does the starfish reproduce? Are there male and female starfishes?

10. Find out how fishes reproduce and study the life history of some fish which care for their young and eggs. Outline one or two of these life histories.

11. Outline the life history of the frog. How does the life history of the toads differ from that of the frog? Make

Make sketches illustrating the life history of the frog.

12. Find out how our reptiles may reproduce. Is there any care for the young by the reptiles?

13. Study the mating habits of the birds, their nesting habits, and their care for the young. What is the territorial theory in regard to birds?

14. Study carefully and outline the story of the development of the chick embryo from the first stages of development to the hatching of the chick.

15. Compare the development of the embryo of the mammal with that of the chick. In what way is it similar? In what general way is it different? Do mammals produce eggs? How do mammals protect the young developing embryo?

16. Make drawings of the stages through which the fertilized egg passes in its early development. Label and study.

17. What is the method by which animal cells divide to produce growth? How does the process of maturation or the process by which the number of chromosomes in the cells of the parent and the offspring is kept the same differ from the process of mitosis?

18. What does a study of the development of the embryo show about the change which has occurred in forms of life on the earth?

19. What are some of the premating behaviors of animals? Give some specific examples of these.

20. Read about some of the secondary sexual characteristics or differences in male and female forms of the higher animals. List some of these. Do they have a purpose in regard to mating?

21. How may migration be connected with mating?

22. Make a list of some of our local forms of wild life which mate seasonally. Name the approximate time at which their young are born.

23. What might we say are the stages of life of the higher animals? What is meant by adolescence? What are some of the changes which occur at adolescence? What are the causes of senility? What is meant by maturity as applied to animals?

24. What general instincts are found in animals which are essential for nature's plan for the continuation of life?

25. What limits the growth of animals? What animals may grow all during their lifetime? Why must the amoeba remain small? Why must insects with a complex metamorphosis remain the same size as adults?

26. What part has the pituitary gland of the higher forms in regulating growth?

27. Compare the sexual and asexual methods of reproduction. List the advantages and disadvantages of each.

Essential vocabulary:

embryo	oviparous	pollination	calyx
sperm	oviviparous	fertilization	corolla
ovum	viviparous	gamete	vegetative reproduction
fruit	conjugation	ovary	alternation of generations
seed	instinct	stamens	parthenogenesis
vegetable	migration	stigma	
spore	budding	anther	
asexual	maturation	petals	
sexual	regeneration	sepals	

Reference outline for the unit:

I. Similar origin and development of all life:

A. All life begins as a single cell.

B. The reproductive processes are based on related principles:

1. Methods of reproduction in plants--asexual--cell division or fission; formation of spores; vegetative process, as budding, layering, runners, underground stems, grafting, budding of fruits, and regeneration. Sexual methods--conjugation; seed formation (there are two forms, unisexual or monoecious and bisexual or dioecious); alternation of generations.

2. Methods of reproduction in animals--asexual--simple division or fission; budding; regeneration; spore formation. Sexual methods--conjugation; hermaphroditism; parthenogenesis; unisexual in higher forms, with the female producing eggs, the male sperms; alternation of generations occurs with some lower forms.

C. Similarity in method of bringing sperms and eggs together:

1. Conjugation in lower forms and the interchange of cellular material.

2. Higher plants: eggs are fertilized by the sperm or pollen which is carried to the flower by wind, water, insects, or other animals.

3. Hydra and starfish: egg and sperms deposited in water. The sperm travels to the egg through the water.

4. Fishes: sperms deposited on eggs some time after they are laid.

5. Amphibians: sperms are deposited on the eggs by the male immediately after they are laid, the male clasping the female at the time.

6. All higher forms of animal life and some lower ones: the eggs are fertilized in the body of the mother.

D. Similarity in method of fertilizing egg of the higher forms of plants and animals:

1. Sperm cells are always more active and much smaller than the egg.

2. The sperm cells make their way to the egg, one sperm piercing the egg cell and fertilizing it.

II. Purpose of reproduction: All life comes from life. The various means used for reproduction are the means by which "mother nature" has provided for the continuation of life on

the earth. Nature's one aim seems to be the production of innumerable forms of life on the earth. Instincts which serve as nature's means of bringing about this new production of life or which have some part are: the mating instinct, the nesting or home-building instinct; parental instinct, and migration.

III. Sex differences in the male and female:

A. Differences in the reproductive organs.

B. Secondary sexual characteristics: males show marked differences from the females—dark chin in males of the frogs and toads; bright coloration of many species of male fish during mating season; males of the birds more brightly colored and usually the songster; male of the mammals is usually larger, the shoulders and head heavier. The males are usually more aggressive, and have heavier antlers or horns, where present.

IV. Parental care of the young:

A. Little or no care among the lower groups.

B. Some forms of animal life eat their own young.

C. Some reptiles carry their eggs in the body until they hatch.

D. Higher forms of life protect their young:

1. Birds protect their eggs and hatch them with their body heat. They protect and feed the young until

they are old enough to fly. There are two distinct types--praecocial, those able to care for themselves soon after birth, and altricial, those which must be cared for by the parents for a few weeks.

2. Mammals: the egg is carried in the body of the mother until the embryo is developed; the young are protected by the mother and are fed from the mammary glands until the next mating season or until the young can use other food and can care for themselves. The male parent often aids in the homebuilding, protection, and care of the young.

V. Growth of organisms: the causes controlling growth are not well known. Plant growth usually continues until the plant dies. Growth of the dicots continues indefinitely, the plant increasing in girth and growing out at the terminal branches. The monocots do not increase in girth to any extent after the first season. Most of them are annuals except in the tropics. Animal growth takes place through cellular division. Size is limited by inheritance, size of the range or habitat, abundance or lack of food, and by the influence of the pituitary and other endocrine glands.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 573-622.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 562-612.

Heiss, Obourn, and Hanser, Our World of Living Things. pp. 136-162.

Hunter, Problems in Biology. pp. 611-620.

Kinsey, New Introduction to Biology. pp. 226-248.

Smith, Exploring Biology. pp. 561-438.

Pieper, Beauchamp, and Frank, Everyday Problems in Biology. pp. 104-130.

UNIT VI. THE EFFECT OF THE LAWS OF HEREDITY ON PLANT AND ANIMAL LIFE

This unit develops naturally from the preceding one on reproduction for the student's natural query is "how do forms of life produce forms like themselves?"

Students are particularly interested in the study of inheritance but because the use of the laws of heredity entail use of new and technical terms, the study must be made very carefully, and each step made clear as it is encountered. Students are always interested in the subject of heredity and thrilled by the way in which heredity is controlled by laws.

Three weeks time is to be used in teaching this unit.

Pupil objectives:

1. To learn that all forms of life tend to reproduce forms like themselves, but with many small variations.
2. To become acquainted with some of the types of variations and to understand their importance in the improvement of a species.
3. To understand the application of Mendel's laws through the

F_1 and F_2 generations.

4. To realize the effect of proper selection on any species and especially the effect of proper selection on the human race.

Generalizations to be developed:

1. No two living things are ever exactly alike.
2. Two great forces at work in nature cause all variations.
3. The combined forces of heredity and environment determine the development of all living forms.
4. A mutant may be very different from the parents.
5. New species may appear through mutations.
6. Acquired characters are never inherited.
7. Heredity is a cause of variation.

Approach:

As an evidence of the effects of inherited changes, the history of the horse is reviewed. The story of the development of the domestic hen from the wild hen of India and of improvement of other domestic animals through selection followed this. Readings are then assigned which give some of the principles back of these changes.

Problem I. What causes the many variations in plants and animals?

1. What is meant by "variations"? If all life develops from a single cell, what causes various forms of life to differ?
2. Are two living things ever exactly alike? Explain.
3. What are the two basic causes of variation?

4. How does environment cause variations? Are these variations inherited or passed on to the next generation?
5. In what way does environment seem to cause changes in the succeeding generations? What part does natural selection play?
6. What is it that causes adaptation to a particular environment? Why is imported seed of little value until after it has been grown for a season or two in a particular locality?
7. It is often said that a child is a "chip off the old block". Would inheritance from all the past ancestors account for all his differences from father and mother?

Problem II. What is the mechanism which controls heredity, and how does it operate?

1. What are the two basic kinds of variations caused by heredity?
2. How does heredity cause variations? Describe the mechanism involved and study the process carefully.
3. What are Mendel's laws? What do they show about heredity? Be sure you understand the terms used in relation to these laws--dominance, recessiveness, the law of segregation, unit characters, incomplete dominance, and hybrid.
4. How can we know that Mendel's laws are true?
5. Are all inherited characters either dominant or recessive? Explain.

6. Make a list of characters which are dominant or recessive.

7. What is a mutation? List some of the outstanding mutations of the plant and animal world. How can mutations be produced by artificial means? How are mutations of value?

8. What are chromosomes? Where are they found? How are they concerned in cell division?

9. Is there much difference in the number of chromosomes found in various organisms? List some of these. Is there always the same number of chromosomes in the members of a species?

10. In the fertilization of the egg cell by the sperm the two cells unite into one. What is the means by which the chromosome number is kept constant, that is, how is it kept from doubling when the two cells unit? Describe the process.

11. What are the carriers of inheritance? What is the carrier of the unit characters?

12. How is the sex of the honeybee controlled through the queen? How is the sex of the young of the mammals determined?

13. What is meant by "sex-linked" characters? What are some of the sex linked characters found in man?

Problem III. What are some of the improvements in plants and animals which have been possible through a knowledge of the laws of heredity?

1. Read all you can find about Luther Burbank's work with plants.

2. What are "pure lines"? How could a pure line be established?
3. What advantages does a plant breeder have over a livestock breeder in the application of the Mendelian principles? What disadvantages might he have?
4. List some of the improvements made in plants and animals through a knowledge of the way in which inheritance works.

Problem IV. How do the laws of heredity apply to man?

1. Read the family history of the Jukes family, the Kallikak family, the Edwards family, and the Darwin family. Summarize the story of each of these families. What do they tell us about the value of good inheritance? Do you think the Jukes family could have done what the Edward's family did if they had been placed in the same environment?
2. What are some of the characters in man which are known to be inherited? List, as dominant and recessive characters.
3. Make a list of some of the characters which man may acquire. Can any of these be inherited?
4. Are diseases ever inherited? Explain.
5. Is intelligence inherited or acquired? Explain.
6. Is alcoholism ever inherited? Explain.
7. Is insanity ever inherited? Explain.
8. Write a short paragraph in answer to each of the following

questions: (a) What are some ways in which man could improve his heredity? (b) Does a person deserve any credit or blame for the things he has inherited? (c) Does a person deserve any credit or blame for his environment? (d) Can a person make his own opportunities?

Essential vocabulary:

mitosis	unit-character	incomplete dominance
heredity	dominant	pure lines
variation	recessive	pure-bred
mutation	chromosomes	euthenics
hybrid	genes	eugenics
cross-bred	instinct	genetics

Reference outline for the unit:

The two basic causes of variation are heredity and environment. Environmental variations affect only the individual, and are not inherited. Inherited variations are produced only through a change in the germ plasm, that is, by a new arrangement of the genes in the chromosomes. The two types of inherited characters are: continuous variation or small variations appearing in every generation; and discontinuous variations or mutations which are either small or large variations which appear suddenly in an individual.

The mechanism of heredity: inheritance is tied up only in the germ cells. Chromosomes in the nucleus of the germ cells are the carriers of the hereditary characters. The number of these chromosomes is usually the same for all animals of a species. In cell division through the process of mitosis each cell maintains its proper

number of chromosomes. Before the germ cells of the male and female unite to form the fertilized egg, the germ cells go through a process called maturation in which instead of the chromosomes splitting as they do in mitosis, half of the chromosomes go to one side of the cell, half to the other, and the cell divides. The mature sperm or egg which results from this process thus contains only half as many chromosomes as the body cells of the organism. They unite into a single cell to give a cell with the ordinary number of chromosomes.

Chromosomes contain parts called genes, each one of which is the carrier of a particular unit character. The division of the chromosomes and the arrangement of their genes in these chromosomes at the time of maturation determines the inheritance of the organism involved.

Mendel's laws show something of the regularity or system by which genes for certain characters appear in any organism:

1. the law of dominance--when two inheritable characteristics are opposed to each other, one (the dominant character) will completely replace or obscure the other.
2. law of segregation--when hybrids (organisms having different characteristics) are mated, one fourth of the offspring will be pure dominants, one half are hybrids, and one fourth are pure recessives. In appearance, there will be a ratio of three to one or three-fourths showing the dominant characteristic.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 625-659.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 613-638.

Heiss, Obourn, and Hanser, Our World of Living Things. pp. 163-184.

Hunter, Problems in Biology. pp. 620-693.

Kinsey, New Introduction to Biology. pp. 389-437.

Smith, Exploring Biology. pp. 441-502.

Robbins and Isenberger, Practical Problems in Botany. pp. 301-322.

UNIT VII. PLANT AND ANIMAL BEHAVIOR

This unit deals with the common forms of behavior found in plants and animals. The student is shown that plants as well as animals have definite reactions to stimuli. A study is made of the common types of responses: tropisms, reflexes, instincts, memory, and reasoning. No technical study is made of these but the pupil is expected to understand the elementary principles underlying each and to associate the various types of responses with the reactions seen in plants and animals.

Three weeks time is to be used in teaching this unit.

Pupil objectives:

1. To gain a lasting understanding of the principal types of plant and animal behaviors.

2. To learn that "behavior" refers to all the activities made by a plant or animal in response to stimuli.
3. To learn that response to stimuli is essential if the plant or animal is to survive.
4. To understand typical reactions in various kinds of plants and animals in relation to typical causes.
5. To find out how the endocrine glands affect behavior in the higher organisms.
6. To learn that proper response to stimuli plays a large part in the success of an organism.

Approach:

A few days before taking up the work of the unit, various kinds of seeds are to be planted in a small window box. The reaction of these seeds to moisture and the reaction of the plants to sunlight are made the basis for the beginning of study on the first problem.

Problem I. What are the principal types of plant and animal behavior?

1. What is meant by "behavior" in reference to plants or animals? Do all plants and animals show response to stimuli?
2. Do plants respond to stimuli in as definite a fashion as do animals? Do they respond as rapidly? Explain.
3. Responses in plants or in animals not having a nervous system may be called tropisms (mechanical responses). What are some

of the tropisms which plants show? List and define each of these. List a number of plants in regard to the tropism which they show.

4. How do the stems and leaves of plants react to light?

5. How do roots react to the presence of light? To gravity?

6. How do tropisms aid plants? Could they live at all without their ability to react to stimuli?

7. What groups of animals show only mechanical response to stimuli? Do these forms have a nervous system?

8. What are reflexes? How does a reflex differ from a tropism? Are reflexes present at birth? Are they inherited? Can they be changed or modified?

9. What are the chief characteristics of a simple reflex?

10. What is an instinct? How does it differ from a reflex?

11. What are some of the instincts possessed by some of the lower animals? What are some instincts found among the vertebrates?

12. Instincts may be modified or changed. Are these changes apt to be greater among the mammals and birds or among the lower forms of life? Explain your answer.

13. Would animals be able to survive if born without instincts?

14. Are instincts always helpful to an animal? Give an illustration to prove your answer.

15. What is meant by "intelligence"? How many of the forms of animal life show some degree of intelligence? How many show

16. What do we mean by the "trial and error" method of learning? Does this method require memory and reasoning for its use?

17. Reasoning and memory are two important elements in intelligence. About where does the possession of a low type of memory begin in the animal kingdom?

18. Are any of our common mammals able to reason? Base your answer on actual examples or on statements made by authors in our reference books. Give the reference quoted. Do you think the bear mentioned in Dynamic Biology, page 847, used memory, reasoning, or both?

19. Is the social life of bees, ants, and wasps based on instincts or intelligence? Explain.

20. Would man have a more pleasant social life if his actions were all based on instincts which he could not modify? Can you imagine a world of men living in this way? Will ability to read or to drive a car or any of the many learned acts man has been doing for many generations ever become instinctive?

Problem II. How do the nervous system and the endocrine glands affect behavior?

1. Make a series of sketches showing the types of nervous systems possessed by various animals in the scale of life. What are the principal characteristics of each of these types of nervous systems?

2. What are the functions of the nervous system of man?
3. What are the two great divisions of the nervous system? What is the function of each?
4. What are neurons? How do they carry messages? What are the three types of neurons?
5. What are the three parts of the brain? What are the functions of each? Make a drawing of the cerebrum showing the various nerve centers, speech, sight, hearing, and so forth.
6. What are the five special senses? Why are they called special senses? Explain briefly how each functions.
7. What are the general senses? What is their purpose?
8. Where are the sense organs for taste located? What are the four taste sensations?
9. Where are the sense organs of equilibrium or balance?
10. Describe the process by which we see. Make a sketch of the eye, and learn the names of its parts. Study the function of each of the parts. What other types of eyes are found in other members of the animal kingdom?
11. Study a picture of the ear. Learn the names of the parts and study the functions of each. How is hearing accomplished? Make a list of some of the means by which some of the lower forms of animals hear.
12. What is the purpose of the autonomic nervous system? Where is it located?

13. List a few of the reflex patterns that are firmly established in man's nervous system. Can these reflexes be modified through learning?

14. What are the steps necessary in the procedure taking place in the carrying out a simple reflex?

15. What are the types of instincts common to man?

16. Our learned activities take the form of habits. Are habits easily formed? Are they easily changed or broken?

17. What are some rules which aid in habit forming?

18. How is intelligence measured in man? What is meant by IQ or P.L.R.? How is it determined?

19. How is man's behavior linked up with the endocrine glands? Outline some of the effects of these glands on behavior. Do other animals have endocrine systems?

20. Can memory be improved? If so, how?

Essential vocabulary:

tropism	stimulus	autonomic system	auditory nerve
reflex	response	retina	optic nerve
instinct	neuron	cornea	behavior
intelligence	psychology	olfactory	phobia
memory	dendrites	hyper-	inhibitions
reasoning	axon	hypo	

Reference outline for the unit:

I. Comparison of plants and animals in regard to their reaction to stimuli: Dynamic Biology, p. 527.

II. The principal tropisms shown by plants and lower animals: Dynamic Biology, pp. 527-528.

III. The three chief characteristics of a reflex: Dynamic Biology, p. 533.

IV. The five steps in a simple reflex: Dynamic Biology, p. 568.

V. The types of instincts common to human beings: Dynamic Biology, pp. 560-561.

VI. Types of nervous systems found in the animalpphyla: Dynamic Biology, p. 551.

VII. Functions of the nervous system: Dynamic Biology, p. 553.

VIII. The parts of the brain and their functions: Dynamic Biology, pp. 556-557.

IX. Rules for habit formation: Dynamic Biology, p. 56.

X. Rules for building a good memory: Practical Psychology, pp. 280-281.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 522-568.

Heiss, Obourn, and Hanser, Our World of Living Things. pp. 115-134.

Kinsey, New Introduction to Biology. pp. 728-849. pp. 617-652.

Smith, Exploring Biology. pp. 579-638.

Pieper, Beauchamp, and Frank, Everyday Problems in Biology. pp. 347-404.

UNIT VIII. THE CONSERVATION OF LIFE

The problems involved in conservation of natural resources is one which is coming to the front more and more in recent years. This unit attempts to cover the phases of conservation most closely allied to the field of biology, that of conservation of wild life and other animal or plant forms.

The teaching of conservation has been neglected in the public schools but there is every justification for giving it a definite place in the course of study. Writers of text books in biology have recognised this fact in the past few years and present day books contain material dealing with wild life conservation.

Five weeks time is to be used in teaching this unit.

Pupil objectives:

1. To develop in the pupil an individual sense of responsibility for the conservation of wild life.
2. To learn how beneficial forms live and feed and thus how they may be protected.
3. To learn how harmful forms live, why they may be harmful, and how they may be controlled.
4. To learn something of what is being done in regard to conservation problems.
5. To expose false ideas in regard to man's natural enemies.
6. To recognize organisms as harmful or beneficial in relation to

man.

Generalizations to be developed:

1. Conservation of wild life is essential for economic reasons.
2. Conservation of soils is essential for the conservation of wild life.
3. Epidemics result where the balance of nature is disturbed.
4. Forests are of value in conserving moisture.
5. The wild life of America has been greatly depleted.
6. The most harmful of all enemies of man among the mammals are the rodents.
7. The stray house cat is the worst enemy of our birds.

Approach:

Following a field trip to see the effects of the washing of soils along streams in the vicinity, a discussion is held of the effect of the filling of the streams on water life and of land life. A description of the streams visited as it was twenty years ago is to be obtained from others. This discussion is to be carried on into the field of wild life in general as it was here twenty or more years ago.

Problem I. How is soil conservation related to the conservation of wild life?

1. Why is soil fertility important to all living things?
2. What materials in our bodies came originally from the soil?

3. What are some of the means used today for conservation of the soil? How is erosion prevented?
4. Why should forests and trees be conserved?
5. What are some of the means being used to conserve our larger forests?
6. Is tree conservation an important problem in Kansas? What is being done in Kansas?
7. How does the building of ponds or lakes aid in the conservation of soils, and in the conservation of wild life?

Problem II. How does man attempt to control harmful forms of life and protect beneficial ones?

1. What are some of the means by which our state and national governments attempt to conserve wild life?
2. Make a list of some of the national parks and forest reserves and summarize briefly the purpose of each, the kinds of trees, and the kind of wild life found in each.
3. What is a game refuge? How may it function in restoring wild game?
4. What are some of the means by which state and national governments are attempting to control harmful pests? How do they determine whether an animal is harmful or beneficial?
5. Make a list of some of the principal organizations having a part in wild life protection and summarize briefly the work

of each organization.

6. What are some of the mistakes which government agencies have made in the past in trying to carry out conservation projects?

7. Make a list of animals which are often killed which biologists tell us should be protected. (animals which the average person thinks harmful but which probably do more good than harm and deserve protection)

8. List some of the chief enemies of wild life or domestic animals which are harmful enough that strict control or even eradication is advisable.

9. What are the general methods used in control of insect pests which are harmful to crops, domestic animals, or man?

10. Make a list of some of the insects which are parasitic or predaceous on other insects. Why are these forms helpful to other forms of life?

Problem III. What is the importance of bird life to man?

1. What is being done in the United States for protection of bird life?

2. How many of the birds are not protected by law? How many birds are there in Kansas that may be taken only during a short season?

3. How many of our nation's birds have become extinct since white men have settled the country? Are there any others near extinction?

4. Why should birds be protected? List some reasons.

5. What are some of the means by which we can aid in protecting birds and keeping them in our locality?

6. What birds might be attracted to our home locality by the use of shelter, baths, or nesting boxes?

7. What are the five groups of birds in reference to their feeding habits?

8. How can one generally tell by the beak what kind of food a bird uses?

9. What kind of foods do most of our winter birds eat? Birds of prey? Summer residents?

10. What has our state fish and game department done in the past few years in conserving game birds? Summarize the methods used in hatching and rearing quail, pheasant, and prairie chicken.

11. What is the present organization of our fish and game department? How do you think it might be improved?

12. What are some of the ways in which man has depleted bird life? List the chief factors connected with man which have caused a decreasing number of birds.

13. List some of the other enemies of birds and tell how they are harmful. What is the worst animal enemy of the birds?

14. What are some of the present day organizations which are aiding in the conservation of birds? Outline their work in

this field.

15. If our game birds and other wild life are to be restored, what will be the part of the farmer in this restoration?

16. Keep a record of the birds common to our locality and give the date first seen for our summer residents.

Problem IV. What is the importance of other animal life to man?

1. Make a list of the common fur-bearing animals found in Kansas and write a short paragraph describing the food habits of each. How many are beneficial to man?

2. What is the harm in killing carnivorous animals which occasionally do some harm but which have a definite place in nature's balance?

3. Why has fur farming grown to be a profitable industry in recent years?

4. What fur-bearing animals have become extinct or nearly so in Kansas?

5. When is the open season in Kansas for fur-bearers? Which of our fur-bearers are not protected?

6. What group of mammals are practically all pests? What foods do they use?

7. In what ways has man enabled the rodent's to increase? What is nature's method of keeping them in check?

8. Why should man protect most of the reptiles? Name those which

should be protected because of their food habits?

9. What is the principal value of fish to man? Have they other values?

10. List some of the principal food and game fish found in Kansas streams. Do we have any fish which are not wanted?

11. Name some of the other forms of water life which are essential for a balance of life in the streams.

12. Read about the snapping turtle. Do you think it can be classified as a pest deserving eradication?

13. What is being done to conserve game fish in Kansas? During what part of the year is there a closed season on game fish?

Essential vocabulary:

conservation	erosion	refuge
epidemic	quarantine	reserve
parasites	raptorial	preserve
biological controls	predatory	park
carnivorous		

Reference outline for the unit:

I. Methods used in conserving wild life:

A. Laws passed by state and national government which provide: closed seasons; daily and season limits on the number taken; limitation on method of taking game, as to time, kinds of equipment, non-use of autos and airplanes.

B. Establishment of sanctuaries, parks, or preserves by the state or federal government, or by other organizations.

C. Artificial propagation of fish, wild game, game birds or

game animals, by various agencies.

D. National and state boards and other organizations are making studies of animal needs, causes for decrease of wild life, and other control problems, with the purpose of remedying bad situations. Some of these are: Bureau of Biological Survey, Forest Survey, bureau of fisheries, state fish and game departments, Audubon societies, American Ornithological Union.

II. Principal methods used for control of pests:

A. Biological controls.

B. Use of poisons in foods, sprays, or dusts.

C. Trapping.

D. Use of resistant strains.

E. Crop rotation.

F. Quarantine.

III. Factors which have caused a decrease in bird life: Game Management, p. 29.

IV. The functions and departments of the biological survey: Governmental Problems in Wild Life Conservation, pp. 81-106.

Bibliography for the unit:

Baker and Mills, Dynamic Biology. pp. 429-481.

Curtis, Caldwell, and Sherman, Biology for Today. pp. 509-551.

Heiss, Obourn, and Hanzer, Our World of Living Things. pp. 221-252.

Hunter, Problems in Biology. pp. 572-603.

Smith, Exploring Biology. pp. 269-288.

Connery, Governmental Problems in Wild Life Conservation. pp. 81-143. pp. 177-224.

RESULTS

The trend of more recent textbooks in biology is toward the teaching of biological processes and principles. The writer found that the teaching content of these books is based on the fundamental biological principles and that the real need is for stressing the importance of teaching principles in such a way that the pupil does not memorize them, but learns to use them or to make specific applications of the principles involved.

The writer believes that the units set up in this study provide this opportunity, because, by drawing on the best materials of each of the texts used as references and by using environmental opportunities, the use of these principles are thoroughly acquired by the pupil. The units have been used during the past two school years, 1937-1939.

The program as taught has led to the development of definite leisure-time interests and hobbies on the part of a number of students. Seven members of last year's class of fourteen members have kept a definite and working interest in some phase of biology. Two are serving as teachers in rural schools and are carrying on active nature study work. Four have been active in the collection of specimens for school use; two of these are doing definite work in bird study. Five of the seven (those in school) are members of the school biology club. Of this year's group of twelve students, one is doing good work in

taxidermy, three are expecting to collect biological specimens this summer for the school museum and also expect to develop a project for presentation before the Kansas Junior Academy of Science next year. One boy expects to carry out experimental work toward production of hybrid corn. Six members of the class are members of the biology club.

The program as set up has held more interest for class groups than would the use of a definite textbook. Twenty-four pupils of the twenty-six represented say they prefer use of the present reference books to the use of a textbook.

Quantitative measurement of results in this course is not conclusive enough to show that the type of course taught by the writer justifies any claims as to its being superior to other courses, due to certain variables which were not or could not be eliminated. These include failure to set up a control group and inability to measure the degree of interest and enthusiasm imparted to the pupils as a result of interest and enthusiasm on the part of the teacher.

Measurement made with the group was through use of the Buch-Cossman Biology Test, a standard test of one hundred-sixteen items published in two equivalent forms, A and B. In its construction, this test was validated by assembling items from the final examination papers of one hundred and twenty-six teachers in thirty-four states, selected by the state superintendents as representative of the best biology teachers in the various states. Three hundred constantly re-curring questions of the two thousand received were then rated by

seventy-seven leading teachers and authorities in the field of biology. A final selection for inclusion in the test was then made from items rated as satisfactory and representative. The coefficient of reliability obtained for Oregon and Iowa pupils range from .80 to .90. The coefficient of reliability obtained by the writer through correlation of forms A and B for twelve students was .89 ± .06. The twelve pupils represented the 1938-1939 group which are shown in table 1 as having had both forms A and B of the test. The 1937-1938 group were given form A only.

Percentile norms and quartile deviations based on 800 high school pupils are furnished with the test. Lack of other information concerning the test has made possible only a comparison of medians and percentile rankings of the test group and the group represented by the norms. In the obtained results the test group of twenty-six pupils in this study have a median score of 52 and a quartile deviation of 7, with a standard error of the median of 1.72. The group of 800 pupils represented by the norm have a median of 40, a quartile deviation of 11.5, with a standard error of the median of .51. The obtained standard error of the difference of these two groups is 1.8 which gives a D/standard D or a critical ratio of 6.6, showing a true difference in favor of the test group.

The Otis self-administering intelligence test for grades 7-12 showed that the test group could be considered a normal or average high school group, on the basis of a mean intelligence quotient of 104,

median I.Q. of 104, SD of 11, all of the individuals being included in a range of 2.1 SD.

No pre-test was given with the group represented by the norm, and a comparison of former knowledge was not possible. Any advantages in previous training would probably be with the group represented by the norm because pupils in the test group have had little science training in the grades or in high school. Six members of the group of twenty-six pupils have had a one-half year course in physiology, twenty have had a one year course in agriculture. None have had any other high school science course. Also the norm scores are on the basis of nine months training in biology; the test group had received seven and three-fourths months training at the time of taking the test.

In computing the coefficient of correlation between I.Q.'s and test scores for the test group, a high correlation of .82 ± .04 was found. This seems to show high efficiency in learning, though the number of cases is small.

Table 1. Intelligence quotients and scores on the Rush-Cossmann biology test, form A and B, for twenty-six pupils enrolled in biology.

I.Q.	Form A	Form B	I.Q.	Form A
117	82	86	112	61
126	81	74	110	56
113	78	79	109	58
116	68	65	107	53
113	66	57	105	45
110	52	46	104	40
94	52	57	104	55
107	51	57	100	45
96	46	54	96	48
104	40	46	94	46
106	39	54	95	57
82	37	26	84	32
110	36		80	25

Table 2. Comparison of scores of a test group of twenty-six pupils enrolled in biology with the percentile norms of eight hundred pupils for the Rush-Cossmann biology test.

Test Group	Norm	Scores
8%	0% reach or exceed	79
15	10% reach or exceed	64
38	20% reach or exceed	56
50	25% reach or exceed	53
58	30% reach or exceed	50
77	40% reach or exceed	44
84	50% reach or exceed	40
88	60% reach or exceed	36
88	70% reach or exceed	33
92	75% reach or exceed	30
92	80% reach or exceed	28
100	90% reach or exceed	23

ACKNOWLEDGMENT

The writer is indebted to instructors in the college departments of Zoology, Botany, Psychology, and Education, and to a number of high school biology instructors for valuable suggestions and criticisms concerning the biological content of this thesis. The writer especially expresses his appreciation to Dr. V. L. Strickland for his guidance and assistance in preparation of this thesis.

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