An Investigation of the Merits of Multi-Sensory Remedial Work in the Teaching of Tenth Grade Biology

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AN INVESTIGATION OF THE MERITS
OF MULTI-SENSORY REMEDIAL WORK
IN THE TEACHING OF TENTH GRADE BIOLOGY

by

Sister Marie Agatha Champagne, I.H.M.

A Project Report
Submitted to the
Faculty of The Graduate College
in partial fulfillment
of the
Specialist in Arts Degree

Western Michigan University
Kalamazoo, Michigan
August 1972
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A special word of gratitude is in order to the superiors of my own religious congregation, the Sisters, Servants of the Immaculate Heart of Mary, for giving me both the time and the money to continue my education at an age when it might not be considered worthwhile.

In a special way I wish to thank the Biology Department for the friendship and assistance that has marked my sojourn at Western Michigan University. Dr. Leo VanderBeek was the first to inspire me with a desire to continue my graduate work, and Dr. William C. Van Deventer maintained a special concern and consideration at every step. A very special word of appreciation is in order to Dr. Imy V. Holt for his interest that extended from a sharing of the intricacies of audio-tutorial instruction to the construction of carrels. In particular I am grateful to him for his meticulous care and unflinching attention to every detail.

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Sister Marie Agatha Champagne
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INTRODUCTION

There seems to be very little evidence available that remedial work in biology has been investigated in any depth. Articles in current science education publications do not show a recognition of the need for remedial work per se. There was no evidence of a formal program of multisensory remedial work in the teaching of biology at the time of this investigation.

Some studies have been made on the use of audio-visual material and forms of programmed learning, but the use of TV and BSCS films in the teaching of biology has not been applied as a remedial program. Emphasis on the teaching of biology in a laboratory situation has been accelerated since the introduction of BSCS materials, but the student who does not achieve through laboratory experience, or grasp the great themes that are the unifying concepts of BSCS biology may require remedial work of some type.

Nothing seems to have been done with respect to remedial help about those students who do not measure up to the national norms on the testing program set up by the BSCS approaches in biology. Achievement tests prepared for use each quarter are not universally used by teachers. The underlying reasons are associated with low scoring by the students in this level of biology.

The major objective in this project was to compare student performance on standardized tests for matched pairs of tenth grade level students following remedial sessions. The experimental group used...
multi-sensory media, and the control group used the conventional printed programmed learning materials available for remedial aid. Some of the latter were supplied by the investigator (See Appendix A).
LITERATURE REVIEW

Research that has been undertaken in the skill subjects, and the remedial work carried out there is important in all teaching. The improvement of reading skills and comprehension in particular has a definite effect on learning ability in biology.

Interdisciplinary studies such as those carried out by Murphy (1968) are of value to the teaching of science and biology in particular because the method provides for a comparative and correlative adventure in the learning process. Peterson and Schepers (1966) presented some information on science skills. Valert (1967) offered methods of dealing with reading disability remediation by the use of communications media. The research begun by Bottoms (1969) made use of multi-sensory media for remedial teaching.

A preliminary review of remedial work in skill subjects showed that this research has not been duplicated in the field of biological education. The multi-sensory approach has been used in direct biology teaching, as evidenced by successful programs in audio-tutorial laboratories at Purdue University, Eastern Michigan University and Western Michigan University. There has been some use made of this method for direct teaching on both elementary and secondary levels. When the original BSCS project was initiated, Tucker (1967) and Glass (1967) indicated their concern that all the national organizations of science teachers be involved in the analysis of instructional practices. The review of science teaching by Hurd and Rowe (1967) and the more recent
work of Moreland (1970) were concerned with the total picture of a science education.

Objectives that have governed all the BSCS publications from the inception of the program have stood the test of a decade of teaching. As indicated in Appendix A, these objectives were used as the fundamental framework and approach in this study. A summary of the rationale behind the ecological orientation of the Green Version that appeared in the first handbook for teachers for the new curricula (Schwab 1963) gives the underlying philosophy of this approach:

Therefore the aims of the Green Version are to introduce the student to the living world, to give him some appreciation of the point of view and the ways of science, and to provide him with such biological information as may be necessary and useful in going through life. ... The writers of the Green Version feel that having some idea of the way in which the biological community functions is as least as important as having some idea of the way in which one's own body functions. ... The problem created by growing human population, by depletion of resources, by pollution, by regional government and the like, all require intelligent community action for solution.

The common objectives outlined in all the teacher handbooks for the various editions of BSCS biology have become the substance of modern biology teaching.

The behavioral objectives and the broad theme content of the BSCS curricula formed the framework for the pattern of learning expected in this program.
DEFINITIONS OF TERMS

BSCS Biology

The revolutionary curricula that ushered in new biology teaching in the high schools of the sixties were developed by the Biological Sciences Curriculum Study groups. There are three versions: Blue, which is a molecular and biochemical approach, emphasizing both physiological and biochemical evolution; Yellow, which follows conventional subject matter with a modern emphasis; and Green with its ecological, community orientation of the ideas of biology. The latter version is the one used by students in this study.

The curricula also include an advanced course, called Biological Science: Interaction of Experiments and Ideas, (1965) and a course for slow learners called Patterns and Processes, (1966). A course for the mentally retarded is now in the process of development, and also a multi-disciplinary approach for biology and the social studies. There is a series of enrichment programs, known as laboratory blocks, that provide intensive study of specific areas by more than usual emphasis on the laboratory. The three original color versions and the advanced course has now gone into second editions.

Multi-sensory Remedial Work

This consists of teacher-directed study to remove obstacles to learning by means of filmstrips, slides, film loops, transparencies, tapes and records, to which is added the manipulation of some objects which reach the student kinesthetically as well as audio-visually. It
is currently used with great success as an immediate approach to learning in the audio-tutorial programs in the biological sciences at the college level.

**Standardized Tests**

These tests were prepared by the BSCS Test Construction Committee, under the chairmanship of Dr. William V. Mayer of Wayne State University, with the technical assistance of The Psychological Corporation. They have norms and constants that make it possible to use them as instruments for measuring achievement.

**Programmed Learning**

This involves the use of sequences in the form of linear instruction arranged with small units of subject matter in which the learner proceeds at his own pace. It requires the learner to master each unit before he proceeds to the next unit. In a printed program, the student usually produces answers on his own sheet. In the multi-media program, a study guide is reinforced by the directions on the tape and the visual materials that accompany it.

**Behavioral Objectives**

These are statements describing the behavior expected of the student during a learning a situation, and indicating the goals to be attained by that situation. (Bloom, 1959)

**Module**

This term, as used in this project, indicates a smaller segment of a conventional unit, selected for intensive study by means of
multi-sensory program or a printed program. The term indicates that
the programs are pre-designed to accomplish a definite remedial activity.
PROCEDURE

The inability of some students to master Green Version Biology was obvious from the achievement test results. In an effort to remedy this situation, we constructed a program of work intended to improve test results. Four different biology classes at Lake Michigan Catholic High School were selected for this program. At the close of the first quarter of work in the Green Version text the Green Version Achievement Test, Form GR-I, was administered by the regular teacher. The results of this test were used to design the content of remedial instruction. The Processes of Science Test was also administered to all four classes as a pre-test and as a post-test.

Forty-eight matched pairs of subjects were set up on the basis of intelligence quotient and reading ability. Individual needs were considered in the design of the modules. A survey of the best commercial materials was made, and the materials listed in Appendix B were chosen. The modules of remedial instruction that were prepared from these materials included film loops, film strips, slides, transparencies and records, together with taped instructions for their use. A detailed description of the modules is given in Appendix A.

The preparation of these materials was structured to the behavioral objectives indicated by a study of missed items on the achievement tests, as indicated in the preface to each module in Appendix A.

To make self-contained units for the administration of the program, portable carrels were constructed of pegboard. Four students could use a carrel simultaneously. Study guides were prepared to correspond
with the material and equipment used. There were no printed program materials available, units were developed to correspond with the same materials available in the carrels.

Fig. 1. A portable carrel with tape recorder, filmstrip viewer and student collected soil samples.

Through the cooperation of the principal, the entire facilities of the science department at Lake Michigan Catholic High School were placed at the writer's disposal for carrying on the project. While the randomly chosen members of the matched pairs used the carrels, the other members of each class worked on the printed program material. The ninety-eight students in the four classes were all involved in the program because of the high school schedule, and it was necessary to use the regular class period for the experiment.

Twelve students participated in the multi-sensory program during each class period. While they worked in the carrels, the remainder of the class, including all those who were not in matched pairs, used the
printed programmed learning modules. All the students in the carrels were drawn from the forty-eight matched pairs. In selecting them, an effort was made to cut through a profile of the class types, so that the selections were made for both members of each pair on all levels of intelligence, rather than only those who needed remedial work. Thus, remedial students and normal students received the same treatment and were evaluated on the same basis.

Fig. 2. A portable carrel with four headsets used on one tape player. A super 8 film loop projector and screen were used in some modules.

Figures 1, 2 and 3 are typical carrel installations, indicating how the equipment was adapted to the audio-visual material being used. The only module in which a tape player was not used for tutorial direction was the unit on the microscope. Here the new multi-media approach to individualized instruction, called Concept was used (A.B. Dick, 1970). This is a Super 8 mm., cartridge-loaded, rear-screen sound projector that can be used with headsets. (See Appendix B).
Another new audio-visual device used was the transparency projector shown in Figure 3. This is a new machine, the Tecnifax Projector, made by the Plastic Coating Corporation, that is used for small group viewing of transparencies (See Appendix B).

Fig. 3. A typical installation using a portable carrel, tape player, and a Tecnifax Projector for transparencies.

Filmstrips, transparencies and film loops were also used in this investigation. There specific titles were not available, as in the module on graphing, transparencies were developed by the investigator to complement the material in the programmed learning exercise, based on the BSCS materials in *Patterns and Processes* (Peterson et al. 1966).

Due to the school schedule, it was necessary to use the three main modules in close sequence to each other, all within a month following the preliminary module. The preliminary module was used for three days to enable the students to adjust to the new equipment and mode of operation. The times required for modules I, II, and III
were varied to provide for student adaptation to the different types of material.

Students in the multi-sensory program were asked to keep their notes in the study guides for review (See Appendix A). Students using the printed programs were allowed to keep the programs. No attempt was made to correct the response pages, since the answers were available to the students to do their own corrections.

Twenty-one class periods for each of the four classes were used in the remedial program, with a grand total of eighty-four hours of remedial work for each student. Of this amount, fifteen hours per class were used for remedial work, and six hours were used for testing.

The remedial program itself was administered by the investigator. All tests, however, except the Processes of Science Test, when used as a pre-test, were administered under the direction of the regular classroom teacher.

At the close of the remedial program, Form GS-1 of the Green Version Achievement Tests was administered to the subjects. The Processes of Science Test was given as a post-test. For the final examination of the year, the BSCS Comprehensive Final Examination in First-year Biology was used.

After the test, the results were tabulated. It was found that ten of the forty-eight matched pairs did not have data that were complete enough to be used for purposes of comparison. Therefore, the number of matched pairs used in the study was reduced to thirty-eight.
Table 1.
Modules and materials used in this investigation.

<table>
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<tr>
<td></td>
<td></td>
<td>Set of transparencies:</td>
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<td>Concept cartridge:</td>
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<td></td>
<td></td>
<td>Using the Triple Beam Balance</td>
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<td>II - CONSERVATION</td>
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<td>Film strip:</td>
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<td></td>
<td></td>
<td>Soil Conservation</td>
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<td></td>
<td>Water</td>
<td>Film strip:</td>
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<tr>
<td></td>
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<td>Mineral Conservation</td>
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<td>Multi-media Unit:</td>
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<td>Water Pollution</td>
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<td></td>
<td>Balance of Nature</td>
<td>Set of Transparencies:</td>
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<tr>
<td></td>
<td></td>
<td>Ecological Principles</td>
</tr>
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RESULTS

The results of the testing program were difficult to interpret.

The final examination scores on the BSCS Comprehensive Final Examination in First-year Biology showed a skewed frequency polygon to the lower end of the scale.

Fig. 4. Percentile ranks grouped for scores on the BSCS Final Comprehensive Test and the Cooperative Biology Test.
When the investigator learned that the test had been given during the same period as the **Cooperative Test in Biology** (Bickford, Anita et al, 1961), and that the latter test had been given first with higher overall performance, the response pattern became more evident.

Figure 4 shows the results of the two tests administered together. The direction of modal tendencies shows testing fatigue, and also shows the stability of the middle third of the subjects. Reference to these data will be made again in the section on discussion. No other evidence in the testing program was quite as revealing as this. The **Processes of Science Test** was selected for use as a norming instrument by which the effectiveness of the remedial program could be gauged. Norms for the entire class were 0.46 lower on the post-test than on the pre-test. The class median for the pre-test was 22.39, and for the post-test, 21.93, but those subjects whose scores ranked in the middle third of the class and of the matched pairs showed a marked increase. This category changed from 43.9 percent on the pre-test to 45.5 percent on the post-test.

A comparison of the pre-test and post-test results on the **Processes of Science Test** for both members of the matched pairs corroborates the data on performance for the entire class (See Figure 5). There was some evidence of variation in the matched pairs in favor of students who used the multi-sensory program.

The scores for the matched pairs are shown in Table 2, where the middle ability group of subjects ranks slightly better for the thirty-eight pairs whose grades were being compared. More students at this level raised their scores than in the other ability levels. The
numbers here indicate that the middle ability student achieved more in subject matter learning by such a remedial program than did either the higher ability students or those of lower ability.

Table 2. Processes of Science Test scores for the matched pairs arranged in percentile ranks.

<table>
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<th>Middle</th>
<th>Lower</th>
<th>Total</th>
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<td></td>
<td>M</td>
<td>M</td>
<td>M</td>
<td>P</td>
</tr>
<tr>
<td>Raised</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>The Same +1</td>
<td>5</td>
<td>1</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Lowered</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>11</td>
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</tbody>
</table>

Note: M = Multi-sensory, P = Print. Scores were raised or lowered from the pre-test to the post-test.
Fig. 5. The Processes of Science Test: Percentile rank groupings for matched pairs. A. Multi-media  B. Printed Program
DISCUSSION

Only in the middle third of the subjects, composed of students with intelligence quotients ranging from 90 through 115, was there a noticeable improvement in achievement. Here both members of the matched pairs (See Table 2) improved in ability to cope with the inquiry type of question found in the BSCS tests in a larger proportion than in the lower or higher ability groups.

The tests in this investigation, with the exception of the Cooperative Biology Test (not originally intended to be used in the plan), did not consist of questions that could easily be answered by memorization. Even the questions concerning graphs on the Processes of Science Test were so designed that the student had to make inferences and see relationships. The data from the results on the BSCS tests used in this investigation indicated that the high number of scores in the lower percentiles on all the tests administered, with the exception of the one test indicated above, showed lack of ability on the part of these students to deal with problem-solving situations.

The behavioral objectives presented in the first two modules were entirely of the skill type. In the preliminary module, tools to extend skills and knowledge in a specific area were used. If such knowledge is to furnish ways and means of dealing with the specific problems of maintaining an ecological balance or decreasing air and water pollution, as in the last module, then the methods of inquiry must be used to a greater extent in remedial programs. The module on the environmental
problems of our time used behavioral objectives that moved from the acquisition of facts to their application in a specific area (See Appendix A). It may be inferred that behavioral objectives from the affective domain must be used to support those from the cognitive domain (Bloom, 1956).

Poorman (1967) recognized the need to use several learning methods in the teaching of *Harvard Project Physics*. His comparison of the multi-media approach with traditional methods of direct teaching has some relation to the results presented in this project. His conclusion that the multi-sensory approach did affect the learning of concepts gave encouragement to such a project in the biological sciences. Perhaps it is not adequate to do this on a remedial basis alone.

The results of this investigation point to a few definite conclusions both for remedial work and for regular class work. First, both the lowest ability group and the highest are less successful with programmed learning. Perhaps the availability of multi-sensory material in the classroom, with class scheduling that makes it possible to use the material on a basis of need, would counteract the tendency to boredom that comes from repetition.

Second, the improvement that took place in the middle ability grouping points to an increased use of both types of programmed learning for this type of individual. This also indicates that a certain amount of individualized learning must be made available to students.

Third, remedial work for the two ability groups that did not improve under this method must be carefully researched, especially for the lower ability type. Further investigation of the kind of remedial work best adapted to their needs is important.
SUMMARY

In this study, an attempt was made to arrive at a partial solution to the problem of learning in the field of tenth grade biology by remedial work. The use of a multi-sensory remedial program for the subjects did not bring about results any different than the use of a printed program of remedial work. Tested on ninety-eight tenth grade students, and particularly on thirty-eight matched pairs with equivalent intelligence ratings and reading ability, the results of the BSCS Processes of Science Test administered both prior to the remedial program and after it, as well as the comparison of results on the Final Comprehensive Test and the older Cooperative Biology Test yielded the best results with the middle ability group. Even though the textbook and laboratory work was of the open-ended type, the traditional approach used in the teaching of the course was not greatly improved by a remedial program. A comparison of the results on the two post-tests showed little evidence of improved achievement.

The results from this study seem significant for the teaching of biology in that special methods such as audioutorial and programmed learning techniques appear too complex for the slower group of students and boring for the superior group. They appear to be most effective for the middle group. The difficulty would lie in justifying their use for this group of students alone.
LITERATURE CITED


APPENDIX A

Student Materials for the Multimedia and Learning Program Modules
Preliminary Module

In order to acquaint the students with the type of work they would be expected to do in the remedial program, without wasting time, a preliminary module was prepared, with the intention of simultaneously reviewing the fundamentals of BSCS Biology with its emphasis on observation, inquiry and interpretation. The behavioral objectives proposed to the students for this part of the program were:

1. To appreciate the importance of exact observation
2. To use graphs in interpreting observed data
3. To recognize the place of open-ended inquiry in the study of biology
4. To see some relationship between structure and function
5. To review the making and use of graphs

This module consisted of taped instructions for studying a set of home-made transparencies about graphs and graphing; a set of overhead visuals from Houghton Mifflin's Earth Science (1969) and the Popular Science Publishing Company's filmstrip Interpreting Biological Data (1963). The printed program material was taken from the BSCS textbook, Patterns and Processes (1966) and from two programs based on the visual aids, but arranged as programmed learning sequences by the experimenter. This program took three days, since the students were not sufficiently familiar with the apparatus to be able to cover them in the twenty minute periods planned.
Each student received a printed direction sheet to use in the program. Those used by the multimedia half of the matched pairs, at the carrels, are called "Study Guide" and those used by the others are called "Printed Program."

Preliminary Module A

Study Guide: Observation

Directions: This is your note sheet for following the multi-media program for remedial work in biology. As you listen to the tape and move the visual aids in accordance with directions, this sheet will give you key words and lines on which to write notes and definitions.

1. Common process used by scientists and others

2. Gathering of observed facts is

3. Exact record is kept in order to

4. On the first transparency, where is it cooler?
   Why do you think this is so?

5. Assumptions:

6. Areas with uniform temperature
   Why?

7. Areas without uniform temperature
   Why?

8. An hypothesis is

9. How is the temperature of the wet sand related to the hypothesis?
10. An isotherm is ________________________________________________

11. What temperatures are represented? ____________________________

12. Why are the temperatures not all on isotherms? ________________

13. Where are transition areas? ________________________________

14. What happened to the patterns? ______________________________

15. Which isotherms fused? ______________________________________

16. Where are the new transition areas? ____________________________
   Why in these areas? _________________________________________

17. Which of the steps in the inquiry process have we done? ________
   ________________________________

18. How can we use the evidence? ________________________________
   Tube animal ________________________________
   Branched animal ____________________________
   Comb-like structure ____________________________
   Burrowing animal ____________________________

19. Which numbers fit idea A? ______________________________
   B? ______________________________
   C? ______________________________
   D? ______________________________

20. Write the answers to the questions on the last slide on your
    report sheet.
Preliminary Module B

Study Guide: Graphs

1. A. ________________ B. ________________
   C. ________________

2. ________________

3. 

4. Range _______ °C to _______ °C.

5. 10°C _______ 20°C _______

6. Temperature increased cover beat _______.

7. Cover beat on _______ axis; Temperature on _______ axis

8. Possible range on graph _______ °C to _______ °C.

9. Space between numbers on the horizontal axis = _______.

10. Space between numbers on vertical axis = _______ beats

11. Possible beat range on graph _______ to _______

12. Smallest number on vertical axis is _______ (nearest to / farthest from) the point where the two axes join.

13. Lowest temperature on horizontal axis is _______ (nearest to / farthest from) the point where the two axes meet.
14. The dot in the lower left of the graph is at ___°C and ____ beats.

15. Each dot represents ________

16. Lowest temperature is ___°C and the rate at that temperature ____

17. Second lowest ___°C ____ Third lowest ___°C ____

18. Fourth (or last) ___°C ____

19. Trout increase ____ to ____ Goldfish increase ____ to ____

20. Graphs A ____________ B ____________ C ____________
   D ____________ E ____________ F ____________
   G ____________ H ____________ I ____________

21. Graphs A ____________ B ____________ C ____________
   D ____________ E ____________ F ____________
   G ____________ H ____________ I ____________

22. Draw your graph here:
Preliminary Module C

Study Guide: Biometric Data

Be sure you know all the definitions listed here. Write them down as you come to them in the script.

DEFINITIONS:

Data ____________________________________________________________

Facts __________________________________________________________

Qualitative ______________________________________________________

Quantitative ____________________________________________________

Standard ________________________________________________________

Control _________________________________________________________

Experimental error _____________________________________________

Average ________________________________________________________

Median _________________________________________________________

Mode __________________________________________________________

Mean __________________________________________________________

Range _________________________________________________________

Reliability ______________________________________________________

Deviation _______________________________________________________  

Standard Deviation ____________________________________________

Variability ____________________________________________________
Preliminary Module

Programmed Learning: Observation

DIRECTIONS: Here is a review of how a scientist works. Use your answer sheet as a cover for the frame below. Read the frame you are working on and write the answer opposite that number on your paper. Move your answer sheet and check your answer with the one given in capital letters.

If you were wrong, be sure to try to find out why and rewrite the correct answer.

1. A scientist often uses the same tools everyone else uses. He looks, he sees, he thinks about what he sees. In other words, he OBSERVES the world around him. What would you call this process?

OBSERVATION

2. As a scientist observes, he likes to gather facts and organize them in an orderly fashion so as to know what it means when he goes back to the facts at some later time. This gathering of known facts that have been observed is called data gathering. What would you call the observed facts?

DATA

3. It is important to keep an exact record of observed facts so that others can check on our analysis and interpretation. Such facts are often arranged in tabular form. What would such a table of facts be called?

DATA TABLE

4. The scientist is not satisfied with just listing facts. He tries to interpret them too, as does every thinking person. This spirit of inquiry makes us wonder why or how. We go to the beach on a summer day, but do we ever wonder why it is cooler there? What would this "wondering why" be called in a scientist?

INQUIRY

5. In order to interpret the facts at hand, called _______, it is often necessary to get them in a set of assumptions to simplify the analysis. So, let us assume that this is a clear, perfectly calm summer day, and we are at the beach. What would this be called?
DATA

ASSUMPTION

6. It is also necessary to remove anything from the analysis that is not really a cause of what we are trying to analyze. So let us disregard the people, the cars, the umbrellas and all the other things on the beach, even if they are there. We will not let this enter into the picture, but concentrate only on the things that are always there: air, water, sand, paving, grass and trees. Would this be an assumption?

YES

7. As we consider the factors of air, water, sand, pavement grass, which of these materials do you think would be the hottest? Coolest?

WATER

PAVEMENT

8. As the scientist observes a situation like this, he wonders why. What do we call this wondering? Because he is interested in why the water is cooler, he checks his idea by gathering facts about the temperature of all the permanent factors on the beach. What would he call his facts?

INQUIRY

DATA

9. A scientist measured the temperature in several places a few inches above the surface of each of these areas and recorded the following facts:

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
<th>Number of places</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>38° Centigrade</td>
<td>18</td>
</tr>
<tr>
<td>Dry sand</td>
<td>36° Centigrade</td>
<td>19</td>
</tr>
<tr>
<td>Wet sand</td>
<td>30° Centigrade</td>
<td>4</td>
</tr>
<tr>
<td>Grass</td>
<td>30° Centigrade</td>
<td>8</td>
</tr>
<tr>
<td>Shallow water</td>
<td>22° Centigrade</td>
<td>2</td>
</tr>
<tr>
<td>Shallow water</td>
<td>20° Centigrade</td>
<td>2 (Different)</td>
</tr>
<tr>
<td>Shallow water</td>
<td>24° Centigrade</td>
<td>4 (Different)</td>
</tr>
<tr>
<td>Deeper water</td>
<td>18° Centigrade</td>
<td>8</td>
</tr>
</tbody>
</table>

Study this data table. Do these facts agree with your answer to number 7? (You decide)

10. You will notice a definite difference in temperatures taken at different places over the same material. Where are the temperatures uniform over the same material?
PAVEMENT

GRASS

11. Can you think of a reason WHY there might be this difference on the water surface? On the sand?

DEPTH

WETNESS

12. When you gave this reason, you were making a guess based on the facts available and your own experience. We sometimes call this an educated guess, but we also can call it a hypothesis. The answer to an inquiry can often be found in the form IF...(certain facts are so), THEN....(might be the reason). This answer to an inquiry is known as the ________.

HYPOTHESIS

13. If the temperature a few inches above the water is different in different places, then the warmth coming from the sun must be affected by the depth of the water. What would you call this statement?

HYPOTHESIS

14. The area where the water wets the sand has lower temperature than the rest of the dry sand, but higher than the water. Is this fact related to the hypothesis?

YES

15. When the same areas, or spots near them, were measured 30 feet above the surface, some important, different facts are found. What do we call these facts recorded from observation?

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
<th>Number of places</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement</td>
<td>34° Centigrade</td>
<td>25</td>
</tr>
<tr>
<td>Dry sand</td>
<td>34° Centigrade</td>
<td>14</td>
</tr>
<tr>
<td>Wet sand</td>
<td>30° Centigrade</td>
<td>4</td>
</tr>
<tr>
<td>Grass</td>
<td>27° Centigrade</td>
<td>7</td>
</tr>
<tr>
<td>Water (shallow and also deep)</td>
<td>25° Centigrade</td>
<td>16</td>
</tr>
</tbody>
</table>

Did the temperature over water change? Where is the most change? Least?
DATA

16. In making this scientific inquiry we used very definite steps: OBSERVATION, COMPARISON, GROUPING AND CLASSIFICATION, FORMULATING PROBLEMS AND HYPOTHESES, ANALYZING DATA, FORMING PATTERNS. Why did we do all these things?

TO FIND OUT WHY

17. Suppose you wished to understand the complementarity (complete relationship of structure and function), in the many things where this theme is found repeated. Essentially this says that where a certain structure works a certain way, the shape helps it do the job well. What would be the first thing to do in order to find this relationship?

OBSERVE MANY PLANTS AND ANIMALS

18. Observing these different animals, a science worker found these facts to exist:

<table>
<thead>
<tr>
<th>SHAPE OF ORGAN</th>
<th>USE OF ORGAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube with branch ending in a network of tubes</td>
<td>Food passes down the tube</td>
</tr>
<tr>
<td>Aquatic animal; organ with many branches</td>
<td>Always certain chemicals in the water around the branch</td>
</tr>
<tr>
<td>Huge fish: comb like teeth</td>
<td>Water strained through comb</td>
</tr>
<tr>
<td>Burrowing animal; dome-like structures on head</td>
<td>Domes get smaller when touched</td>
</tr>
<tr>
<td>What does the evidence suggest?</td>
<td></td>
</tr>
</tbody>
</table>

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### SOME CONNECTION BETWEEN FORM AND WORK

19. What effect did your observation have on your decision in each case? Here is a list of facts and a list of organs. Please indicate after the letters for the organs which of the numbered facts are connected with your decision.

<table>
<thead>
<tr>
<th>ORGAN</th>
<th>EVIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. SMALL TUBE</td>
<td>1. General shape and appearance</td>
</tr>
<tr>
<td></td>
<td>2. Change or motion of organ</td>
</tr>
<tr>
<td>B. BRANCHED IN WATER</td>
<td>3. Relationship to environment and other parts of animal</td>
</tr>
<tr>
<td>C. COMB LIKE ORGAN</td>
<td>4. Shape and appearance of parts</td>
</tr>
<tr>
<td>D. DOME SHAPED ORGAN</td>
<td>5. Characteristic change or movement</td>
</tr>
<tr>
<td></td>
<td>6. Relationships among parts of organ</td>
</tr>
<tr>
<td></td>
<td>7. Behavior of organ</td>
</tr>
</tbody>
</table>

A: 3-4-6  
B: 3-4-5-6  
C: 1-4-5-7  
D: 2-3-4-5-7  

20. On the basis of this evidence, how would you express the relationship between structure and function? Write your answer on the report sheet for this module and hand it in.
Programmed Learning: Graphs

Program S 17 in *Patterns and Processes*, Biological Sciences Curriculum Study (1966) was used for this section of the program.
Preliminary Module C

Programmed Learning: Biometric Data

Biology consists of a body of facts, together with the ideas and principles that give these facts meanings. For example, it is a fact that fossils have been found, and by taking this fact, and noting the relationship that exists between fossils and living things today, we have one indication of how living things have evolved. To be a good biologist, it is important to know how to interpret data that has been collected. This program will introduce you to some ways in which scientists interpret data.

1. Facts are what really happen, and are confirmed by repeated observations. When collected facts are used to help solve a problem they are called data. When we use our senses, and instruments to extend our senses, we are collecting --- that will furnish us with biological ---.

FACTS DATA
2. Sometimes facts are said to be qualitative because they involve the quality or characteristic of some particular subject. What would you call the fact that male stickleback fish become colored during the mating season?

QUALITATIVE
3. Other observations are quantitative because they involve ideas like "How many?" "How much?" "How tall?" "How fast?" What kind of data would you call Mendel's observations about the number of certain types of pea in each generation?

QUANTITATIVE
4. In order to get a quantitative measurement, we need to compare it with a known standard, such as a weight or measure. If we compare the amount of water absorbed by roots in clay soil with that absorbed by roots in normal soil, the normal soil is known as the ---.

STANDARD
5. When Priestley did his famous experiment with the mouse and the mint plant, he used a plant without a mouse as a control. Scientists plan their experiments so that data can be compared with some standard they use as a ---.
6. The investigation of biological problems requires data that is both descriptive or ---, and measurable or ---.

QUALITATIVE      QUANTITATIVE
7. No matter how accurate the data may be, it is meaningless unless it is analyzed or interpreted. Instruments must be carefully checked for accuracy so that investigators may use them precisely. This helps avoid ---.

ERRORS OR MISTAKES
8. Even the careful experimenter finds errors because of inaccuracy of measurement, instrument or method. A scientist compensates for this by recording repeated readings and dividing by the number of readings. This gives him an --- reading.

AVERAGE
9. Data must be recorded as accurately as the instruments permit. The average cannot be more accurate than the data. Two readings of 5.01 and 5.03 cannot average out to 5.021 but only to ---.

5.02
10. Scientists cut down on experimental error by keeping detailed notes retaining all data and reporting exact conditions. These are all ways of being more ---.

ACCURATE
11. Data alone, no matter how accurate, is not enough. It must be analyzed so that the meaning can be ---. This has led to great discoveries.

INTERPRETED OR UNDERSTOOD
12. Sometimes inaccurate data must be accepted because the errors are unavoidable, as in the dating of fossils. Even so, if they are properly ---, they can lead to scientific understanding.

ANALYZED
13. The best biological ideas are those that are expressed in quantitative data, like Mendel's Law or population cycles. Such data is easy to analyze because it can be expressed in ---.
14. In order to test the data and analyze it in the best way, scientists often use statistics to find relationships, reliability and grouping. This is called biometry when it deals with analysis of precise data concerning living things. The biological branch of statistics is called ____.  

BIOMETRY  
15. Most data about biological populations has a normal distribution known as the bell curve, because the larger number of units in any data are similar, and numbers tend to grow larger in the center and smaller at the edges. This larger number is known as the _____.  

AVERAGE  
16. The average, or center of the bell curve is the measure of the central tendency of the data. Sometimes the exact middle of a series of facts is taken as the median. The median is always the center of a series of ---.  

DATA or FACTS  
17. Another way of finding the central tendency of a number of facts is to see which one occurs the oftenest. This is known as the manner or mode. This mode is very similar to both the --- and the --- but it is not always the same.  

MEAN  MEDIAN  18. These three measured of the central tendency of a set of data are the ---, the --- and the ---. In a normal distribution is not normal they may appear in different places.  

MEAN  MEDIAN  MODE (any order)  
19. The mean may not supply enough information if we do not know the range of numbers or facts that it represents. In these two curves the mean and the median and the mode are the same but if you look at the curves, you will see that none of the three numbers lets you know how far apart the highest and lowest are. This is the spread or ___. 

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RANGE
20. To see how reliable these central tendencies are, it is also important to see how the facts vary from each other. We do this by seeing just how far each measurement is away from the average or mean. This distance from the mean is called the standard deviation. It tells a great deal about the --- of the data that central tendencies do not tell.

RELIABILITY or VARIABILITY
21. The reliability of data also depends on the number of cases studied. Would you think it important to have a few accurate measurements, or as many as possible that are still accurate?

MANY

On the preliminary module report sheet, answer these three questions. You may need to go back over the program and your answers in order to do this.

Questions to be answered on the report sheet:

1. How is the accuracy of data increased?
2. How do graphs help to analyze data?
3. What are the names of some useful biometric units? What do they measure?
A. What is the relationship of structure and function?

B. What is the importance of a graph?

C. What must be considered in interpreting data?
Module I

The first module dealt with the tools by which man extend his powers of observation. The printed program for the Microscope was taken from Patterns and Processes (1966). The other two printed programs were devised by the experimenter from the cartridge films of Thorne Publishing Company.

The multimedia program utilized the new A.B. Dick tape cartridge film together with their new projector with self-contained screen just released, and the two cartridge films on the uses of the two pan balance and the triple beam balance. Microscope and balances were available, and employed as part of the module.

Although this module on the microscope was definitely a review program, the other two programs were review chiefly for those who had been in the physical science program of the year before. They also were the balances the regular instructor had utilized in the preparation of certain laboratory exercises that required the use of the balance. Both types of balance were regularly available in the laboratory.

This section of the remedial program was organized around the concept of man extending his powers of observation by using accurate and carefully made precision instruments. It was not directly related to any of the general objectives of BSCS Biology, nor to the content themes. It was intended primarily as a tool remedial program.
The behavioral objectives proposed in this module were:

1. To effectively use the parts of the microscope.
2. To use the microscope with accuracy and ease.
3. To use a laboratory balance with care and precision.
4. To measure weights with accuracy.
Module IA

Study Guide: Microscope

Directions: This is the first of the regular modules. In this module you will use a completely new medium, the tape cartridge and a new projector. Be sure to sit where all students in your group can see the screen of the projector. It is not a large screen and you will need to sit fairly close. You do not use the tape recorder for this exercise. Watch the film, listen to the tape and refer to the microscope in your carrel whenever necessary.

I. Review parts of the microscope. Check them on the diagram on the chart furnished you.
   Take notes on these activities:
   Proper handling of microscope:

   ________________________________________________________________

   Cleansing of lenses

   ________________________________________________________________

   Adjusting low power

   ________________________________________________________________

   Adjusting light

   ________________________________________________________________

   Mirror

   ________________________________________________________________

   Diaphragm

   ________________________________________________________________

   TURN OFF THE PROJECTOR WHILE YOU CHECK THE PARTS, USING YOUR CHART.

II. Turn on the projector to review the steps in slide making.
   Each one in the group should use the paper provided and make a slide.

   TURN OFF THE PROJECTOR WHEN THE EXPERIMENTER HAS TURNED THE COARSE ADJUSTMENT, AND MAKE YOUR SLIDES. DIVIDE THESE ITEMS TO BE CHECKED AS EACH LOOKS AT THE SLIDES: objective, center, diaphragm, dryness.

III. FINISH THE FILM.REWIND. Get a chart without labels and fill it in as your final test on this area.
Module IB

Study Guide:  The Two Pan Balance

1. What common object is most like an equal arm balance? ________

Look at the film all the way through, then check off on this list and with the balance in the carrel all the parts listed:

<table>
<thead>
<tr>
<th>PART</th>
<th>ON FILM</th>
<th>ON BALANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal arms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pans: chemical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gram rider</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linkage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knife edges: pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>center</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zero indicator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zeroing knobs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

General rules:

Never put chemicals directly in the pan. Why?__________________

Never weigh hot or warm objects. Why?__________________________

Handle the balance gently. How?______________________________

Why?______________________________
Weigh 13.5 grams of the chemical given in your carrel. Have instructor check your work when you have balanced the scale. List here what you do.

   a. paper
   b. zeroing in
   c. weights
   d. chemical
   e. adjust amount
   f. remove from pan
   g. adjust balance

List the weights you used: (give grams of each)

   

Indicate their position on gram rider arm
Module IC

Study Guide: The Triple Beam Balance

1. What is the purpose of this instrument?

2. Look at the film all the way through, and then check off on this chart all the parts that are listed. Turn the film off and use the balance in your carrel.

<table>
<thead>
<tr>
<th>PART</th>
<th>ON FILM</th>
<th>ON BALANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams: units</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tens</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenths</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arresting lever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knife edge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leveling screws</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bubble</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Study Guide: Triple Beam Balance

To test your ability to use the triple beam balance, you are to measure the weight of some of the blue liquid (copper sulfate) in your carrel. Record the total weights and position of riders as read by each member of your team. Take an average. Record position of riders also.

<table>
<thead>
<tr>
<th>WEIGHT OF</th>
<th>READ BY</th>
<th>RIDERS USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaker and solution</td>
<td>1. _____</td>
<td>Units Tens Tenths</td>
</tr>
<tr>
<td></td>
<td>2. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 4. _____</td>
<td></td>
</tr>
<tr>
<td>Average:</td>
<td>________</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tare (Beaker alone)</td>
<td>1. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 4. _____</td>
<td></td>
</tr>
<tr>
<td>Average:</td>
<td>________</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of solution alone</td>
<td>1. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. _____</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+ 4. _____</td>
<td></td>
</tr>
<tr>
<td>Average:</td>
<td>________</td>
<td></td>
</tr>
</tbody>
</table>

To fix this all in your mind, check the two balances on display on the counter and see if you can find any differences from the one you worked with. List them here.

DIAL BALANCE

PLATFORM TRIPLE BEAM BALANCE
Module IA

Programmed Learning: The Microscope

Module IB

Programmed Learning: The Two Pan Balance

Directions: Use the same method you have used for other programs.

1. The two pan balance used in laboratories is fundamentally the same as the ones used thousands of years ago. You find the mass of an object by balancing it on a beam against another object or group of objects. In other words, to weigh an object is to --- it with another object of a known weight.

COMPARE or BALANCE

2. This is the same principle you used on a see-saw years ago when you were little. You --- your weight against someone on the other end.

BALANCE

3. In order to balance your weight and make the see-saw work, you had to change your distance from the ---.

CENTER

4. In a laboratory balance, the arms are of equal length, so you find the point of balance by adjusting weights that you know until they --- the object you want to weigh.

BALANCE

5. The object you wish to weigh is placed on the left pan of the balance and the known weights on the right pan until they move the two pans equally on either side of the center point. This is ---.

BALANCING or WEIGHING

6. A lower linkage keeps the pans balanced by connecting in the middle with a center indicator. When they are balanced, the needle moves equally on both sides of the ---.

CENTER POINT

7. To find this as a true weight, it is necessary to start with a balanced scale. A pair of adjustable knobs restores balance. They adjust the pans so they move equally on either side of the center. The scale balances when the divisions on either side of center are --- when the pans are in motion.
8. To read small fractions of weights, a rider bar on the front of the scale moves from left to right, to mark grams and tenths of grams. Why is the weight placed on the right pan?

WEIGHT ON RIDER MOVES IN THAT DIRECTION
9. Balance is indicated on a pointer by equal swings on either side of center. This shows that the two masses on the pans are now in --- balance.

EQUAL
10. In operating a balance, you should never place a chemical or other object to be weighed directly on the pan, in order to --- the balance.

PROTECT
11. Another rule is never to place a warm or hot object on the pan to be weighed, both to give true --- and protect the balance.

WEIGHT
12. In placing objects on the balance, or removing them from the balance, stop the motion of the pans with your hands until the object is in position. This is done to --- the delicate knife edge on which it swings.

PROTECT
13. In using a container, do not include it in the weight of the substance. To do this, weigh the container empty and subtract its weight from ---.

THE WEIGHT OF THE FULL CONTAINER
14. If you are not using a container, you must balance the weight of the paper you use to protect the pan from a chemical by placing the same kind and size of paper on ---.

THE OTHER PAN
15. To measure the weight of a solid, place the solid on paper on the left pan, add the needed number of weights to the right and add or remove solid until they ---.
BALANCE
16. It is important to hold the balance with one hand while you add or take away material in order to --- the balance.

PROTECT
17. Before weighing any substance, be sure the balance is exactly at --- by adjusting the knobs under the --- until it moves equally in both directions.

ZERO or CENTER: INDICATOR
18. If the amount of the substance is unknown, do not change the amount of the substance, but change the size and number of ---.

WEIGHTS
19. The idea behind the two pan or equal arm balance is to change the known weights until they balance the unknown ---.

CRITERION: Sometime today, examine the balances on display to find all the parts mentioned in this program.
Module IC

Programmed Learning: The Triple Beam Balance

Loose weights are easily lost and may often be misread or misinterpreted. In order to increase the accuracy of his sense extension weighing, man's ingenuity led him to balance the material pan with a constant set of weights.

1. The triple beam balance uses units, multiples of units and fractions of units. On a simple balance of this type, the smallest unit is usually in decimals to one place. These are ___.

TENTHS

2. If the fractional unit measured tenths of a gram, the multiple unit would need to be in multiples of ___.

TEN

3. The triple beam balance must also be brought to a point of equal balance by making sure that the needle moves ___ distances above and below a center point.

EQUAL

4. When this pointer moves to equal distances above and below the center point, the scale is set at ___.

ZERO

5. When the pointer moves in equal distances on either side of zero the scale is said to be in ___.

BALANCE

6. To insure consistent results, the balance must be level. This is done by changing the height of the balance itself above the table by moving screws until an enclosed air bubble shows it is balanced. This will be when the bubble is in the exact ___ of its case.

CENTER

7. To protect the knife edges, a lever called the arrest moves the edge away from the base when a load is placed or the balance adjusted in order to protect the ___ of the balance.
ACCURACY
8. To protect the pan from chemicals, a ___ of some kind must be used.

CONTAINER
9. When recording the weight of a chemical that is being weighed, it is important to remember to ___ the weight of the container.

SUBTRACT
10. Instead of adding or subtracting weights, the rider is moved along the ___ to the point where the indicator shows ___.

BEAM: BALANCE or ZERO
11. What protects the knife edges of the balance?

ARREST
12. What shows that the balance is level?

BUBBLE
13. What is the place to read the weights?

ADD UNITS OF THREE BEAMS
14. How do you protect the pan from chemicals?

USE PAPER OR CONTAINER

Sometime today find all the parts listed in this exercise on the triple beam balances on display on the counter.
Module IC

Report Sheet

DIRECTIONS: Turn in on this sheet the indications that you have done the measurements required if you were in the multimedia program and check the parts you found if you were in the printed program.

MICROSCOPE: Turn in your labeled chart with this sheet.

TWO PAN BALANCE: Weight of copper sulfate: ______

List the important parts you found.

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________

TRIPLE BEAM BALANCE: Weight of beaker _____ solution:_____

____________________________________________________________________

____________________________________________________________________

____________________________________________________________________
Module II

This module was developed with the idea that man controls his environment by the proper use of natural resources, especially soil, water and minerals. The idea of conservation is basic to the themes and objectives of the BSCS Green Version Biology. It is also basic to the problems confronting man today in the environment.

In this module, the BSCS objective of understanding the biological basis of problems in conservation was the most important idea developed. The theme of complementarity of organisms (man in this case) and environment is stressed in the student materials.

The audiovisual components of the module were the Conservation series of multi-media units developed by the Society for Visual Education Publishing Company. They consist of a filmstrip and a record. The filmstrips were used directly, the records were put on tape, with comments by the investigator to direct the student in the use of the filmstrip.

Behavioral objectives proposed were:

1. To investigate the extent of our resources.

2. To analyze the relation of man's needs, use and abuse of his natural resources.

3. To recognize the factors that cause waste and misuse.

4. To find ways to deal with the problem in the immediate area.
Module IIA

Study Guide: Soil

Take your notes particularly around these topics:

1. How does soil serve man?
   - Source of food
   - Protection of watershed

2. Where does soil originate?
   - Weathered rocks from
   - Broken down into soil by

3. What are the layers of soil on the earth?

4. What are the main types of soil erosion?

5. What causes soil erosion?

6. What is soil depletion?

7. What causes it?

8. What is the solution to soil erosion?

9. How can soil depletion be cured?

10. What are the basic principles of Soil Conservation?
Module IIB

Study Guide: Water Conservation

1. What is the problem of adequate water supply?

2. How do these use water? Crops and animals
   People
   Industry
   Recreation

3. What are the basic sources of water?

4. What are the immediate sources of water for use?

5. What are the causes of these water problems?
   Shortage
   Flood
   Pollution

6. How would each of these solve the water problem?
   Reforestation
   Contour planting
   Check dams
   Efficient reuse

7. What will these do for water conservation?
   Make plans
   Work together
   Recognize interdependence

CRITERION: The answer to the questions on the report sheet about all three areas of conservation together.
Module IIC

Study Guide: Minerals

1. Why are minerals vital to modern living?

2. How are minerals used in manufacture?
   Transportation?
   Power?

3. What minerals are used for fuel?
   As metals?
   As building material?

4. What is the importance of coal?
   Iron?
   Copper?
   Aluminum?
   Limestone and granite?

5. What are these short supply minerals used for?
   Lead
   Diamonds
   Platinum
   Tin
   Asbestos

6. How will these help mineral conservation?
   Efficient use
   Search for new sources
   Careful planning
   Efficient mining
7. What means of reusing metals might be considered?
   
   Junk: _________________________________________________________________
   
   New combinations: ______________________________________________________
   
8. What further sources of metal might be considered?
   
   Junk: __________________________ Low grade: __________________________
   
9. What are the basic problems of mineral conservation with regard to
   
   Variability: _________________________________________________________
   
   Use: __________________________________________________________________
   
   Research: __________________________________________________________________
   
   Criterion questions on report sheet
Programmed Learning: Soil

One of man's most valuable resources is soil. It is indispensable to man and serves him in many ways. This program intends to point up the necessary role of soil conservation; to analyze the uses and results of poor soil practices, to show the basic principles involved and demonstrate the need for awareness, background and incentive in order to solve the problems of today.

1. Most of the crops which furnish our nation's food supply are grown in ___.

SOIL

2. Not only the food we eat, but the grasslands on which livestock and wild animals feed are supported by the layer of ___ on the globe. We are dependent on soil either directly or indirectly for all types of ___.

SOIL FOOD

3. Soil also supports all our forests which in turn protect our watersheds. A watershed is the area from which water drains into a river system. Forests prevent excessive water run-off in the ___ and thus prevent floods and regulate our ___ supply.

WATERSHED WATER

4. Theodore Roosevelt once said that when the soil is gone, man must go, and he added, "The process does not take long." Today many people consider the importance of ___ and give us twenty years.

SOIL and/or WATER

5. Soil originates from rocks that have broken down or "weathered" over a long period of time by means of natural forces such as wind, rain, heat and frost. This resulting ___ material is also enriched by addition of the remains of plants and animals.

SOIL

6. Soil consists of three distinct layers: topsoil, subsoil and substratum. The surface layer of ___ is richest in organic matter and produces better growth of plants.
TOPSOIL
7. Although this layer is seldom even a foot deep, and varies in many localities, it is formed very slowly. From 500 to 1000 years are needed to make an inch. So it is essential to keep this layer of --- fertile and productive.

TOPSOIL
8. Here in the United States, we are fortunate to have a wide variety of soils that can grow many kinds of crops. This great --- makes possible many crops.

VARIETY
9. The many storage places for crops across the USA show that we have surpluses, but we also have serious problems because many of our best soils have been wasted, by erosion and poor land use that have --- almost one sixth of our best soils.

DESTROYED or WASTED
10. There are many types of soil erosion. When heavy rains remove --- from large areas of land surface, we call it sheet erosion.

SOIL
11. Rill erosion appears when water cuts into the soil. Then too much --- from heavy rains flows through the cut and carries away more and more soil.

WATER
12. Severe gully erosion results from rill erosion when streams of water cut wider and deeper into the earth and so cause permanent loss of good --- and cropland if not checked.

SOIL
13. A type of erosion called undercutting may damage the banks of a swift river or a large, active lake. The water cuts under the banks and eventually breaks away large chunks of land by ---. Often the water becomes clogged with the silt it picks up, so it is deposited along curved shores, or on islands.
EROSION
14. In areas where the ground is dry, wind can become a powerful agent of erosion. The wind picks up the smaller, lighter particles from the surface and thus depletes the ---. It also causes dust storms that do another type of damage.

TOPSOIL
15. Soil depletion is a type of damage in which soil is losing enriching minerals and organic matter. When fields are planted with the same crop, season after season, it removes the same chemicals from the soil, and thus causes soil ---.

DEPLETION
16. The badlands of South Dakota are probably one of the most dramatic examples of soil erosion and depletion. Most of it will no longer raise crops. Many other examples of --- --- are not so obvious but just as serious.

SOIL EROSION
17. When soil erosion becomes really serious, many farms will not produce crops and have to be abandoned. This affects too many people in the nation besides the farmer to disregard it. In most cases, soil erosion is the result of lack of cover, especially on sloping ground. When forest lands are burned or cut, --- --- is destroyed. The soil also loses the nutrients from decaying leaves that it needs to be able to grow ---.

SURFACE COVER CROPS
18. Poor farming methods expose soil to erosion because nothing is left to prevent the --- from rushing down between the furrows and carrying the --- with it.

WATER SOIL
19. If too many animals are permitted to graze an area of grassland, the surface cover is destroyed. Without this surface cover to hold the --- in place, erosion agents can do more ---.

SOIL DAMAGE
20. Soil erosion is not restricted to rural areas, because land that is cleared for construction in urban areas is also exposed to ---.
EROSION
21. Soil conservation is a program aimed at preventing soil erosion and maintaining the elements which keep the soil fertile. It involves insuring a healthy forest cover on upland watersheds to prevent the downward rush of --- that would carry away large volumes of ---.

WATER TOPSOIL or SURFACE SOIL
22. Steep slopes should be planted with vegetation that would act as a holding agent for the --- exposed to running water to prevent washing out plants and crops.

SOIL
23. Row crops should be planted along the contour or shape of the land rather than up and down slopes so that --- drains into the --- rather than running down the furrow and off the soil surface.

WATER SOIL
24. After certain crops have been harvested, the stubble and roots of the crop may be left in the ground. Bare land may be covered by material such as straw that will keep the rain water from washing away ---.

TOPSOIL
25. Gully erosion is the most severe type of water-caused soil destruction. It can be checked by placing dams at strategic points to curb the speed of running ---.

WATER
26. Where a severe type of erosion has started and is expanding, vegetation planted along the sides and bottom of the --- will furnish a protection against further effects of water erosion.

GULLY
27. Strip cropping is an aid to the control of water erosion. To do this wide --- of crops planted in rows may alternate with --- of cover crops like rye or wheat.
28. As wind velocity increases, the damage is greater from wind erosion. Planting shrubbery or trees to --- the wind is an effective method of control. There are several other effective ways, especially by planting cover crops to hold --- in place.

29. Soil depletion can also be controlled. Some plants like alfalfa can restore nitrogen to the soil by means of bacteria on the roots. Thus when this plant is harvested, the roots leave --- in the soil.

30. Fertilizers also help to restore depleted soil. If an analysis of the soil indicates some chemical is missing, such as potash, calcium or phosphate, it can be added to make the --- fertile once more.

31. Crop rotation to suit the nature of the soil is important if good crops are to be expected. New or different crops add new material to the soil, help build it up and thus control soil ---.

32. To sum up, there are three basic principles of soil conservation:
   A. Maintain and preserve fertility of the soil by --- it properly.
   B. Seek advice of experts who understand the ---.
   C. Include soil, water, forest and wildlife conservation in the same program to recognize their --- on each other.

CRITERION: The following questions are to be answered on your report when you have finished all three parts of this program:

   How do these ideas fit together for soil, water, mineral conservation?
   What other similarities do you see in the conservation picture?
1. One of the greatest problems facing our nation is that of an adequate water supply. Water is indispensable to all our activities, and modern living keeps on using more and more of it. Among the essential daily activities, food production, both plant and animal, requires much --- if it is to be successful.

2. Industrial centers need --- to operate the factories, remove wastes and produce manufactured goods. In residential areas, cooking, bathing, waste removal, and heat use --- also.

3. Our rivers, lakes and canals serve as channels for transportation. Since the beginning of time, --- has been used for this purpose, and it still is used thus.

4. Hoover Dam, and many other reservoirs furnish water power to produce electricity. Probably 1/4 of all the electricity used in the United States today comes from --- power.

5. Many recreational activities such as boating, swimming, diving, skiing and scuba diving depend on clean --- if they are to be enjoyed.

6. Thus it is obvious that water is essential for many activities of human beings, such as ---, ---, ---.

Choose any three of these: TRANSPORTATION FARMING RECREATION MANUFACTURE LIVING

7. Basically all forms of water come from the atmosphere as --- and --- so they freely become available to man underground or on its surface.
RAIN  SNOW
8. Surface water as it is found in ---, ---, and --- supplies most of the water needs of cities. Underground water is found buried in the earth in rock structures and used from ---.

RIVERS  LAKES  STREAMS  WELLS or SPRINGS
9. There are three main types of water problems: shortage, floods, and pollution. Since human beings use so much water in so many activities, --- is an ever present problem, especially in dry areas.

SHORTAGE
10. Valuable water is wasted when flood conditions prevail on low river-plains in the spring. The causes of both these problems are mainly interrelated because poor land-use causes surface water run-off and results in --- in the dry season and --- in the rainy season.

SHORTAGE  FLOODS
11. Destruction of forests on our watersheds prevents ground storage of usable water and also causes ---, as do urbanization and highway use of concrete.

SHORTAGE  and/or FLOOD
12. Poor land use contributes to water shortage and floods by --- on pasture land, destruction of --- that soak up water and prevent erosion and loss of water on covering soil with --- to prevent any water getting in it at all.

OVERGRAZING, FORESTS and/or COVER, CONCRETE
13. Recent events prove that our increased industrialization increases water consumption but also causes water pollution. Petroleum refineries often add --- to surface water and thus pollute it.

OIL
14. Industries all contribute wastes to our water supply. We see it when the color of water near a factory is different because the factory is discharging raw --- into the water.
15. Even our efforts to be clean and have clean clothes can pollute our streams and rivers. Synthetic detergents often leave a lasting foam in lake or river that can even kill fish and/or any other aquatic living things.

16. Irrigation is becoming more of a necessity if food enough is to be produced for our increasing population. This means that more water is being used and can cause water shortage especially in dry seasons.

17. Some basic ways of relieving water problems would be:
   A. Reforestation of hills and water sheds to provide cover that would soak up rain and snow to maintain underground water.
   B. Contour plowing and strip cropping to prevent soil erosion and soak up surface water.
   C. Check dams to curb water speed and minimize run-off of water.

18. Replanting trees on hills and watersheds would hold water in the ground better. Contour plowing would prevent soil erosion and floods. Check dams would curb water erosion.

19. There is a great deal of water in the ocean but it cannot be used for some things because it contains salt. If this could be removed, it would add to our usable water supply and prevent floods.

20. When water becomes polluted, it is not fit for human use and destroys all forms of water life, especially fish.

21. Efficient planning of water use in urban areas must include plans to reuse the water. Harmful waste products like sewage from industrial plants, detergent from laundry and homes, and effluent from human habitations must be removed before water can be reused.
CHEMICALS or WASTES DETERGENTS SEWAGE
22. Large and small cities alike need efficient sewage treatment plants so that shortage could be decreased by water ---.

WATER PURIFICATION
23. Since water in urban areas must be purified before being distributed to homes, good planning will use this --- to its best advantage.

SUPPLY or PURIFIED WATER
24. Large reservoirs can be used to store water for farms to use for ---, for factories to use for ---, vacationers to use for ---, and people to use for all their needs.

IRRIGATION POWER and/or MANUFACTURING RECREATION
24. There are three basic ways to conserve water
   A. Plan to remedy the increasing ---.
   B. Treat the problem over a broad ---, not just a limited place.
   C. Include all conservations problems in one program because they are all ---.

POLLUTION and/or SHORTAGE AREA INTERDEPENDENT or RELATED

CRITERION: Refer back to Module IIA
Module IIC

Programmed Learning: Minerals

1. Minerals play a vital part in modern life because industry uses them to provide --- --- from which products we use are made. Transportation and manufacturing also need them for ---.

RAW MATERIALS        POWER
2. As population increases, production of goods increase, so the need of --- is constantly increasing.

RAW MATERIALS or MINERALS
3. Because of our high standards of living, we use more minerals than any other country for --- of needed products, --- of these products to a market, as well as --- to manufacture them. (run machines)

MANUFACTURE         TRANSPORTATION         POWER
4. Unfortunately, once they are used, they never can be replaced. It has taken millions of years to form our mineral deposits and once they are gone, they are gone --- (how long?)

FOREVER
5. Minerals are classified according to their use. Coal is a mineral used for --- in large quantities, so a steady supply is needed.

FUEL
6. The United States has seemingly unlimited sources of coal, but some of it is not top grade, so other energy sources need to be used, such as ---.

OIL or PETROLEUM
7. Petroleum is not unlimited in supply, and is becoming more expensive as we exhaust our resources, so we now import much --- to use in all our needs in this country.

OIL
8. Our most important metallic mineral is ---, basis of the steel industry. Next in importance is ---, used for electricity and many other industrial installations.
IRON COPPER

9. Although we have many rich mineral deposits in this country, we also import many of our minerals such as:

- Copper to supplant local ores
- Bauxite (aluminum ore) for household utensils and building
- Lead for electrical and plumbing
- Platinum to use as a catalyst
- Tin to coat cans
- Asbestos for fireproofing

Conservation of --- involves efficient, intelligent use of these and many other materials.

MINERALS

10. Wasteful methods of mining must be replaced with more efficient ones and also ways of using all minerals must be improved. This increase efficiency is almost as good as finding --- minerals to use.

MORE

11. Present fuel supplies can be extended if more use is made of low quality fuels, and not wasting the by products of --- use.

INDUSTRIAL or EXTENSIVE

12. Searches are being made in junk yards to recover more --- to be reused; another possible saving on metals would be the substitution of materials like --- wherever possible.

METALS PLASTICS

13. Our dependence on imported minerals makes it imperative that we continue to keep good relations with the countries that can --- these minerals to us.

SUPPLY

14. There are three basic problems of mineral conservation:
   A. Realize the fact that most of our mineral --- vary in quality and cannot be replaced.
   B. Produce and utilize all mineral products efficiently to reduce --- and conserve them.
   C. Carry on extensive research into ways to discover uses for those minerals which are abundant, or to --- those we throw away.

RESOURCES WASTE REUSE
Module II

Report Sheet

How do you see the following ideas in regard to soil, water, mineral conservation?

Need for planning: ____________________________

Efficiency: ____________________________

Interdependence: ____________________________
Module III

This module was developed on the current problem of pollution. The investigator used the two multimedia units devised by the Plastic Coating Corporation on the topics of Air and Water Pollution which were easily handled. These units consist of a filmstrip, a transparency and a record combined in a unified presentation. They were utilized as published, with the addition of instructions by the investigator on tape for group use. The balance of nature was developed by a set of transparencies developed by the investigator from various sources, combined with the color transparencies produced by the Millikan Company.

The following behavioral objectives were presented to the students:

1. To investigate the causes of pollution;
2. To recognize the ways pollution can be controlled;
3. To observe those factors that keep the environment in balance;
4. To develop ways to improve our use of the environment and its natural resources.

This module corresponds with the BSCS objective of the dependence on the nature of the society and technology of each age of each biological concept. It places the emphasis on man's dependence on his environment and the danger of abuse.
Module IIIA

Study Guide: Air Pollution

1. Man's need for air ____________________________

2. Sources of pollution: ____________________________
   _____________________________________________
   _____________________________________________
   _____________________________________________

3. Losses due to air pollution ______________________
   Vegetation ___________________________________
   Human ________________________________________

4. Air pollution from automobiles ___________________
   Effect on humans: personal ______________________
   dwellings ______________________________________

5. Air pollution from industry ______________________
   Power plants _________________________________
   Waste disposal ______________________________
   Heating effects ______________________________

6. Effect of population growth ______________________

7. Atmosphere depth ______________________________
   Photochemical smog __________________________
   Particulate matter ___________________________

8. Controls ______________________________________
   Cities dispose wastes properly _________________
   Industries re-use waste materials ______________

9. Effects of air pollution: _________________________
   Greenhouse effect _____________________________

10. Prevention of air pollution ______________________
Module IIIB

Study Guide: Water Pollution

1. Effect of population increase

2. Sources of water pollution
   - Urban
   - Industrial
   - Agricultural

3. Effects of pollution on aquatic life
   - Detergents
   - Farm chemicals
   - Thermal pollution
   - Silt, sand, debris

4. Natural water purification
   - Effect of oxygen
   - Balance of living things

5. Some types of purification
   - Desalinization
   - Removal of solids

6. Pollution control

7. Water uses and effect on pollution

8. Natural purification cycle

9. Treatment of water used by man

10. What can we do?
    - Maintain natural balance
    - Control use and misuse
Module IIIC

Study Guide: Balance of Nature - Abiotic Factor

1. How does man upset the environment?
2. How does the sun affect the earth?
3. What is topography?
4. How does it affect the environment?
5. How does climate affect vegetation and animals?
6. What is a biome?
7. What are the physical factors in a biome?
8. What is there about ocean water that makes it different from freshwater?
9. What effect does water have on the climate of the land adjoining?
10. What changes take place as water flows into the sea?
11. What controls the circulation of oxygen in the atmosphere?
12. Why is this important?
13. How does the circulation of energy differ from the circulation of matter?
14. What levels of the soil profile do your soil samples fit?
Study Guide: Balance of Nature – Food Web

15. What concept of energy forms the basis for environmental problems?

16. Why are green plants so important?

17. How is the pyramid of numbers developed?

18. Why are plants more numerous than the top level carnivores in the pyramid?

19. What is a carnivore?

20. What is a herbivore?

21. What is a producer?

22. What is a consumer?

23. What is a reducer?

24. What plants are not producers? Why?

25. How does leaf litter make soil? (Use your leaf litter samples)

26. What is the relationship of soil to water? Use soil samples and water in the plan shown on filmstrip.

27. What is the relationship of energy to food chains?

28. How does man change the balance of nature when he kills animals?

29. How do plants control energy loss?

30. How do poisons like DDT affect food chains?
31. What is meant by succession in a pond? _______________________

32. What is the tundra biome like? _______________________________

33. What is the difference between a forest of conifers and one of broadleaf trees? _______________________________

34. Why are birds important in a forest biome? ______________

35. What is a grassland biome? _______________________________

36. Why do we have prairie birds in Michigan? ______________

37. What is a desert biome like? _______________________________

38. Is there an ocean biome? or many? _____________________

39. What is a pond community? _______________________________

40. How do freshwater plants differ from saltwater plants? _______

41. What differences are there between freshwater and saltwater animals? _______________________________
Module IIIA

Programmed Learning: Air Pollution

1. Man cannot live long without breathing ---, and this necessity of life must be in good condition when he breathes, or all kinds of difficulties arise.

AIR
2. There are many sources of air pollution in the world around us that come from the things man uses, such as ---.

Any one of these: FACTORIES  AUTOMOBILES  FURNACES

3. When the air is polluted, the proportions of necessary chemicals in the air is interfered with, especially ---.

OXYGEN
4. This interference with the balance of chemicals in the air affects the oxygen-carbon dioxide cycle. This interferes with ---.

BREATHING
5. Air pollutants affect different parts of the body. Carbon monoxide from car exhausts affects the bloodstream by interfering with the oxygen in the ---.

BLOODSTREAM
6. Sulfur dioxide which comes from the use of coal and oil as fuels has an acid reaction when mixed with water. If this is breathed in, it can affect our ---.

LUNGS
7. Another product of fuel burning that affects the eyes, nose and lungs is nitrogen dioxide. Like sulfur dioxide it injures tissue because it mixes with the moisture in the air and has an --- reaction.

ACID
8. The worst forms of air pollution are photochemical smog and particulate matter. In the first, gasoline fumes from the exhaust pipes of --- collects in large amounts and the sun's energy turns it into dangerous hydrocarbons.
9. When there is particulate matter in the air, a larger than usual amount of poisonous fumes is formed from the increased amount in the --- and injures the lungs.

10. When there is too much carbon dioxide in the air, it collects high in the atmosphere and acts as a cloud to reflect back the sun's rays and raise the --- of the air.

11. All these effects of air pollution affect the ecological balance because all living things need ---.

12. When these pollutants change the chemical content of the air, they interfere with all --- ---.

13. Some people are against government control of pollution because they make and sell things that cause the oxygen-carbon dioxide cycle to be put out of ---.

14. Even home owners can help control air pollution by watching that home wastes such as garbage and leaves are not --- in such a way as to add more pollutants to the air.

15. We must do our part to be aware of the causes of air pollution so that they can be controlled and preserve our ---.
Module IIIB

Programmed Learning: Water Pollution

1. Man's use and misuse of water has become a threat to his environment. As population increases, so also the ___ of water increases.

USE

2. In 1960 there were 179,323,175 people using water. By the year 2000 there will be 483,371,000. This means a great strain on the ___ supply of the world.

WATER

3. In the city, sewage disposal for so many people is a great problem, and causes streams around the city to become ___.

POLLUTED

4. Industrial wastes are an ever present source of ___ ___ that must be controlled if man is to survive.

WATER POLLUTION

5. Industries also increase the temperature of the waters and cause thermal pollution that can kill ___ and other aquatic life.

FISH

6. When fish and other aquatic life die, the streams and rivers become clogged with organic material that causes the ___ supply to be polluted.

WATER

7. Man causes the balance of nature to be upset when he sends waste materials into the streams to ___ them.

POLLUTE

8. If man is to live in the world of the future, he will have to stop the practices that upset the ___ of nature in the environment.
BALANCE
9. Besides avoiding those practices which upset the balance of nature, man must take steps to increase the supply of usable --- if he is to survive.

WATER
10. Some of the means possible for the increasing of water supply are desalination and processing used water for ---.

REUSE
11. Man uses water for many purposes in industry, recreation and the home. As the --- increases, these needs will use more water.

POPULATION
12. The natural purification cycle is no longer sufficient for all the people to use all the water they need, because there is so much land area in cities that is covered with buildings and concrete so that water cannot soak into the ground to furnish --- in storage.

WATER
13. Not as much water vaporizes from industrial surfaces as from field and woods and stream, so the water cycle is not --- in this aspect either.

SUFFICIENT
14. If man is to have enough water for all his needs, industry must control the dumping of ---, cities the dumping of --- and all groups must be able to --- the water.

WASTES  SEWAGE  REUSE
15. All of us can help the water problem by watching the kinds of --- we use for laundry purposes, insisting that city govern­ments control what goes into--- and making ourselves aware of the need for --- conservation.

DETERGENTS (SOAPS)  RIVERS and/or STREAMS  WATER
Module IIIC

Programmed Learning: Balance of Nature

1. Man upsets his environment by his misuse of its factors. For instance, when man kills all the insects, he also affects bird life. The use of DDT to kill insects has been the cause of the death of many kinds of ____.

BIRDS
2. All the factors of the environment are very closely interrelated. An area has its own type of climate because of the topography or land forms in the area. Thus land areas near a lake have their temperatures made milder by the nearby ____.

WATER
3. The plants in an environment have two important parts to play. They help maintain the oxygen in the air and make food from carbon dioxide. Are these two chemicals biotic or abiotic factors?

ABIOTIC
4. In every environment there are living things and nonliving things. The living things are biotic factors and the nonliving abiotic. Which type of environmental factor is man?

BIOTIC
5. Matter and energy circulate through the environment in cycles, thus making possible continual reuse of the factors. What kind of a cycle of matter do plants play a part in?

OXYGEN-CARBON DIOXIDE CYCLE
6. Food webs are cycles of biotic and abiotic factors. The living things in the food web get their energy by eating other living things. Plants are the means of making the sun's energy available to ____.

ANIMALS or MAN
7. Plants also help to keep the soil replenished with mineral matter when they decay and turn back to earth. In your soil samples, what material comes from plants?

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LEAF LITTER or ORGANIC MATERIAL
8. Animals eat plants and they also eat other animals. A plant eater is a herbivore and an animal eater is a carnivore. Are insect eating animals herbivores or carnivores?

CARNIVORES
9. What class do animals that eat grass belong?

HERBIVORES
10. Some biotic factors produce energy building materials and others consume them, but a third class reduces both these classes to the chemicals of which they were made. They get their names from the work they do. Which class would animals come in?

CONSUMERS
11. Plants change chemicals and energy into a usable form for other living things as well as themselves. What would they be called?

PRODUCERS
12. Some plants, like the toadstool can never produce energy from sunshine and chemicals. Are they producers or consumers?

PRODUCERS
13. When man uses chemicals that are long lasting, like DDT, he is upsetting the balance of nature because the DDT kills more than the insects he is trying to get rid of, so it is dangerous. Is DDT biotic or abiotic factor?

ABIOTIC
14. Abiotic factors of climate and topography control the type of plant and animal life in a given area. Which is the major control in a desert biome?

CLIMATE
15. In the ocean environment, the depth of water is a factor in the type of life that can flourish there. Is this an abiotic or a biotic factor?
BIOTIC
16. Because the biotic factors of a certain area are characteristic of that soil and climate, and are dependent on it, we can pick out certain areas where certain types may be found. This is called a biome. The stunted plants and small animals of the tundra biome are a result of the --- there.

CLIMATE
17. In each biome, the passage of years shows a change in both the abiotic and the biotic factors, so that the plants they grow in a certain place, for instance, gradually change. This is called succession. Thus a pond can fill up with debris and sand and become a marsh, and finally a meadow, giving us a --- succession.

POND
18. As sand blows in from the lake shore, plants gradually get a foothold in the sand dunes that have piled up and make it possible for animals to live there. This is sand dune ---.

SUCCESION
19. In a biome, we are first conscious of the plants that grow there, as in a subtropical biome like Florida, we would expect to find palm trees. Animals that are found in a biome are very --- on the plants that grow there for food and shelter.

DEPENDENT
20. The abiotic factors in water biomes are the most important in determining the type of plant and animal life found there. What is the most evident abiotic factor that makes an ocean biome different from a pond biome?

SALT WATER
21. A biotic community consists of the sum of all the interactions among the species populations at some particular time and place. In a forest community, which factors are not as active in winter?
TREES or PLANTS
22. Every biotic community is part of an ecosystem, which is a complex of all the biotic and abiotic interactions within a definable unit of space and time. The energy of an ecosystem is dependent on the --- in that system, to a large degree.

PLANTS
23. South facing slopes of a mountainside are hotter and drier than north facing slopes. This would bring about a difference in the --- factors of the two sides.

BIOTIC
24. The best measure of the interaction of biotic and abiotic factors is found in the number of individuals of a given species during a period of time. This interaction produces ---.

SUCCESSION
Report Sheet

DIRECTIONS: Fill in the blanks in these tables.

<table>
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<th>Pollutants</th>
<th>What They Affect</th>
<th>Where They Come From</th>
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<tr>
<td>Carbon dioxide</td>
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<tr>
<td>Sulfur dioxide</td>
<td>burning fuels</td>
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<tr>
<td>Nitrogen dioxide</td>
<td>eyes, nose, lungs</td>
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<tr>
<td>Hydrocarbons</td>
<td>burning gasoline</td>
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<td>DDT</td>
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<table>
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<tr>
<th>Balance in Nature</th>
<th>Abiotic Factor</th>
<th>Biotic Factor</th>
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<tr>
<td>Prairie</td>
<td>topography</td>
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</table>
APPENDIX B

Materials and Equipment
MATERIALS AND EQUIPMENT


Constructed by Dr. Imy V. Holt for this project

"Black Box" connection for multiple headsets
Portable carrels of hinged pegboard
Small projection screen (artist's canvas)
Kalamazoo: Western Michigan University

Film-loop Projector (Super 8)
Technicolor 810
Hollywood, California: Technicolor Corporation

Filmstrip Viewer
Graflex P P-50 Study Mate
Rochester, New York: Graflex Inc.

Headsets
P & E Model Headphone
East Providence, Rhode Island: P & E Electronics Company

Rear Screen Sound Projector
Model 95-60 Projector

Slide Projector
Kodak Carosel
Rochester, New York: Eastman Kodak Co.

Tape Player
Audiotronics Model 110 Transistor
North Hollywood, California: Audiotronics Corporation

Transparency Viewer
Tecnifax
Holyoke, Mass.: The Plastic Coating Corporation

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