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A Comparative Investigation of Understanding of Ecological Content between Eighth and Tenth Grade Pupils

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A COMPARATIVE INVESTIGATION OF UNDERSTANDING OF ECOLOGICAL CONTENT BETWEEN EIGHTH AND TENTH GRADE PUPILS

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APPROVED FOR THE GRADUATE FACULTY

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I would like to acknowledge the time and effort donated by Mr. Jim Alban, the BSCS instructor at Camas High School, and to both the Camas and Evergreen School Districts for allowing me to do this study.

A very special thanks goes to my wife Jody for her many patient hours of help and encouragement, and to my four day old baby girl, Jennifer, for her holding off to make me work harder to complete this writing.

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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

The United States and the entire world, can be recognized to be in an ecological crisis. This crisis not only affects our young people, but in part must be solved by them. There has recently been a large scale effort through education to make Americans, particularly young Americans, aware of the problems in our environment (11:6-10). As an environmental educator, the investigator wanted to determine if complex environmental ideas and facts, presented in a one semester course, could be understood at an eighth grade level at Covington Junior High School, Vancouver, Washington, and could therefore warrant the continuation of a course of this nature.

I. THE PROBLEM

Statement of the problem. The study had two major purposes. One purpose was to determine if Covington Junior High School eighth grade pupils understood the basic ecological ideas and facts presented to them in a teacher-designed one semester course entitled Environmental Concepts Orientation. The second purpose was to find out the degree of competence attained by the eighth grade pupils as compared to tenth grade pupils taking a one year ecologically oriented course in the nationally developed Green Version BSCS biology series at Camas, Washington.

Limitations of the study. The limitations of the study were: four eighth grade and four tenth grade classes were used; a single evaluation instrument was used; the study was conducted only for one school year; scores from group administered I.Q. tests were used; the test items used as an evaluation instrument were selected from a Green Version BSCS standardized test. The review of the literature was limited to reported research found in the Central Washington State College and the Portland State University libraries.

Need for the study. The question as to whether younger pupils could understand complex ideas as well as older pupils, given the same information, had been tested to some degree by Blane, 1962 (4:496-498); Walters, 1963 (17:170-176); Mathes and Blanc, 1960 (10:23-26); Burkey, 1965 (5:66-71); and Shrader, 1968 (13:196-203). This particular study involved not only different age groups, but information presented in different school districts under a variety of different methods and facilities.

The results of this investigation would help the investigator and the Evergreen School District Science Curriculum Committee to determine more objectively if they should continue to offer the Environmental Concepts

Orientation course at the eighth grade level.

<u>Basic assumptions and hypothesis</u>. A premise of the investigator was that the abilities and methods used by the different instructors and the different facilities and classroom environment were not appreciably different enough to affect the achievement of the two groups on a cognitive measuring instrument.

The hypothesis was that eighth grade pupils in the teacher-designed course situation can learn basic ecological facts and ideas as well as tenth grade pupils in the Green Version BSCS course situation.

<u>Procedure of the study</u>. The study lasted one school year beginning September 1970 and ending June 1971. The following procedures were carried out:

1. A teacher-designed course was developed and taught for one year before this investigation began.
2. The consent to run the investigation was obtained from the superintendents of both school districts involved in the study.
3. The eighth grade and tenth grade populations were selected.
4. A single evaluation instrument was constructed for the use as a pre-test and a post-test.
5. The first semester eighth grade and the tenth grade populations were pre-tested.

6. The teacher-designed course was taught to the first semester eighth grade pupils.
7. The first semester eighth grade population was post-tested.
8. The second semester eighth grade was pre-tested, and the teacher-designed course was repeated.
9. The second edition of the one year Green Version BSCS course was taught to the tenth grade pupils by the Camas instructor.
10. Both the second semester eighth grade and the tenth grade populations were post-tested.
11. I.Q. scores were obtained and the means of the two populations were determined.
12. Analyses of the pre-test and post-test scores were made.

II. DEFINITIONS OF TERMS USED

BSCS. These initials have been used to identify the Biological Science Curriculum Studies. A desire to develop a sound science curriculum in the life science fields fostered a national effort which resulted in the development of three different approaches to teaching high school biology. These three versions were yellow (cellular and physiological), blue (molecular and chemical), and green (ecological). The second edition of the Green Version was used at Camas High

School.

ECO. The ecology course at Covington Junior High School was entitled Environmental Concepts Orientation. The initials ECO were selected to be used to identify the course.

Ecology. Ecology is a natural science which studies the relationships between plants and animals and their environment (12:4).

CHAPTER II

REVIEW OF THE LITERATURE

In order to establish a clearer focus for the study and to design a procedure for investigation of the problem the investigator used the reported literature found in the Central Washington State College and Portland State University libraries.

In no study that could be found in the current available literature dating back ten years could the investigator find any science education research that directly related to a comparative study between eighth grade pupils and any older group of pupils. For example, Bennett (2:468-476) reported in the Review of Educational Research that during 1964 research in science education in the junior high school was almost completely lacking.

However, two related studies dealt with comparisons between ninth grade science classes and tenth grade science classes. The studies by Mathes and Blanc (10:23-26) and Burkey (5:66-77) compared accelerated ninth grade biology pupils to equally paired tenth grade biology pupils under the same treatment. They both concluded that the accelerated ninth grade pupils could achieve as well, and in many cases better, than tenth grade pupils of the same ability.

A third comparative study was done by Walters (17:170-176) involving randomly selected ninth and tenth grade biology pupils. Each grade received equal treatment and were tested to find achievement differences. Comparisons of the mean scores of high-ninth to high-tenth and low-ninth to low-tenth ability groups were made. Under all statistical treatments no significant differences between the ninth and tenth grade pupils could be found. A comparison of understanding of different selected areas of biology also resulted in no significant differences in the achievement of ninth and tenth grade pupils. Walters (18:230-234) did a follow-up study on the original test populations during their twelfth year. Upon retesting for biological knowledge, Walters concluded that no differences could be found between pupils having been enrolled in biology as a ninth or as a tenth grade pupil.

Blane (4:496-498) did a study using a group selected on the basis of ability, interest, and teacher recommendation of ninth grade pupils who took biology. He compared them to both unselected and selected tenth and eleven-twelfth grade groups. He found that selected ninth grade pupils achieved considerably higher than an unselected group in the senior high school. Blane further determined, that when selected ninth graders are matched to paired groups of tenth and eleven-twelfth grade groups they still achieved slightly higher.

Two studies were carried out by Johnson (8:123-126) and Wise (20:418-424). Both compared the ability of junior high school pupils to high school and college students. The results of their separate studies can be summarized by a statement made by Wise,

> ...that in planning a program of general education the major effort to develop qualitative understanding of important principles of science need not be postponed until the college, or even the high school years.

Shrader (13:196-203) compared the understanding of fifth and sixth graders to that of college students on selected principles in chemistry in which he concluded that, "fifth and sixth graders were capable of learning aspects of chemistry commonly taught to college pupils."

The results of the research cited above have been supported by work in educational psychology. Inhelder and Piaget (7:347) stated that analytical-type thinking has its beginning near the onset of adolescence. Piaget (7:337) also states that "formal thinking as well as the age at which adolescence itself occurs....is dependent on social as much as and more than on neurological factors." Piaget, according to Carlson (6:246-250), believed that during the ages of eleven to fifteen, "a final reorganization takes place that allows the child to operate in the abstract world of propositional statements."

Tagatz (16:40) and Wier (19:1-18) concluded that the only restrictive characteristic that prevented a nine to twelve year old child's thinking from being on an equal basis with adult thinking was that their memory or information processing skills were not completely developed. Tagatz also thought that a large increase in information processing occurs in pupils during the eighth and ninth grades.

The research reported here, although limited, tended to support the assumption that junior high school pupils could learn subject matter commonly relegated to senior high school classes.

CHAPTER III

COURSES, GROUPS, TESTS AND ANALYTICAL PROCEDURES

The information presented in this chapter was intended to provide a reasonably detailed accounting of the ECO course, the BSCS course, the testing process and the several analysis operations.

I. THE COURSES

It was not the specific intent of the investigator to make a comparative analysis of the content and methods used within the ECO and BSCS courses. It was a premise of the study that the ecological course content and methods included in the two courses were basically similar. However, the course content and methods have been summarized here to assist the reader in reviewing this premise.

ECO Course

The following is an outline of subject areas presented in the one semester course in Environmental Concepts Orientation.

I. Introduction
   A. Place in scientific world (one day)
   B. History and man's future (two days)

II. Environmental Make-up
   A. The ecosystem (two days)
      1. Adaptation
      2. Natural selection

B. Physical factors (ten days)
   1. Light, temperature
   2. Atmosphere, moisture
   3. Soil
C. Biotic factors (ten days)
   1. Energy transfer - food chain
   2. Biochemical cycles

III. Environmental Organization
   A. Biosphere (one day)
   B. Community (two days)
   C. Population (six days)
      1. Density, stability
      2. Predation, parasitism
      3. Migration, dominance
      4. Commensalism, mutualism

IV. Types of Ecosystems
   A. Forests (twelve days)
      1. Physical factors
         a. Light, temperature
         b. Soil, moisture
      2. Biotic factors
         a. Succession, climax
         b. Life zone, plant identification
      3. Conservation - logging, public use, future
   B. Inland waters (fifteen days)
      1. Physical factors
         a. Light penetration, turbidity
         b. Heat capacity, turnover
         c. Dissolved nutrients and gases
      2. Biotic factors
         a. Succession - bog formation
         b. Food chains
         c. Biochemical cycles
   C. Oceans (five days)
      1. Physical factors
         a. Light, salinity
         b. Temperature, currents, climates
         c. Tides, upwelling
      2. Biotic factors
         a. Food chains, life zones
         b. Phytoplankton bloom
   D. Grasslands and Deserts (four days)
      1. Physical factors
         a. Temperature, moisture
         b. Soil, land management
      2. Biotic factors
         a. Adaptation
         b. Succession

V. Man Changes His Environment
   A. Air pollution (eight days)
      1. Causes - cars, industry, domestic
      2. Effects - human, plant, animals
      3. Solutions
         a. Transportation, technology
         b. Adaptation, extinction
   B. Water pollution (ten days)
      1. Causes - industry, domestic, agriculture
      2. Effects - humans, plants, animals
      3. Solutions - treatment, recycle, desalt
   C. Natural resources (nine days)
      1. Solid waste - recycling
      2. Wildlife, forests
      3. Soil, minerals
      4. World food supply

Varied reading sources were used to present information in the ECO course. In addition to the list of textbooks, periodicals, and printed materials given below, other current sources, such as daily newspaper articles and television broadcasts of ecological interest were used in class discussions as much as possible. There were at least thirty copies of each of the sources listed which were used for classroom work, with the exception of two magazine periodicals which were only single issues.

HARD BOUND BOOKS:

Brandwein, Paul F., Alfred D. Beck, Violet Strahler, Leland Hollingworth, and Matthew J. Brennan. The World of Living Things. New York: Harcourt, Brace and World, Incorporated, 1964.

Farb, Peter. The Forest. Life Nature Library Series. New York: Time Incorporated, 1961.

Thurber, Walter A. and Robert E. Kilburn. Exploring Science Nine. Boston: Allyn and Bacon, Incorporated, 1966.

PAPERBACK BOOKS:

Armstrong, Herbert (ed.). Our Polluted Planet. California: Research Department, Ambassador College.

Burnett, R. Will, Harvey Fisher, and Herbert Zim. Zoology. New York: Golden Press, 1958.

Fichter, George and Herbert Zim. Insect Pests. New York: Golden Press, 1966.

Lehr, Paul, Will Burnett and Herbert Zim. Weather. New York: Golden Press, 1957.

Mitchell, Robert T. and Herbert Zim. Butterflies and Moths. New York: Golden Press, 1964.

Reid, George and Herbert Zim. Pond Life. New York: Golden Press, 1967.

Shuttleworth, Floyd and Herbert Zim. Non-Flowering Plants. New York: Golden Press, 1967.

Zim, Herbert and Clarence Cottam. Insects. New York: Golden Press, 1956.

Zim, Herbert and Alexander Martin. Flowers. New York: Golden Press, 1950.

Zim, Herbert and Hobart Smith. Reptiles and Amphibians. New York: Golden Press, 1956.

SCIENCE UNIT BOOKLETS:

Dewarrd, E. John. What Insect Is That? (Current Science Unit Book). Connecticut: American Education Publications, Incorporated, 1965.

Phillips, M. V. Physical Geography. (Current Science Unit Book). Connecticut: American Education Publications, Incorporated, 1966.

AMERICAN EDUCATION PUBLICATIONS UNIT BOOKLETS:

Aylesworth, Thomas. Our Polluted World. Connecticut: American Education Publications, Incorporated, 1970.

Harris, Jacqueline L. Living In Space. Connecticut: American Education Publications, Incorporated, 1968.

Harris, Jacqueline and Erwin Steinkamp. Ecology. Connecticut: American Education Publications, Incorporated, 1970.

Pollock, George. The Conservation Story. Connecticut: American Education Publications, Incorporated, 1969.

Steinkamp, Erwin and Jacqueline Harris. Living in the Sea, Man's Next Great Conquest. Connecticut: American Education Publications, Incorporated, 1969.

BASIC SCIENCE EDUCATION SERIED BOOKLETS:

Parker, Bertha and Orlin D. Frank. Adaptation to Environment. Illinois: Harper and Row, Incorporated, 1965.

Parker, Bertha and Ralph Buchsbaum. Balance in Nature. Illinois: Row, Peterson and Company, 1958.

PERIODICALS:

Armstrong, Herbert (ed.). The Plain Truth. California: Research Department, Ambassador College.

Bianco, Joseph R. (ed.). "Air", The Sunday Oregonian Northwest. Oregon: September 21, 1961.

Bianco, Joseph R. (ed.). "Our Polluted Environment", The Sunday Oregonian Northwest. Oregon: September 7, 1961.

Bianco, Joseph R. (ed.). "Treatise for a Shrinking World", The Sunday Oregonian Northwest. Oregon: October 12, 1961.

Strohm, John (ed.). National Wildlife. Washington, D.C.: National Wildlife Federation.

PUBLICATIONS FROM THE UNITED STATES DEPARTMENT OF THE INTERIOR, FEDERAL WATER POLLUTION CONTROL ADMINISTRATION:

A New Era For America's Waters. Washington, D.C.: U.S. Government Printing Office, 1967.

A Primer On Waste Water Treatment. Washington, D.C.: U.S. Government Printing Office, CWA-12, October, 1969.

Estuaries, Cradles or Graves. Washington, D.C.: U.S. Government Printing Office, September, 1969.

Heat Can Hurt. Washington, D.C.: U.S. Government Printing Office, September, 1969.

Showdown. Washington, D.C.: U.S. Government Printing Office, CWA-11, October, 1968.

What You Can Do About Water Pollution. Washington, D.C.: U.S. Government Printing Office, 1967.

Clean Water, It's Up To You. Washington, D.C.: U.S. Government Printing Office.

Clean Water News. Washington, D.C.: U.S. Government Printing Office.

PAMPHLETS AVAILABLE THROUGH THE WASHINGTON AND OREGON STATE GAME COMMISSIONS.

UNPUBLISHED MATERIAL:

Hamer, Austin, Ernest McDonald and Margaret Milliken. Field Study Manual For Outdoor Learning. Portland, Oregon: Division of Information and Education, United States Forest Service.

Department of Game. Wildlife, Crop of the Land. Olympia, Washington: Washington State Department of Game.

BOOKLETS AVAILABLE FROM THE NATIONAL AIR CONSERVATION COMMISSION OF THE NATIONAL TUBERCULOSIS AND RESPIRATORY DISEASE ASSOCIATION:

National Air Conservation Commission of the National Tuberculosis and Respiratory Disease Association. Air Pollution Primer. New York: The National Tuberculosis and Respiratory Disease Association, 1967.

National Air Conservation Commission of the National Tuberculosis and Respiratory Disease Association. Air Pollution, The Facts. New York: The National Tuberculosis and Respiratory Disease Association, 1967.

A brief summary of the approximate time and number of different classroom methods used by the ECO teacher is as follows:

CATEGORY	NUMBER	PERCENT
Laboratory exercises	16	20
Demonstrations	25	20
Lecture	--	15
Discussion	--	10
Films	15	10
Slide sets and filmstrips	10	8
Study time	--	7
Field observations	10	5
Quarter projects	2	3
Free time	--	2
	TOTAL	100%

BSCS Course

The following is an outline of subject areas presented in the one year BSCS Green Version biology course.

I. Section One - The World of Life - The Biosphere
    A. The web of life (chapter one - three weeks)
        1. Producers and consumers
        2. Balance in nature
        3. Source of energy
            a. Radiant
            b. Chemical
                (1) Photosynthesis
                (2) Energy Pyramid
        4. Metric system
            a. Diffusion
            b. Osmosis

5. Matter
    a. Carbon cycle
    b. Water cycle
    c. Calcium cycle
6. Food webs
7. The biosphere
    a. Man and the biosphere

B. Individuals and populations (chapter two - three weeks)
1. Population
    a. Density - cycles
    b. Growth - steady state
2. Effects of environment on population
    a. Biotic - other organisms
    b. Abiotic - nutrients, weather
    c. Density
3. Kinds of population changes
    a. Closed population
    b. Open population
    c. Steady state - fluctuations
    d. Meaning of species

C. Communities and ecosystems (chapter three - three weeks)
1. Investigating the biotic community
2. Ecological relationships
    a. Predation - parasitism
    b. Commensalism - mutualism
    c. Competition
3. Species structure of communities
    a. Community boundaries
    b. Succession
4. Ecosystems
    a. Effects of organisms on abiotic environment
    b. Ecological niches
    c. Continuity of the ecosystems

II. Section Two - Diversity Among Living Things (emphasis is on variety not on a "type study")

A. Animals (chapter four - three weeks)
1. Principles of classification
2. Adaptation and geographical distribution
3. Animal kingdom
    a. Major phyla (covered in text, but not listed here)

B. Plants (chapter five - three weeks)
1. Plant classification and phyla (covered, but not listed here)
2. Adaptation and geographical location
3. Binomial nomenclature

C. Protists (chapter six - three weeks)
  1. History of discovery
  2. Kingdom protists
    a. Phylum schizomycetes - culture techniques
    b. Major phyla covered, but not listed here
    c. Spontaneous generation

III. Section Four - Within the Individual Organism (chapters eleven through fourteen)
  A. The cell (chapter eleven - two weeks)
    1. History
    2. Cell theory
    3. Cell structure
    4. Diversity in structure
    5. Cell physiology
      a. Metabolism
      b. Diffusion
      c. Active transport
    6. Reproduction
      a. Differentiation
      b. Aging
  B. Bioenergetics (chapter twelve - two weeks)
    1. Energy-releasing processes
      a. Calories
      b. Catalysis
    2. Biochemical reactions
      a. Cellular respiration
        (1) ADP-ATP cycle
        (2) Glycolysis-Krebs cycle
        (3) Fermentation
      b. Synthesis
        (1) Carbohydrates
        (2) Fats
        (3) Proteins
        (4) Nucleic acid
      c. Photosynthesis
        (1) Light reaction
        (2) Dark reaction
  C. The functioning plant (chapter thirteen - two weeks)
    1. Vascular plants
      a. Leaves - structure, function
      b. Roots - structure, function
      c. Stems - structure, function
      d. Growth
        (1) Phototropism
        (2) Growth stimulants - inhibitors

2. Nonvascular plants

D. The functioning animal (chapter fourteen - two weeks)
   1. Structure and function - Frog dissection
   2. Acquiring energy and materials
      a. Ingestion
      b. Digestion
         (1) In general
         (2) In man
   3. Obtaining oxygen
   4. Transporting materials in the body
      a. Circulatory system
         (1) Invertebrate
         (2) Vertebrate
      b. Blood - plasma
   5. Excretion, secretion, elimination
   6. Chemical coordination - hormones
   7. Nervous coordination
   8. Adjustment to the external environment
      a. Senses
      b. Movement - muscles, skeleton
   9. Physiological steady state as a whole
   10. Chemoreceptors

IV. Section Five - Continuity of the Biosphere
   A. Reproduction (chapter sixteen - one week)
      1. Asexual reproduction
      2. Sexual reproduction
         a. Plant reproduction
         b. Animal reproduction
   B. Heredity (chapter seventeen - two and one-half weeks)
      1. Mendel's work and experiments
      2. Mendel's theory and conclusions
      3. Sutton's Chromosome Theory
      4. Mendelism modified
      5. Human genetics
      6. Mutations theory

V. Section Three - Patterns in the Biosphere (Field Study)
   A. Patterns of life in the microscopic world (chapter seven - one and one-half weeks)
      1. Ecology of microorganisms
         a. Microbes and disease
            (1) Transmission of
            (2) Humus
            (3) Organisms

b. Chemical characteristics of soils
c. Community relationships in soil
(1) Saprovores
(2) Mycorrhizae
(3) Parasites and predators
d. The nitrogen cycle

B. Patterns of life on land (chapter eight - three weeks)
1. Geographic range
2. Survival
3. Tolerance
4. Distribution
a. Climates
b. Biomes
(1) Tundra - abiotic, biotic factors
(2) Taiga - abiotic, biotic factors
(3) Middle-latitude deciduous - abiotic, biotic factors
(4) Tropical rainforest - abiotic, biotic factors
(5) Middle-latitude grassland - abiotic, biotic factors
(6) Middle-latitude deserts - abiotic, biotic factors
(7) Other biomes
(a) Tropical deciduous
(b) Savanna
(c) Middle-latitude rainforest
(d) Chaparral
(e) Mountain
(8) Dispersal
(9) Barriers
(10) Man's influence on terrestrial ecosystems
(a) Agent of dispersal
(b) Cultivation
(c) Succession on abandoned land
(d) Urban and suburban ecosystems
(11) Effects of fire on biomes
(a) Grasslands
(b) Forest

C. Patterns of life in the water (chapter nine - two weeks)
1. Inland waters
a. Ponds
(1) Producers - plant zones, plankton
(2) Consumers - zooplankton
(3) Succession

b. Lakes
   (1) Turnover
   (2) Nutrient build-up
c. Flowing-water ecosystems
   (1) Headwaters
   (2) Middle reaches
   (3) Lower reaches
d. Inland waters and man
   (1) Drainage
   (2) Dams
   (3) Pollution

2. Oceans
   a. Open sea
      (1) Salinity
      (2) Temperature, currents
      (3) Photosynthetic zones
      (4) Exploring the depths
   b. Coastal waters
      (1) Littoral zone
      (2) Intertidal zone

The main text used by the BSCS population, from which the above course outline was taken, was the second edition, 1970 printing of the Green Version BSCS textbook. The standard Green Version BSCS Laboratory Manual was used in association with the classroom text.

In addition to the main text and laboratory manual, the following books and printed material were used to supplement the main text.

HARD BOUND BOOKS:

Eckert, Allan W. _Wild Season_. Boston: Little, Brown and Company, 1967.

Lyons, C. P. Trees, _Shrubs and Flowers to know in Washington_. Toronto: J. M. Dent and Sons (Canada) Limited, 1956.

Miller, William B. and Carol Leth (ed.). _BSCS Green Version High School Biology_. Second Edition. Chicago; Rand McNally and Company, 1968.

MANUALS:

Lawson and Paulson (ed.). Green Version Laboratory and Field Studies In Biology. New York: Holt, Rinehart and Winston, Incorporated, 1960.

Van Norman, Richard W. Blue Version Laboratory Investigations. Utah: Department of Experimental Biology, University of Utah.

PAMPHLET:

Nagel, Werner C. (ed.). Habital Improvement, Key to Game Abundance. Washington, D.C.: National Wildlife Federation, 1956.

UNPUBLISHED MATERIAL AND REPRINTS:

Department of Game. Wildlife, Crop of the Land. Olympia, Washington: Washington State Department of Game.

"Animal Arithmetic", Nature and Science, Volume 3, February 21, 1966.

"How to Make and Read a Graph", Program S-17.

A brief summary of the approximate time and number of different classroom methods used by the BSCS instructor is as follows:

CATEGORY	NUMBER	PERCENT
*Laboratory exercises	40	30
Films and slide sets	30	15
Discussions	--	12
*Field observations	23	10
Demonstrations	20	10
Lectures	--	10
*Projects (Individual observations) (1 major)	3	5
Study time	--	7
Free time	--	3
	TOTAL	100%

*It should be noted that the BSCS instructor feels that these categories should be considered as one, totaling approximately 45%, but for purposes of comparison, the investigator has separated them.

II. GROUPS STUDIED

ECO. The seventy ECO eighth grade pupils were selected from one hundred and twenty-one enrolled ECO pupils. Twenty-three of the ECO pupils eliminated themselves either by withdrawal from the course, or by being absent when the post-test was given. Of the ninty-eight pupils that took both the pre-test and the post-test, seventy were randomly selected by alphabetizing all pupils and eliminating every third pupil from the study. The ECO population was limited to seventy, in order to match the BSCS population. The ECO test population comprised approximately seventeen percent of the total eighth grade population at Covington Junior High School. The ECO test population was not heterosexually balanced with forty-seven boys and twenty-three girls.

All ECO pupils had received a semester of seventh grade physical science. The first semester ECO pupils had limited instruction in life science. Thirty-five percent completed a nine week life science course that semester. Of the second semester ECO pupils, fifty-four percent took life science concurrently and the remaining forty-six percent had taken the life science course during the first semester. The life science course is not ecologically oriented.

<u>BSCS</u>. Of the original eighty-four BSCS pupils that began the course in September, 1970, seventy finished. The fourteen pupils were eliminated either by absence during post-testing or by withdrawal from the course during the year. The BSCS population used in the study was thought to be a random sample, because the BSCS course was required for all

tenth grade pupils at Camas High School. The BSCS heterosexually balanced group composed of thirty-three girls and thirty-seven boys comprised approximately twenty-five percent of the total tenth grade population at Camas High School. These pupils had received very little instruction in life science during their one year study of general science in the ninth grade.

III. THE PRE- AND POST-TEST

The Ecology Achievement Test used in pre-testing and post-testing of all groups consisted of thirty-nine multiple choice items (see Appendix C). Each item had four foils. The test items were selected from four nationally standardized BSCS tests (copyright 1968) constructed by the BSCS Test Construction Committee. Of the one hundred and eight questions contained in the four tests, only sixty-five questions dealt with ecological ideas. Two members of the thesis committee checked the subject matter content of the sixty-five test items. The investigator randomly selected thirty-nine test items for use on both the pre-test and the post-test. The tests were administered to the classes by the regular teachers. Both teachers held to similar conditions with respect to preventing cheating; to providing test information; and to giving aid to pupils. There was no penalty for guessing. A forty-seven minute time period was allowed for testing. The test results were machine scored by the Clark College Data Processing Center, Vancouver, Washington, and the major analysis of the scores was done with the computer at the same institution.

IV. ANALYTICAL PROCEDURES

The following analysis operations were used to measure the achievement of the ECO and BSCS groups.

1. An item analysis of the test was made by using the top and bottom quartiles of the post-test scores made by the ECO and BSCS groups.
2. Standard deviations and means for the pre-test and post-test scores for both the ECO and BSCS groups were calculated.
3. To find out if significant score increase occured from pre-testing to post-testing for each group the following was determined:
   a. The t value for the difference between the means of the ECO pre-test and post-test. The Product Moment Correlation Coefficient (r) for this large correlated sample was calculated.
   b. The t value for the difference between the means of the BSCS pre-test and post-test. The Product Moment Correlation Coefficient (r) was calculated.

4. To find out if a significant difference between the ECO and BSCS pre-test scores existed the t value for the difference between their means was calculated.
5. The t value for the difference between the ECO and BSCS post-test means was calculated to find out if a significant difference remained after each course was taught to the respective groups.
6. I.Q. scores were obtained for both the ECO and BSCS populations and the means of each group was determined.
   a. I.Q. scores for the ECO pupils, taken from the Otis Lenin Test, were obtained by permission of the principal Mr. Mack Fairbanks from the Covington Junior High School accumulative records.
   b. The BSCS pupil's I.Q. scores, taken from the California Mental Maturity Test, were obtained by permission of the high school principal Mr. Ron Whitiker from the Camas High School accumulative records.

The actual presentation of data for the above mentioned procedures will be presented in chapter four.

CHAPTER IV

RESULTS OF THE STUDY

The degree of understanding achieved by the ECO and BSCS groups were measured by means of pre-testing and post-testing each group. An analysis of the measuring instrument was made by comparing the correct responses of pupils in the top and bottom quartiles. The quartile scores were earned on the post-test by both groups. This was done to determine if the test items were discriminatory. A standard procedure was used for identifying the degree of discrimination of the test items. The results of this analysis, found in Tables I and II, pages 31 and 32, indicated that the test was a fair discriminatory instrument.

A summary was made in Table III, page 33, of the pre-test and post-test results with respect to ranges, means, and standard deviations for both the ECO and BSCS groups. The increase in the means, ranges and standard deviations of both groups was evident. The significance of these increases was treated in four separate tables.

In Table IV, page 34, the t value for the significance of the difference between the pre-test and post-test means for the ECO group has been provided and the method used in calculating the t value was presented. The t value showed that a substantial increase occured in the mean from pre-testing to post-testing with a significance at the .0027 level of confidence. The t value for the significance of the difference between the pre-test and post-test means for the BSCS group was calculated in the same manner. The gain made by the BSCS group was also significant at the .0027 level of confidence. However, the gain as shown in Table V, page 35 was much less than that made by the ECO group.

The t value for the significance of the difference between the ECO and BSCS pre-test means was calculated and the results recorded in Table VI, page 36. The process used to determine this t value is also shown. The difference between the means was significant at the .0027 level of confidence. The t value for the significance of the difference between the ECO and BSCS post-test means was determined in the same way and recorded in Table VII, page 37. The results were significant at the .16 level of confidence. The results showed that there is no significant difference between the means of the groups on the post-test. It is obvious, therefore, that the difference in increase of the means from pre-testing to post-testing was significantly greater for the ECO group.

A comparison was made of the I.Q. scores to determine if there were any differences in I.Q. between the ECO and BSCS groups. The results of the Otis Lenin I.Q. Test given to the ECO group, found in Table VIII, page 38, were given during their seventh grade year. The scores from the California Mental Maturity Test, given in Table IX, page 39 were given during the current school year. Because the difference between the means of the I.Q. scores of both groups was small (four points), it was assumed that both groups were nearly equal in mental ability.

TABLE I

ITEM ANALYSIS OF POST-TEST RESULTS FOR ECO GROUP

Item	Disc. Value	Top Quartile Right	Top Quartile Wrong	Bottom Quartile Right	Bottom Quartile Wrong
1	.22	15	3	11	7
2	.60	16	2	5	13
3	.22	13	5	9	9
4	.45	14	4	6	12
5	.05	6	12	5	13
6	.45	10	8	2	16
7	.77	17	1	3	15
8	.28	14	4	9	9
9	.34	14	4	8	10
10	.60	16	2	5	13
11	.45	10	8	2	16
12	.28	12	6	7	11
13	.45	10	8	2	16
14	.48	13	5	5	13
15	.05	5	13	4	14
16	.39	9	9	2	16
17	.05	4	14	3	15
18	.39	10	8	3	15
19	.22	10	8	6	12
20	.34	12	6	6	12
21	.05	6	12	5	13
22	.50	17	1	8	10
23	.50	18	0	9	9
24	.11	2	16	0	18
25	.22	15	3	11	7
26	.17	4	14	7	11
27	.45	13	5	5	13
28	.28	8	10	3	15
29	.05	7	11	6	12
30	.22	10	8	6	12
31	.45	15	3	7	11
32	.22	9	9	5	13
33	.60	15	3	4	14
34	.34	9	9	3	15
35	.05	8	10	7	11
36	.50	12	6	3	15
37	.45	15	3	7	11
38	.17	10	8	7	11
39	.28	10	8	5	13

$$\frac{\text{Top right}}{n} - \frac{\text{Bottom right}}{n} = \text{Discrimination value}$$

30 - good items = .20-.80
3 - fair items = .10-.19 and .81-.90
6 - poor items below .10

TABLE II

ITEM ANALYSIS OF POST-TEST RESULTS FOR BSCS GROUP

Item	Disc. Value	Top Quartile Right	Top Quartile Wrong	Bottom Quartile Right	Bottom Quartile Wrong
1	.22	16	2	12	6
2	.50	17	1	8	10
3	.45	17	1	9	9
4	.39	16	2	9	9
5	.34	14	4	8	10
6	.72	17	1	4	14
7	.66	17	1	5	13
8	.45	16	2	8	10
9	.77	17	1	3	15
10	.39	16	2	9	9
11	.56	14	4	4	14
12	.50	11	7	2	16
13	.34	9	9	3	15
14	.50	11	7	2	16
15	.34	10	8	4	14
16	.45	13	5	5	13
17	.28	9	9	4	14
18	.05	6	12	5	13
19	.56	13	6	3	15
20	.22	9	9	5	13
21	.45	13	5	5	13
22	.39	16	2	9	9
23	.39	18	0	11	7
24	.17	3	15	0	18
25	.56	17	1	7	11
26	.11	4	14	2	16
27	.22	9	9	5	13
28	.17	7	11	4	14
29	.45	10	8	2	16
30	.72	17	1	4	14
31	.60	16	2	5	13
32	.66	15	3	3	15
33	.56	17	1	7	11
34	.28	8	10	3	15
35	.17	7	11	4	14
36	.45	16	2	8	10
37	.05	13	5	12	6
38	.45	13	5	5	13
39	.39	16	2	9	9

$$\frac{\text{Top right}}{n} - \frac{\text{Bottom right}}{n} = \text{Discrimination value}$$

33 - good items = .20-.80
4 - fair items = .10-.19 and .81-.90
2 - poor items below .10

TABLE III

RANGES, MEANS AND STANDARD DEVIATIONS
FOR ECO AND BSCS PRE-TESTS
AND POST-TESTS

GROUP	ECO (n=70)		BSCS (n=70)	
TEST	pre-test	post-test	pre-test	post-test
RANGE	10-49	18-72	18-69	13-85
MEAN	30	45	43	52
SD	9	12	12	16

TABLE IV

COMPARISON OF ECO PRE-TEST AND ECO POST-TEST MEANS

TEST	PRE-TEST (X)	POST-TEST (Y)
RANGE	10-49	18-72
MEAN	$\overline{X} = 30$	$\overline{Y} = 45$
*STANDARD DEVIATION	$S_x = 9$	$S_y = 12$
STANDARD ERROR OF THE MEANS	$S_{\overline{X}} = 1.08$	$S_{\overline{Y}} = 1.44$
STANDARD ERROR OF DIFFERENCE BETWEEN MEANS	$S_{DIFF.} = 1.31$	
PRODUCT-MOMENT CORRELATION COEFFICIENT	$r_{XY} = .49$	
t value	t = 11.4 (significant at .0027 level of confidence with 69 degrees of freedom)	

*n = 70

$$S_{\overline{X}} = \frac{Sx}{\sqrt{n_x - 1}}$$

$$r_{XY} = \frac{\Sigma xy}{\Sigma x^2 \cdot \Sigma y^2}$$

$$S_{DIFF.} = \sqrt{(S_{\overline{X}})^2 + (S_{\overline{Y}})^2 - 2r_{XY}S_{\overline{X}}S_{\overline{Y}}}$$

$$t = \frac{Y - X}{S_{DIFF.}}$$

TABLE V

COMPARISON OF BSCS PRE-TEST AND BSCS POST-TEST MEANS

TEST	PRE-TEST (X)	POST-TEST (Y)
RANGE	18-69	13-85
MEAN	$\overline{X} = 43$	$\overline{Y} = 52$
*STANDARD DEVIATION	$S_x = 12$	$S_y = 16$
STANDARD ERROR OF THE MEANS	$S_{\overline{X}} = 1.44$	$S_{\overline{Y}} = 1.9$
STANDARD ERROR OF DIFFERENCE BETWEEN MEANS	$S_{DIFF.} = 1.34$	
PRODUCT-MOMENT CORRELATION COEFFICIENT	$r_{XY} = .71$	
t value	t = 6.7 (significant at .0027 level of confidence with 69 degrees of freedom)	

*n = 70

SEE FORMULAS IN TABLE IV

TABLE VI

COMPARISON OF ECO PRE-TEST MEAN
TO THE BSCS PRE-TEST MEAN

TEST	ECO PRE-TEST (X)	BSCS PRE-TEST (Y)
RANGE	10-49	18-69
MEAN	$\overline{X} = 30$	$\overline{Y} = 43$
*STANDARD DEVIATION	$S_x = 9$	$S_y = 12$
STANDARD ERROR OF THE MEANS	$S_{\overline{X}} = 1.08$	$S_{\overline{Y}} = 1.44$
STANDARD ERROR OF DIFFERENCE BETWEEN MEANS	$S_{DIFF.} = 1.8$	
t value	t = 7.2 (significant at .0027 level of confidence with 69 degrees of freedom)	

*n = 70

$$S_{\overline{X}} = \frac{Sx}{\sqrt{n_x - 1}}$$

$$S_{DIFF.} = \sqrt{(S_{\overline{X}})^2 + (S_{\overline{Y}})^2}$$

$$t = \frac{\overline{Y} - \overline{X}}{S_{DIFF.}}$$

TABLE VII

COMPARISON OF ECO POST-TEST MEAN
TO THE BSCS POST-TEST MEAN

TEST	ECO POST-TEST (X)	BSCS POST-TEST (Y)
RANGE	18-72	13-85
MEAN	$\overline{X} = 45$	$\overline{Y} = 52$
*STANDARD DEVIATION	$S_x = 12$	$S_y = 16$
STANDARD ERROR OF THE MEANS	$S_{\overline{X}} = 1.44$	$S_{\overline{Y}} = 4.3$
STANDARD ERROR OF DIFFERENCE BETWEEN MEANS	$S_{DIFF.} = 4.23$	
t value	t = 1.41 (significant at .16 level of confidence with 69 degrees of freedom)	

*n = 70

SEE FORMULAS IN TABLE VI

TABLE VIII

I.Q. SCORES AND THE MEAN OF THE ECO POPULATIONS

PUPIL NO.	I.Q. X	PUPIL NO.	I.Q. X	PUPIL NO.	I.Q. X
1	97	24	96	48	108
2	98	25	90	49	80
3	91	26	100	50	103
4	104	27	105	51	103
5	96	28	110	52	130
6	110	29	98	53	97
7	115	30	130	54	91
8	96	31	103	55	109
9	96	32	87	56	88
10	109	33	96	57	101
11	89	34	88	58	107
12	103	35	96	59	128
13	107	36	108	60	101
14	108	37	81	61	113
15	123	38	101	62	113
16	101	39	102	63	91
17	108	40	113	64	100
18	106	41	120	65	123
19	107	42	100	66	104
20	90	43	97	67	108
21	115	44	107	68	90
22	108	45	88	69	98
23	89	46	101	70	102
		47	118		

$\Sigma X = 7302$ $n = 70$ MEAN $= \bar{X} = \frac{\Sigma X}{n} = \frac{7302}{70} = 104$

RANGE 81-130

TABLE IX

I.Q. SCORES AND THE MEAN OF THE BSCS POPULATIONS

PUPIL NO.	I.Q. Y	PUPIL NO.	I.Q. Y	PUPIL NO.	I.Q. Y
1	109	24	117	48	114
2	131	25	123	49	104
3	110	26	108	50	132
4	116	27	111	51	109
5	123	28	119	52	96
6	111	29	109	53	117
7	81	30	120	54	129
8	126	31	79	55	100
9	109	32	127	56	80
10	109	33	124	57	118
11	72	34	129	58	122
12	125	35	116	59	106
13	110	36	123	60	117
14	129	37	87	61	100
15	112	38	123	62	95
16	104	39	115	63	107
17	95	40	110	64	113
18	64	41	113	65	120
19	88	42	87	66	125
20	81	43	100	67	126
21	73	44	112	68	74
22	103	45	118	69	116
23	116	46	104	70	100
		47	96		

$\Sigma Y = 7585 \quad n = 70 \quad \text{MEAN} = \bar{Y} = \frac{\Sigma Y}{n} = \frac{7585}{70} = 108$

RANGE 64-132

CHAPTER V

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

I. SUMMARY

Purpose of the study. The study had two major purposes. One purpose was to determine if Covington Junior High School eighth grade pupils understood the basic ecological ideas and facts presented to them in a teacher-designed one semester course entitled Environmental Concepts Orientation (ECO). The second purpose was to find out the degree of competence attained by the eighth grade pupils as compared to tenth grade pupils taking a one year ecologically oriented course in the nationally developed Green Version BSCS biology series at Camas, Washington.

Hypothesis. The hypothesis of this study was that eighth grade pupils in the teacher-designed course situation could learn basic ecological facts and ideas as well as tenth grade pupils in the Green Version BSCS course situation.

Procedure. The study lasted one school year during which four one semester ECO classes from Covington Junior High School were compared with four BSCS classes from Camas High School for their abilities to understand basic ecological facts and ideas. The degree of their understanding and achievement was measured with the use of an objective thirty-nine question test used as both a pre-test and post-test.

The test was developed from questions taken from the BSCS nationally standardized four quarter tests.

Standard deviations for all tests, the product-moment correlation coefficients for reliability between the pre-test and post-test scores for each group was calculated and the t test for significance of these analysis were done as measures of pupil achievement. An analysis of the measuring instrument was made to determine the discriminatory value of the items. The I.Q. scores for both groups were obtained to determine the mental abilities of the ECO and BSCS groups.

Results of the study. Results of the item analysis for the ECO group and the BSCS group showed that for both groups thirty or more questions are considered good discriminators. Three to four questions for each group were fair questions and two to six are considered poor discriminators. These results indicated that the test, generally, was a good discriminatory instrument.

In comparing the achievement made by the ECO group from pre-test to post-test the t results indicated that a positive gain occured at the .0027 level of confidence. The gains made by the BSCS group from pre-test to post-test were also significant at the .0027 level of confidence.

The BSCS group increased an average of nine percent from pre-testing to post-testing and the ECO group increased an average of fifteen percent. The fact that the ECO group made greater gains in their mean score might be attributed to their starting at a lower level. However, there were so many variables which could not be controlled that the cause for the difference in increase of the mean of the ECO group as compared to the BSCS group could not be identified.

A thirteen percent difference between the means of the ECO pre-test and the BSCS pre-test is significant at the .0027 level of confidence.

A seven percent difference between the means of the ECO post-test and the BSCS post-test is significant at the .16 level of confidence.

The difference between the means of the I.Q. scores of the two groups indicated there was no major difference in their mental ability.

II. CONCLUSIONS

The hypothesis for this study was accepted. The statistical results showed that an unselected group of eighth grade pupils at Covington Junior High School, taking the teacher-designed course, could understand basic ecological facts and ideas with a competence approximately equal to that of unselected tenth grade pupils, taking the nationally developed Green Version BSCS biology series, at Camas High

School.

From these results it can be concluded that ecological concepts presently taught in the BSCS biology course need not be restricted to the high school level.

III. RECOMMENDATIONS

The investigator recommended that this study be repeated to test its reliability. However, several additional controls should be added. Such controls might include using eighth and tenth grade classes; subjecting the experimental groups to similar teaching styles; having one teacher teach all experimental groups; using identical content, and providing a similar classroom environment. A variation of this study could compare a selected group of fifth or sixth grade pupils to an eighth, ninth or tenth grade group.

From the results of this study, from results of research found in the literature, and from observed reaction of pupils in the ECO course, and from written evaluation by pupils it is recommended that the Environmental Concepts Orientation Course (ECO) be continued and that more pupils be encouraged to take the course at Covington Junior High School. Pupils who have not received significant instruction in ecology prior to senior high school should be strongly encouraged, if not required, to become involved with such subject matter in order that they may make better decisions related to man's survival.

BIBLIOGRAPHY

1. Ausubel, David P. "Can Children Learn Anything That Adults Can and More Efficiently?", Elementary School Journal, 62:171-172, February, 1962.

2. Bennett, Lloyd M. "The Present Plight of Junior High School Science", Science Education, 49:468-476, December, 1965.

3. Bianchi, Ennio. "Report on Two Courses in Chemistry Taught at Craigin Elementary School", Science Education, 55:5-14, January-March, 1971.

4. Blane, S. S. "Achievement in General Biology of Ninth Grade Pupils Compared with Tenth, Eleventh and Twelfth Graders", Science Education, 46:496-498, December, 1962.

5. Burkey, Betty and William Asher. "A Comparison of Ninth Grade Accelerated Students and a Group of Tenth Grade Students in Their Ability to Comprehend Biology", Journal of Research in Science Teaching, 3:66-71, March, 1965.

6. Carlson, Jerry S. "Developmental Psychology and It's Implications for Science Education", Science Education, 51:246-250, April, 1967.

7. Inhelder, B. and J. Piaget. "The Growth of Logical Thinking", New York Basic Books, United States of America, 1958, pp. 356.

8. Johnson, Lloyd K. "A Comparison of Understandings of Selected Principles of Physics Developed by Students at Three Levels of Instruction", Science Education, 49:123-126, March, 1965.

9. Kolb, Haven. "The Role of Secondary Education in Solving Environmental Problems", The American Biology Teacher, 33:214, April, 1971.

10. Mathes, George E. and Sam Blanc. "Biology Achievement in Grades 9-10", Science Teacher, 27:23-26, March, 1960.

11. Marland, Jr., S. P. "Environmental Education Cannot Wait", American Education, 7:6-10, May, 1971.

12. Odum, Eugene P. Ecology. 2d ed. Philadelphia: W. B. Sanders Company, 1959.

13. Shrader, John S. "The Understanding of Selected Principles of College Chemistry by Intermediate Grade Pupils", Science Education, 52:196-203, March, 1968.

14. Singer, Fred S. "Education for Today's Ecological Crisis", Science Education, 54:349, October-December, 1970.

15. Smith, Milton G. A Simplified Guide to Statistics. 3d ed. New York: Holt, Rinehart and Winston, Incorporated, 1962.

16. Tagatz, Glenn E., Elmer A. Lemke, and Dean M. Meinke. "The Relationships Between Learning Concepts and Student Achievement", Cooperative Research Project Number S-493, Indiana State University, 1966, pp. 1-104.

17. Walters, Louis L. "Ninth Versa Tenth Grade Biology - A Comparison of Achievement", Journal of Research in Science Teaching, 1:170-176, June, 1963.

18. Walters, Louis L. "Ninth Versa Tenth Grade Biology - A Follow-up Study", Journal of Research in Science Teaching, 3:230-234, September, 1965.

19. Weir, Morton W. "Age and Memory as Factors in Problem Solving", Center for Human Growth and Development Michigan University, Ann Arbor, Report No. UM-CHGH-8, November 30, 1965, pp. 1-19.

20. Wise, Harold E. "A Comparison of the Effectiveness of Courses at Three Levels of Instruction in Developing Understandings of Selected Principles of Physics", Science Education, 41:418-424, December, 1957.

APPENDIXS

APPENDIX A

SCORES FOR ECO GROUP PRE-TEST AND POST-TEST

PUPIL NO.	PRE- X	POST- Y	DIFF. Y-X	x	y	x^2	y^2	xy
1	23	54	31	- 7	9	49	81	- 63
2	31	38	7	1	- 7	1	49	- 7
3	21	38	17	- 9	- 7	81	49	63
4	21	28	7	- 9	-17	81	289	153
5	26	41	15	- 4	- 4	16	16	16
6	18	38	20	-12	- 7	144	49	84
7	41	59	18	11	14	121	196	154
8	36	38	2	6	- 7	36	49	- 42
9	46	64	18	16	19	256	361	304
10	15	36	21	-15	- 9	225	81	135
11	31	41	10	1	- 4	1	16	- 4
12	41	38	- 3	11	- 7	121	49	- 77
13	38	56	18	8	11	16	121	88
14	28	38	10	- 2	- 7	4	49	14
15	31	54	23	1	9	1	81	9
16	49	54	5	19	9	361	81	171
17	21	51	30	- 9	6	81	36	- 54
18	21	51	30	- 9	6	81	36	- 54
19	26	59	33	- 4	14	16	196	- 56
20	23	36	13	- 7	- 9	49	81	63
21	44	62	18	14	17	196	289	238
22	23	49	26	- 7	4	49	16	- 28
23	10	33	23	-20	-12	400	144	240
24	18	36	18	-12	- 9	144	81	108
25	33	26	- 7	3	-19	9	361	- 57
26	21	41	20	9	- 4	81	16	36
27	41	59	18	11	14	121	196	155
28	21	36	15	- 9	- 9	81	81	81
29	26	41	15	- 4	- 4	16	16	16
30	41	72	31	11	27	121	729	297
31	28	41	13	- 2	- 4	4	16	8
32	23	28	5	- 7	-17	49	289	119
33	10	28	18	20	-17	400	289	340
34	23	28	5	- 7	-17	49	289	119
35	31	36	5	1	- 9	1	81	- 9
36	44	59	15	14	14	196	196	196
37	31	28	- 3	1	-17	1	289	- 17
38	31	31	0	1	-14	1	196	- 14
39	26	49	23	- 4	4	16	16	- 16
40	41	67	26	11	22	121	484	242

APPENDIX A (continued)

PUPIL NO.	PRE-X	POST-Y	DIFF. Y-X	x	y	x^2	y^2	xy
41	33	64	31	3	19	9	361	57
42	36	33	- 3	6	-12	36	144	- 72
43	31	38	7	1	- 7	1	49	- 7
44	36	64	18	6	19	36	361	114
45	23	38	15	- 7	- 7	49	49	49
46	23	44	21	- 7	1	49	1	7
47	23	38	15	- 7	- 7	49	49	49
48	28	44	16	- 2	- 1	4	1	2
49	31	18	-13	1	-27	1	729	- 27
50	13	44	31	-17	1	289	1	17
51	33	62	29	3	17	9	289	51
52	31	59	28	1	14	1	196	14
53	36	33	- 3	6	-12	36	144	- 72
54	26	46	20	- 4	1	16	1	- 4
55	36	49	13	6	4	36	16	24
56	26	38	12	- 4	- 7	16	49	28
57	36	49	13	6	4	36	16	24
58	33	56	23	3	11	9	121	33
59	46	64	18	16	19	256	361	304
60	23	49	26	- 7	4	49	16	- 28
61	38	49	11	8	4	64	16	32
62	49	62	13	19	17	361	289	323
63	26	41	15	- 4	4	16	16	16
64	26	38	12	4	- 7	16	49	28
65	33	56	23	3	11	9	121	33
66	36	41	5	6	- 4	36	16	- 24
67	38	49	11	8	4	64	16	32
68	38	18	-20	8	-27	64	729	-216
69	28	28	0	- 2	-17	4	289	34
70	28	44	16	- 2	1	4	1	2

APPENDIX B

SCORES FOR BSCS GROUP PRE-TEST AND POST-TEST

PUPIL NO.	PRE- X	POST- Y	DIFF. Y-X	x	y	x^2	y^2	xy
1	38	49	11	- 5	- 3	25	9	15
2	56	62	6	13	10	169	100	130
3	49	56	7	6	4	36	16	24
4	33	31	- 2	-10	-21	100	441	210
5	44	59	15	1	7	1	49	7
6	41	15	-26	- 2	-37	4	1369	74
7	31	21	-10	-12	-31	144	961	372
8	51	67	16	8	15	64	225	120
9	44	51	7	1	- 1	1	1	- 1
10	41	56	15	- 2	4	4	16	- 8
11	26	15	-11	-17	-37	289	1369	629
12	46	67	21	3	15	9	225	45
13	28	26	- 2	-15	-26	225	676	390
14	69	67	- 2	26	15	676	225	390
15	36	51	15	- 7	- 1	49	1	7
16	46	67	21	3	15	9	225	45
17	38	54	16	- 5	2	25	4	- 10
18	26	26	0	-17	-26	289	676	442
19	33	49	16	-10	- 3	100	9	30
20	21	18	- 3	-22	-34	484	1156	748
21	38	41	3	- 5	-11	25	121	55
22	44	41	- 3	1	-11	1	121	- 11
23	54	59	5	11	7	121	49	77
24	59	85	16	16	33	256	1089	528
25	62	69	7	19	17	361	289	316
26	38	44	6	- 5	- 8	25	64	40
27	44	56	12	1	4	1	16	4
28	41	51	10	- 2	- 1	4	1	2
29	38	59	21	- 5	7	25	49	- 35
30	36	49	13	- 7	- 3	49	9	21
31	28	41	13	-15	-11	225	121	165
32	49	49	0	6	- 3	36	9	- 18
33	51	64	13	8	12	64	144	96
34	59	67	8	16	15	256	225	240
35	62	74	12	19	22	361	484	418
36	67	82	15	24	30	576	900	720
37	33	36	3	-10	-16	100	256	160
38	41	59	18	- 2	7	4	49	- 14
39	51	67	16	8	15	64	225	120
40	59	59	0	16	7	256	49	112

APPENDIX B (continued)

PUPIL NO.	PRE- X	POST- Y	DIFF. Y-X	x	y	x^2	y^2	xy
41	18	49	31	-25	- 3	625	9	75
42	44	54	10	1	2	1	4	2
43	31	46	15	-12	- 6	144	36	72
44	44	67	23	1	15	1	225	15
45	49	59	10	6	7	36	49	42
46	38	54	16	- 5	2	25	4	- 10
47	31	56	25	-12	4	144	16	- 48
48	54	51	- 3	11	- 1	121	1	- 11
49	49	59	10	6	7	36	49	42
50	51	72	21	8	20	64	400	160
51	38	51	13	- 5	- 1	25	1	5
52	46	51	5	3	- 1	9	1	- 4
53	49	56	7	6	4	36	16	24
54	18	51	33	-25	- 1	625	1	25
55	62	77	15	19	25	361	625	475
56	28	54	26	-15	2	225	4	- 30
57	46	41	- 5	3	-11	9	121	- 33
58	67	67	0	24	15	576	225	360
59	36	23	-13	- 7	-29	49	841	203
60	64	67	3	21	15	441	225	315
61	36	44	8	- 7	- 8	49	64	56
62	28	46	18	-15	- 6	225	36	90
63	49	54	5	3	2	9	4	6
64	51	64	13	8	12	64	144	96
65	41	62	21	- 2	10	4	100	- 20
66	54	64	10	11	12	121	144	132
67	28	54	26	-15	2	225	4	- 30
68	31	13	-18	-12	-39	144	1521	468
69	41	51	10	- 2	- 1	4	1	2
70	51	56	5	8	4	64	16	32

APPENDIX C

ECOLOGY ACHIEVEMENT TEST

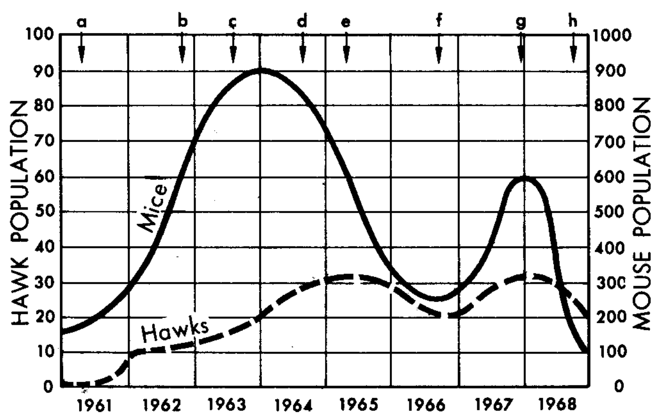
Questions 1-3 are based upon the following information: In a certain region the eyes of deer are parasitized by flies. Assume that the "eye-flies" can live only as parasites on the eyes of the deer. The principal food in the diet of the deer is blueberry bushes.

1. What is the food chain in this situation:
   (A) Producer: blueberries. First-order consumer: deer. Second-order consumer: "eye-flies"
   (B) Producer: "eye-flies" First-order consumer: deer. Second-order consumer: Blueberries.
   (C) Producer: sun. First-order consumer: deer. Second-order consumer: "eye-flies"
   (D) Producer: sun. First-order consumer: blueberries. Second-order consumer: deer

2. An oriental beetle that feeds only on "eye-flies" is now brought into the region. If the beetles thrive, what will be the probable effect on the organisms in the food chain?
   (A) The deer population will increase.
   (B) The blueberry population will increase.
   (C) The "eye-fly" population will increase.
   (D) All populations other than the beetle population will decrease.

3. Assume that the beetles kill all the "eye-flies" in the region. It could be reasonably predicted that the
   (A) blueberry population will increase in proportion to the beetle population.
   (B) beetle population will increase in proportion to the deer population.
   (C) deer population will increase to the limit of its food supply.
   (D) deer population will decrease.

Questions 4-7 are based upon the following information: On a newly formed island successful populations of grasses and a species of mouse appeared. Later a species of hawk flew in. The population levels of mice and hawks are represented below.



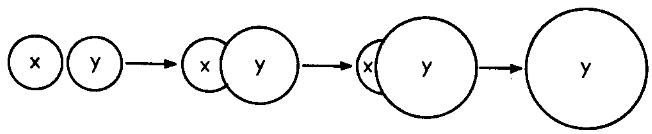
4. The increase in numbers of mice beginning at a was most probably due to an increase in which of the following?
(A) Parasites
(B) Predators
(C) Producers
(D) Emigration

5. If emigration was a major factor in causing changes in the population of mice, it most likely began at times represented by points
(A) c and g.
(B) e and f.
(C) e, g, and h.
(D) d, e, f and h.

6. A parasite infection that reduced mouse and hawk populations is most likely to have begun at the point represented by
(A) a.
(B) c.
(C) f.
(D) g.

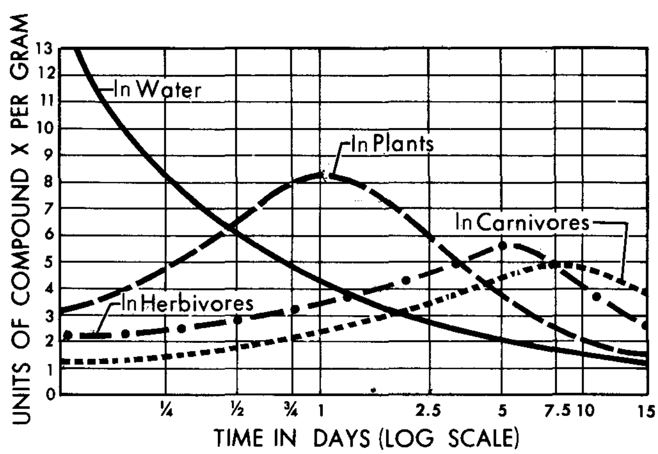
7. Of the following possibilities, which is most likely to have caused the change in the size of the mouse population between a and c?
(A) Natality increased and mortality decreased.
(B) Natality decreased and mortality increased.
(C) Natality decreased and mortality decreased.
(D) Natality unchanged and mortality increased.

8. The best evidence that two populations belong to the same species is that they have
(A) similar characteristics
(B) infertile offspring produced from interbreeding in captivity.
(C) the same niche requirements.
(D) fertile offspring produced under natural conditions.



9. If the diagram represents populations X and Y, then the sequence shown is best described as
(A) mutalism
(B) a habitat
(C) an ecosystem
(D) succession

Questions 10-12 are based upon the following information:



The graph presents data from an experiment in which compound X was put into an aquarium at 0 days.

10. By the second day, the CONCENTRATION of compound X is greatest in the
    (A) water
    (B) producers
    (C) first-order consumers
    (D) second-order consumers

Questions 11-12 are also based on the following explanations for differences in CONCENTRATION of compound X:

I. Uptake and concentration of compound X by producers.
II. Uptake and concentration of compound X by first-order consumers.
III. Elimination of compound X through insoluable waste products and dead organisms.

11. The decrease in the CONCENTRATION of compound X in the water can best be explained by
    (A) II only.
    (B) III only.
    (C) II and III only.
    (D) I and II only.

12. The changes in the CONCENTRATION of compound X during the first two hours are apparently the result of
    (A) I only.
    (B) II only.
    (C) I and II only.
    (D) I, II, and III.

Questions 13-15 are based on the following information about pathways that energy may take when leaving a given level in the ecosystem:

I. Energy goes to the next higher level in the food web.
II. Energy goes to saprovores.
III. Energy goes to the atmosphere through conversion of food to heat energy.
IV. Energy goes to the atmosphere in ways other than by conversion of food to heat energy.

13. Which pathways may energy follow in reaching a third-order consumer directly?
    (A) I and II
    (B) II and III
    (C) III and IV
    (D) I, II, and III

14. Which pathways can energy of producers follow so that it becomes available to herbivores?
    (A) I only
    (B) I and III only
    (C) I, II, and III only
    (D) II, III, and IVonly

15. Energy entering the biotic community is equal to that which leaves the producers by pathways
    (A) I and III only.
    (B) I and IV only.
    (C) II and IV only.
    (D) I, II, III and IV.

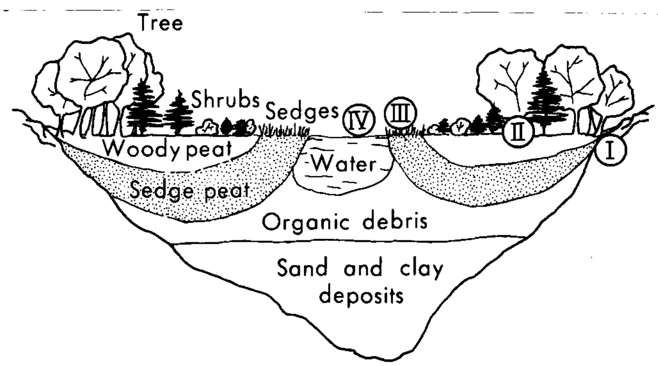
16. After deer predators were killed, the deer in an area increased to a point where they ate up most of the vegetation they could reach. The deer then starved. This is an example of the operation of
   (A) abiotic factors that were independent of the density of the deer.
   (B) biotic factors that were independent of the density of the deer.
   (C) abiotic factors that were dependent upon the density of the deer.
   (D) biotic factors that were dependent upon the density of the deer.

17. Which of the following statements could apply to both an open-sea biome and a grassland biome?
   (A) First order or second-order consumers grow to large size.
   (B) The amount of carbon dioxide available for photosynthesis varies greatly with temperature.
   (C) Most producers are microscopic in size.
   (D) Pressures may be as high as 250 kg per cm^2.

18. The pH of humus is nearest to
   (A) 1.
   (B) 5.
   (C) 8.
   (D) 14.

19. Which of the following would decrease the amount of energy available to the second-order consumers in a pond?
   (A) Increasing light penetration
   (B) Increasing the turbidity of the water
   (C) Removing all third-order consumers
   (D) Maintaining a stable population of producers

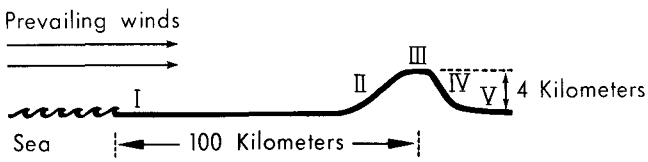
Questions 20-21 are based on the figure below:



20. Which of the following concepts is best represented in the fugre?
   (A) Dispersal
   (B) Succession
   (C) Energy flow
   (D) Spontaneous generation

21. The materials deposited in the peat layer at position II mainly represent
   (A) stored energy.
   (B) energy lost to the biosphere.
   (C) net energy lost between consumer levels in the food web.
   (D) energy stored from excess numbers second-order consumers.

Questions 22-23 are based on the diagram below, which represents the West Coast of the United States:



22. Which location will probably receive the most moisture during a year?
(A) II
(B) III
(C) IV
(D) V

23. Wild cactus plants would most likely be found at
(A) I
(B) II
(C) III
(D) V

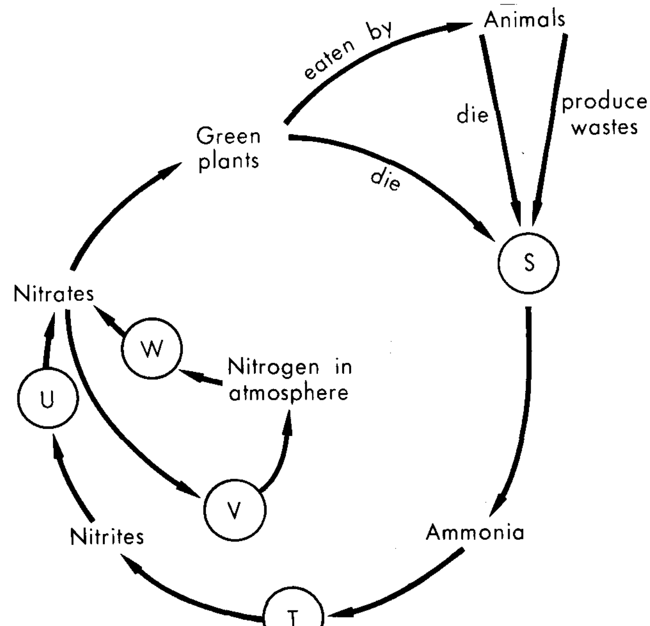
Question 24 is based on the following hypothetical data:

Depth (In Meters)	LAKE TELAGA (TROPICAL) Temperature (in °C)		LAKE LANCASTER (MIDDLE LATITUDE) Temperature (in °C)	
	July 1, 1967	Feb. 1, 1968	July 1, 1967	Feb. 1, 1968
1	27.8	24.4	26.2	0.3
5	26.0	23.7	8.8	2.0
15	24.5	20.2	5.9	4.0
20	24.0	20.0	5.6	4.0

24. The water in Lake Lancaster is most dense at
(A) 1 meter in July.
(B) 20 meters in July.
(C) 5 meters in February.
(D) 15 meters in February.

25. Which of the following pairs of organisms is normally found together in the same habitat?
(A) Moose--cactus
(B) Echinoderms--lichens
(C) Kangaroo rat--spruce
(D) Beaver--cattails

Question 26 is based on the following diagram of the nitrogen cycle: The microorganisms (letters S through W) play a part in the nitrogen cycle.



26. Nitrogen-fixing organisms are represented by
(A) S.
(B) U.
(C) V.
(D) W.

27. The leaves in a forest canopy are equivalent to which of the following in the ocean?
(A) Zooplankton
(B) Coral
(C) Crustacea
(D) Phytoplankton

Question 28 is based on the following information and table: Soil samples from four biomes were dried, and 100 grams of each were soaked with water. The wet soils were weighed and the pH was determined.

Soil	Wet Weight	pH
I	110 grams	7.3
II	140 grams	7.7
III	160 grams	5.7
IV	170 grams	6.9

28. The sample most likely to have come from a sand dune is
    (A) I.
    (B) II.
    (C) III.
    (D) IV.

Questions 29-30 are based on the following situation: Leaves of geranium plants kept in the dark for two days are found to contain no starch. After the plants are exposed to sunlight for a day, tests show that starch is present in the leaves.

Six geranium plants were kept in the dark for two days. Then, for two more days, the plants were treated as noted in the following table. Then the leaves of the plants were tested for starch.

PLANT	TREATMENT	PLACED IN THE:	RESULTS
I	Half of each leaf covered with aluminum foil	Light (entire plant)	Starch present only in exposed halves of leaves
II	Leaf surfaces covered with vaseline	Light (entire plant)	No starch present
III	Plant placed in sealed jar with NaOH solution	Light (entire plant)	No starch present
IV	Leaves removed and leaf stalks placed in glucose solution	Dark (leaves from plant)	Starch present especially along veins of leaves
V	Leaves removed and leaf stalks placed in distilled water	Dark (leaves from plant)	No starch present
VI	None	Dark (entire plant)	No starch present

29. Which of the following is the most reasonable conclusion that can be drawn from the experiment?
    (A) Starch is used only in the dark.
    (B) Starch is used only in the light.
    (C) Removing the leaves stops starch formation.
    (D) Glucose is necessary for starch formation.

30. From the experimental data, it is most reasonable to conclude that plant II
    (A) took in no CO_2.
    (B) took up more water than the other plants.
    (C) gave off more oxygen than the other plants.
    (D) had normally functioning stomates.

Questions 31-32 are based on the following experiment: Leafy shoots of several kinds of plants from different biomes were placed in the same controlled environment, and water loss was measured. The following results were obtained:

PLANT	I	II	III	IV	V
WATER LOST PER MINUTE (in ml)	.05	1.30	.85	.25	1.00

31. With regard to water loss only, which of the following plants is most likely to have come from a tropical rain forest?
(A) I
(B) II
(C) III
(D) IV

32. If a rancher wished to plant vegetation on a large area devoted to storage and conservation of ground water, which of the following plants would be best?
(A) II
(B) III
(C) IV
(D) V

33. If all green plants disappeared, then which of the following substances, found in the atmosphere, would disappear first?
(A) oxygen
(B) nitrogen
(C) water vapor
(D) carbon dioxide

34. The removal of a ring of bark from the trunk of a tree kills the tree primarily because the
(A) supply of food to the roots is cut off.
(B) supply of CO_2 to the leaves is cut off.
(C) supply of water to the leaves is cut off.
(D) trunk loses required strength and protection.

35. Which of the following factors best accounts for the development of a distinct variety of deerfly in each region?
(A) Natural selection
(B) Formation of hybrids
(C) Migration
(D) Random mating

36. The major reason human populations have increased so rapidly in the last 50 years is that
(A) medical knowledge has decreased the number of childless marriages.
(B) mortality has greatly increased.
(C) public health measures have decreased the infant mortality rate.
(D) the number of years during which reproduction can occur has been increased.

37. Human populations first rapidly increased in number when man learned to
(A) control disease.
(B) plant crops.
(C) use machines.
(D) make fire.

38. A wise management program involving our resources would be most likely to succeed if concentrated upon
(A) coal.
(B) oil.
(C) timber.
(D) iron ore.

Question 39 refers to an area that at present contains a middle-latitude deciduous forest. This area has 102 cm of rainfall per year, with cold winters and summers.

For question 39 assume that a lumbering company cut all the trees from the area. The area was then left undisturbed:

39. Which of the following would most probably occur?
    (A) Soil erosion would be decreased.
    (B) The number of annual weeds would begin to decrease.
    (C) The total number of animal species would immediately begin to increase.
    (D) The total number of shrubs would increase.