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Changed Teaching Method Affects Outcome:
Ecology and a Stream

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Howard J. Hagerman
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CHANGED TEACHING METHOD AFFECTS OUTCOME:
ECOLOGY AND A STREAM

By

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ABSTRACT

CHANGED TEACHING METHOD AFFECTS OUTCOME: ECOLOGY AND A STREAM

By

Wayne Gilbert Miller

Students often fail to learn Science with understanding. Either they misunderstand their teacher and text book, or they just memorize enough facts and definitions to get by (Berkheimer, 1990). Changing the method of instruction in an Advanced Biology class should produce improved understanding. The general topic is ecology as studied through the described activities relating to the water quality of Huntoon Creek. By using concept mapping, pre and post testing, multiple activities (creative ecological collage, computer simulations, classroom aquatic ecosystems, lab practice techniques, on-site water quality stream analysis and a culminating booklet of the study by the student, clinical interviews and revised lesson plans), there was a measurable increase in knowledge and understanding of ecology and water quality. This is shown with test data from the previous four years, pre and post testing and clinical interview results. Experiencing the real world and its problems through field trips (hydroelectric power plant, fish weir and waste water treatment plant) helped connect book knowledge to personal experience.

ACKNOWLEDGEMENTS

I would like to especially thank my wife, Dottie, and family for their patience and consideration. A special friend, Denise Weber, deserves thanks for the many hours of typing.

Were it not for the caring group of Dr. Clarence Suelter, Dr. Merle Heidemann, Dr. Martin Hetherington and Dr. Howard Hagerman and their science program for teachers, I would not have had this opportunity.

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INTRODUCTION

Students often fail to learn science with understanding; they either misunderstand their teacher and text books, or they just memorize enough to get by (Berkheimer, 1990). Because science is so complex, no individual can hope to understand it all; therefore covering content is not the most important goal of Science Education, but some knowledge of science is essential for full participation in the economic, political and cultural functions of our society.

It is my observation over the past several years that the above problem developed in my ecology and water quality units of the advanced biology course.

My premise is that by making changes in teaching methods and student activities there will be an increase in learning and interconnectedness in the ecology unit of my Advanced Biology course and in the real world. The process to accomplish this change in the ecology unit is: to assess previous test results (1987-1991), make changes in the method of instruction, pre-test the students, post-test the students, conduct clinical interviews, increase time spent at the Huntoon Creek water test sites and develop a team concept. The composition and responsibilities of creek research teams will be discussed in detail later. My data will substantiate the afore mentioned premise.

Currently, ecology including studies of water quality are only taught in Advanced Biology for a nine-week term. It is therefore necessary to introduce the students to the basics of ecological concepts, and then progress to the real world and their interconnectedness with it.

Beginning in the early 1970's, I designed and orchestrated a K-12 environmental education program where a group of high school students learned, practiced and then taught various ecological topics in the elementary classrooms and at the Russell Miller Nature Center. This was one of several steps leading to this current study.

In the '70s, I began developing and teaching a 6-week ecology unit in my two Advanced Biology classes. The basis of that module was the Rand McNally High School Biology BSCS Green Version, 1963. The one outdoor activity at that time was a natural plant succession transect.

As water pollution - especially in Michigan - became an increasing concern as is evidenced by dioxin pollution in mid-Michigan rivers, pollution in south-eastern River Rouge area and south central to central western rivers, I retained the ecology theme, but changed the core field activity from a transect to water quality using Huntoon Creek. The basic text used is Prentice-Hall Environmental Pollution, 1972, using the first three chapters: Basic Principles and Problems, Chemical and Physical Aspects of Water Pollution, and Biological Aspects of Water Pollution.

To develop this module, I used students text Andrews, 1972. Updated materials used by the students were from Christman, 1990, Terrell, 1989, and Nassbaum, 1991.

The following resources were helpful teacher background material, useful for additional student information and understanding of both general ecology and the ecology of aquatic ecosystems.

To expand the teacher's and students' view from local to world-wide, Miller, 1988, and Nebel, 1990, were helpful.

To expose more capable students to a strong academic illustration of research, Haynes, 1987, and its application to environmental changes, Plafkin, 1989, are available.

Other available books on fresh water ecology that provide interesting examples of methods and processes for students interested in expanding their knowledge beyond that of the regular classroom activities are Caduto, 1985, Jeffrie, 1990, and Cavacara, 1989. For complete references, please see the Bibliography on Page 36.

AUDIO VISUALS

There are two films and one filmstrip that I used with the central emphasis on water quality. Even through it is not current, "What Is Ecology?", Encyclopedia Britannica, 1977, excellently presents and illustrates the basic terms of ecology and ecosystems. The "Lorax", BSA Films, 1972, presents many ecological problems in an interesting manner. I require my students to take notes as the film is stopped occasionally, write a summary and give their personal opinion on the films relationship to today's ecological events. "Understanding Wetlands", Michigan Department of Natural Resources, 1979, not only discusses and illustrates the importance of wetlands in Michigan, but portions of this audio-filmstrip related directly to the lake and creek study with some of the surrounding marsh lands.

Since the overall topic is ecology, using a stream study as a model, there are some basic terms that must be clearly understood before delving into the more complex concepts. An understanding of terms such as ecology, population, community, ecosystem, biosphere and ecosphere are important to this study. The relationship of various levels of organization from the ecosphere to individual cells in an organism makes it necessary to understand at least the rudiments of organism physiology. Since the most involved aspect of this study is the field activities at Huntoon Creek and Huntoon Lake draining into it, background in standing and flowing waters is necessary.

The ways in which the ecosystem components are affected by various forms of pollution are also critical to the students' overall understanding of the functional environment. The students need to understand trophic levels and transfer of energy in the ecosystem to grasp the larger picture of environmental interrelationships. The ecosystem concept and the interrelationships between biotic and abiotic components must be understood. The various trophic levels and energy transfers are other basic terms/concepts that must be understood by the student.

Along with all of the above concepts and terms, it is necessary to understand the effects of photosynthesis and respiration on an organismic level as well as a global level and the effects of pollution on both. This naturally necessitates the understanding of a food chain and food web relating to the various ecological pyramids of numbers, biomass, and energy.

Another area to be understood is the impact of the natural cycles on: water, carbon, nitrogen and phosphorus.

Niches (the role of an organism in an ecosystem), whether they are full or whether some are empty, affects changes in animal population.

Another major concept area is that of the biological aspects of pollution and index species. Inherent is an understanding of eutrophication, bottom fauna, bacteria, algae, zooplankton and fish. The effects of total dissolved solids (TDS), total suspended solids (TSS), heated effluents and organic effluents on the biota are rather difficult parameters for the student to understand. It is necessary to have a basic understanding of these terms and concepts to understand the events, changes and impacts of the stream ecology that the class is about to study.

The following flow chart (Figure 1) beginning at the top is a generalization of the topics and activities experienced by the students throughout the nine-week unit.

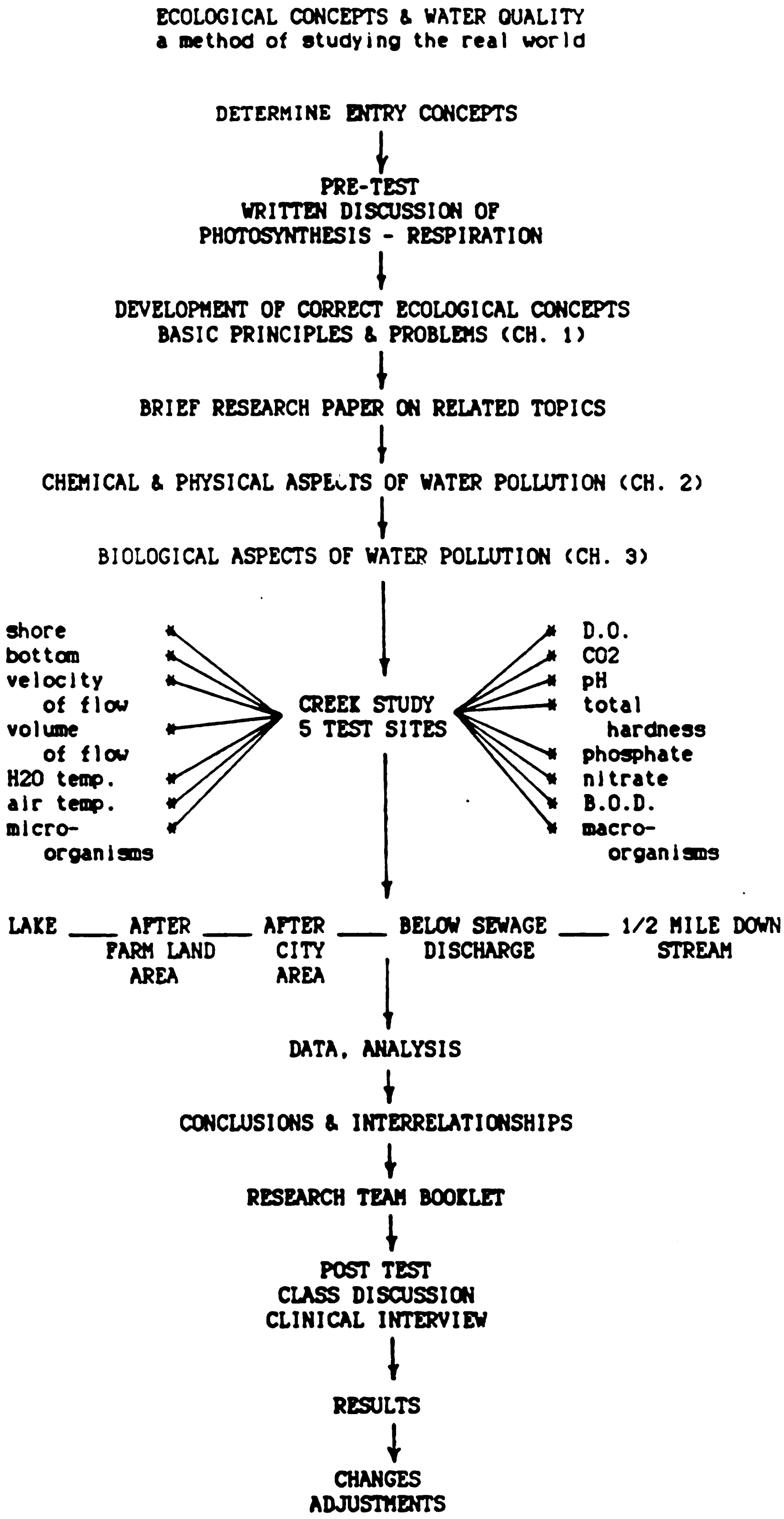
ECOLOGICAL CONCEPTS & WATER QUALITY
a method of studying the real world
DETERMINE ENTRY CONCEPTS
PRE-TEST
WRITTEN DISCUSSION OF
PHOTOSYNTHESIS - RESPIRATION
DEVELOPMENT OF CORRECT ECOLOGICAL CONCEPTS
BASIC PRINCIPLES & PROBLEMS (CH. 1)
BRIEF RESEARCH PAPER ON RELATED TOPICS
CHEMICAL & PHYSICAL ASPECTS OF WATER POLLUTION (CH. 2)
BIOLOGICAL ASPECTS OF WATER POLLUTION (CH. 3)
shore
bottom
velocity of flow
volume of flow
H2O temp.
air temp.
micro-organisms
CREEK STUDY
5 TEST SITES
D.O.
CO2
pH
total hardness
phosphate
nitrate
B.O.D.
macro-organisms
LAKE
AFTER FARM LAND AREA
AFTER CITY AREA
BELOW SEWAGE DISCHARGE
1/2 MILE DOWN STREAM
DATA, ANALYSIS
CONCLUSIONS & INTERRELATIONSHIPS
RESEARCH TEAM BOOKLET
POST TEST
CLASS DISCUSSION
CLINICAL INTERVIEW
RESULTS
CHANGES
ADJUSTMENTS

Figure 1.

INSTRUCTION

I divided the nine-week unit of instruction into three general instructional segments. The first segment was spent studying the basic concept of an ecosystem and maintenance of like relationships between photosynthesis and respiration. The second segment was the study of the chemical and physical aspects of water pollution. The third segment was using the text to identify the organisms associated with water pollution.

The second segment includes field testing the water in Huntoon Lake and at several sites along Huntoon Creek. This will be expanded on at a later point in this thesis. I also developed a concept map (see Appendix B, P. 96) for this segment. It begins blank and is developed as we progress through the concept.

There are several time considerations relating to the length of this study. Currently Advanced Biology is divided into the following semester units: Semester One: First Period (9 weeks); ecology and water quality; Second Period (9 weeks); genetics, bacteriological techniques, and electrophoresis. Semester Two: Human anatomy and physiology.

Because of the early release of Seniors in the spring and lack of student seriousness, I have chosen the beginning of the fall semester for the study of ecology and water quality. Our school has 55 minute class periods five days per week. The class period is just long enough for the students to travel to the test sites, complete the required exercises and return to the school for their next class. Because of the time constraints, discussion of the data and problems encountered are left to the following day in class.

About twelve class periods are spent discussing basic ecology before beginning the core module. The core of the module including student preparation and organization, stream work, classroom work, other in class lab experiences and other field trips takes about 32 class periods.

This general outline details the topics and activ-ties of the second segment and core of the study. An (*) indicates a laboratory activity.

CORE INSTRUCTION OF THE CHEMICAL AND PHYSICAL ASPECTS OF WATER POLLUTION

I. Dissolved Oxygen (*)

Most significant, acceptable level, activities affecting the concentration

II. Carbon Dioxide

How it mixes with water, affects of wave action, spring and fall overturn, rain water, rain water passing through the soil, formation of calcium bicarbonate (*), CO2 from metabolism, acceptable levels

III. pH

Range supporting life, changes as a body of water ages

IV. Alkalinity

capacity to neutralize acids (*), acceptable levels

V. Acidity

Capacity to neutralize bases (*), acceptable levels

VI. Hardness

Causes (*), acceptable levels, effect

VII. Nutrients

Nitrogen (*)

Importance to aquatic biota, main reservoirs, possible sources of nitrogen in waters, types as most convenient indicators, effects of varying concentrations, acceptable levels

Phosphorus

Importance to cells, pathway through a typical aquatic ecosystem, limiting factors, pollution control, acceptable levels

VIII. Total Suspended and Dissolved Solids

Total suspended solids

Types, measurement, acceptable levels

Total dissolved solids

Measurement, acceptable levels

IX. Physical Factors

Temperature (*), water flow (*), stream bottom (*), stream banks

X. Biological Oxygen Demand (B.O.D.) (Five day test)

XI. Detergents

Types

Alkyl Benzene Sulfonates (A.B.S.), Linear Alkyl Sulfonates (L.A.S), effect, acceptable levels, solution to problem

XII. Biological Aspects of water pollution

Index species, eutrophication, bottom fauna and pollutant effects

Dissolved solids, inorganic suspended solids, heated effluents, inorganic effluents,

Bacteria

Algae

Blue-Green algae (now monarians), green algae, golden algae

Zooplankton

Protozoans, rotifers, crustaceans

Fish

LABORATORY AND OTHER ACTIVITIES

The intent and value of all of the activities described here is to give the students hands-on experience with the real world and an opportunity to perform scientific investigations.

The activities are divided into three groups. The first group provides the students with a hands-on approach to basic ecology (see Appendix A-1). The second group is a series of experiments designed to give the student field practice in techniques so that they can begin to develop an understanding of the relatedness of the various test results (see Appendix A-2). The third group is the onsite testing of Huntoon Lake and Huntoon Creek (see Appendix A-3).

GROUP ONE: Basic ecosystem concept and maintaining a life balance with photosynthesis and aerobic respiration.

BIOLOGICAL SCIENCE RESEARCH REPORT

OBJECTIVES:

1. Expose the students to current environmental problems through research articles
2. Write an appropriate citation
3. Summarize the author's purpose, methods, results, and conclusions
4. Analyze the articles content for importance and express personal feelings on the topic. (See Appendix A-1, P. 39)

COMMENTS: I was pleased with the students' effort and results. I discovered the concern that students do have for the environment. After having three of my students who were in AP English read, help choose, and make some corrections, we included these in a booklet that I will discuss later.

ECOSYSTEM COLLAGE ACTIVITY

OBJECTIVES:

1. To mentally create an ecosystem with all its related parts
2. To physically create a natural ecosystem of their choice using magazine pictures pasted on construction paper
3. To write a one page explanation describing the various interrelationships of that ecosystem.

COMMENTS: This proved to be more difficult than I expected. As a result, they began to develop an appreciation for the complexity of an ecosystem. The collages were displayed on the wall for the remainder of the study.

LAKES: A LESSON UNIT

OBJECTIVES:

1. To understand how lakes originate
2. What controls their size
3. How they may change over time.

COMMENTS: Each student receives three different contour maps showing a river flowing into a depression. As the water rises in the depression, they are to determine what is the highest level the water can reach and where the lake outlet will be. This is a very simple activity, yet it gives the student a brief background on lakes, understanding contour lines and water flow. (See Appendix A-1, P.43)

FRESHWATER ECOSYSTEMS IN YOUR AREA

OBJECTIVE:

1. To familiarize the students with topographic maps and ecosystems in their own community. (See Appendix A-1, P. 47)

COMMENTS: Each pair of students receive a contour map of the Huntoon Creek water shed and surrounding area. They are expected to answer a series of questions pertaining to a specific ecosystem within this area (lake, pond, stream, river). In addition to classroom activity, the students visit the ecosystem and observe some of its general characteristics.

MEASUREMENT OF PLANT AND ANIMAL CELLS:

OBJECTIVE:

1. To develop a sense of size relationship about microscopic cells and organisms.

COMMENTS: By progressing in the field of view from one millimeter on a ruler to a cheek cell and to an onion cell, with appropriate calculations, the students begin to develop a sense of size through the microscope. (See Appendix A-1, P. 49.) As student observes microscopic organisms in Huntoon Lake and Creek, it is helpful to estimate size for identification purposes.

MAKING A MODEL AQUATIC ECOSYSTEM

OBJECTIVE:

1. To observe, record data and make observations in large fish bowl aquatic ecosystems.

COMMENTS: Students in groups of two or three collect their own natural materials to place in the bowls. Interest is high because of the initial organism diversity and succesional changes that occur over time. Even though data is collected weekly, each student will check his/her bowl and compares it to others daily.

GROUP TWO: Physical factors affecting water quality, water pollution computer simulation and case studies.

The following six laboratory experiments could be considered optional depending on time and the students comprehension of carbohydrate production in plants, chlorophyll and photosynthesis, light and photosynthesis, carbon dioxide and respiration (see Appendix A-1). An understanding of these activities is critical to the analysis of Huntoon Lake and Creek.

SOLUBILITY OF OXYGEN IN WATER

OBJECTIVE:

1. Test water at two different temperatures and determine that dissolved oxygen (D.O.) concentration is inversely proportional to the temperature.

COMMENTS: D.O. concentration as an indicator of pollution is very easily understood by the students. But they also need to be asked questions like, "How much plant life is there?" "How much light is penetrating the water?" "What evidence of decomposition exists?" "What are the concentrations of heterotrophs?"

ALKALINITY

OBJECTIVE:

1. To show by experiment that a solution can have a high alkalinity and not be highly alkaline.

COMMENTS: Performed with care, this activity works well and enhances the discussion of acidity and pH.

HARDNESS

OBJECTIVE:

1. Test the hardness of four solutions, understand that hardness may be caused by the geology of the area and not industry.

COMMENTS: This activity along with alkalinity may be optional depending on time and class room discussion.

UPSETTING THE NUTRIENT BALANCE IN AN ECOSYSTEM

OBJECTIVE:

1. To begin understanding the effects of nitrogen on aquatic organisms.

COMMENTS: By having two jars with the same pond water, same number of snails, same plants, but a small amount of fertilizer added to one jar, the effects of nitrogen pollution is easing observed.

WATER POLLUTION (COMPUTER SIMULATION)

OBJECTIVES: See Appendix A-2, P. 68. This program will help the students to:

1. Understand the variables that improve and

degrade water quality.

2. Determine the impact of water pollution on aquatic populations.
3. Predict the effects of manipulating one or more variables.
4. Improve data interpretation, problem-solving skills and graphing skills.
5. Evaluate hypotheses in light of experimental results.
6. Design experiments and plan a research project.

COMMENTS: Water pollution is an interactive computer simulation consisting of two parts:

1. Introduction -- reviews the basics of water pollution including physical properties of water, factors affecting dissolved oxygen levels, types of water pollution, fish-kills, biochemical oxygen demand, primary and secondary water treatment.
2. Experiment Mode -- setting up and running water pollution experiments.

The students with very little assistance understand the objective and enjoy the activity.

EFFECT OF A LARGE TOWN ON A RIVER AND EFFECT OF AN AGRICULTURAL AREA ON A RIVER (CASE STUDIES)

OBJECTIVE: To expose the students to the effects of sewage from a town and run-off from farm fields on stream biota and abiota with an assignment and discussion of these two case studies. This has a direct relationship to the Huntoon Creek study.

COMMENTS: Time spent on this activity is variable. It is another method to build background knowledge for use later.

GROUP THREE: Core laboratory activity with preparation and testing the water quality of Huntoon lake and Creek.

At this time, the class was divided into five heterogenous research teams based on their academic grades. The top students were placed in one of each team. Then the low students were placed in one of each team. The others were filled in respectively. Student personalities were another factor for student placement.

Analyzing an unknown water sample activity in the class room by research teams familiarized the students with the water testing equipment and procedures. Each student had his/her specific responsibilities within a team. For efficiency and reliability, a student performed the same tests each time at the assigned test sites on Huntoon Lake and Creek (see figure 2).

Prior to on site testing, the entire class visited each site, video taped the surrounding area, and hypothesized about their expected results. Each team then tested at their respective site weekly for five weeks (see Appendix A-3).

Following data collection with study and discussion, the original hypothesis concerning the water quality at each test site was either accepted or rejected. When all tests were completed and the data analyzed the students published a booklet on the Huntoon Lake and Creek study with related topics (see Appendix A-3).

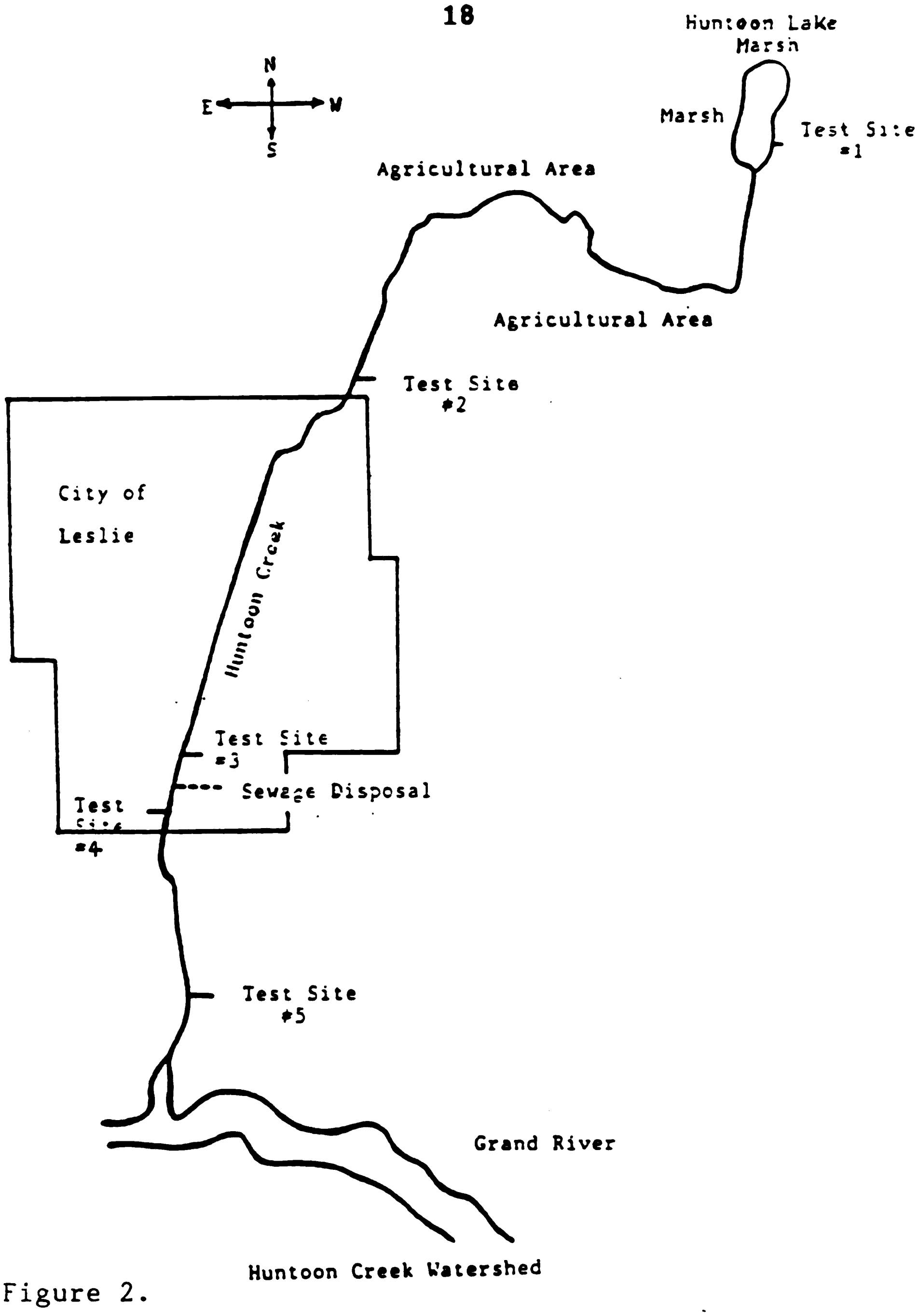

Figure 2.

The total distance is approximately 3½ miles.
Scale ⊢———⊣ = 0.5 miles
Students tested at each of the 5 sites: Site #1 Huntoon Lake shore, Site #2 - Race Street Bridge after the agricultural area, Site #3 - After the city and before the sewage plant discharge, Site #4 - Directly after the sewage discharge, Site #5 - Olds Road Bridge ½ mile downstream.

FIELD TRIP ACTIVITIES

The students were taken to the Ludington Pump Storage Hydroelectric Plant, the Little Manistee River Fish Wier, and the Leslie Waste Disposal Facility (see Appendix E). These two trips were taken near the end of the unit.

The power plant pumps water up into a reservoir taking fish with it. Many fish die going up and some die going down during the electricity producing cycle. Because of this problem, a two mile net has been installed. Studies on the effectiveness of the net, fish movement with temperature variation and feeding habits is an example of an ecosystem changed by human intervention.

By understanding the food webs and food chains in an ecosystem, the Michigan Department of Natural Resources is taking advantage of the migration of salmon, brown trout and steelheads. They remove the eggs, culture them and distribute them to other rivers to improve their populations. The fish are sold to a wholesaler and then become part of an ecosystem including humans.

The students were pleased to discover that their D.O. test results agreed with those of the local waste water disposal facility. This trip helps the student realize how difficult it is to restore waste water to an acceptable quality before it is released back into the natural system that they were studying.

ACTIVITY SUMMARY

The following is an abbreviated summary of the scope and sequence of the study.

* Determine the students entry concepts (see Appendix B).
* Student pre-test and written discussion of photosynthesis and respiration (see Appendix C).
* Basic ecological principles and problems (see Appendix B).
* Related laboratory activities (see Appendix A).
* Brief research paper on related topics (see Appendix A).
* Chemical and physical aspects of water pollution (see Appendix B).
* Related laboratory activities (see Appendix A).
* Biological aspects of water pollution.

* Field study of five water quality testing sites (see Appendix A).
* Data analysis and conclusions.
* Research team booklet (see Appendix A-3).
* Post test (see Appendix C), class discussion, and clinical interview (see Appendix D).
* Changes, adjustments and improvements.

EVALUATION RESULTS OF THE UNIT

CLASS DEMOGRAPHICS

The students taking Advanced Biology were heterogenous. A total of 41 students were divided into two classes with 17 in one section and 24 in the other. Students were from middle to low income families, all caucasian except for one student of partial Hispanic origin. Leslie is a rural community with a high number of families being on government assistance. Many working residents have their employment in Lansing or Jackson.

STUDENT PRE-TEST AND POST-TEST

This study compares the results of teaching methods and laboratory activities of 1987 to 1991 with the results over the same material using the improved methods and activities discussed earlier. During 1987 to 1990, there were no inclusions of entry concepts, student pre-testing and post-testing, or a brief research paper on related topics. The core field Huntoon Creek testing activity was a single two hour event with classroom follow-up. The 1991 unit included the entry concepts, student pre-testing, student post-testing, a brief research paper on related topics, five days at each test site and other activities discussed earlier.

The pre and post tests are compilations of questions that originated from tests previously given over the same topic material from 1987-1991 (see Appendix C). On the 1991 pre-test, the combined mean for both classes was 54.8% (Table 1). On the 1991 post-test, the combined mean for both classes was 72.9%, resulting in a 33% mean increase (Table 2).

By performing a t-test on the ecology and water quality student pre-test compared to the post-test, the t-value was 9.1267 which results in less than a .1% probability that these results were due to chance alone with 41 students in each group (Table 2). This was with 80 degrees of freedom. With a pre and post test, it is reasonable to expect these positive results.

By performing a t-test on the ecology and water quality, student chapter one and two combined tests for 1987-1990 with the same test for 1991. The t-value was 2.6744 which allows rejection of the null hypothesis beyond the 0.01 level of probability at df= ∞ (Table 3).

Table 1. ECOLOGY AND WATER QUALITY STUDENT PRE-TEST 1991

Pre-Test	Mean	Standard Deviation
2nd Hour	26.45	3.63
4th Hour	28.32	3.86
Mean	27.39	3.75
Mean %	54.8%	
n = 41; df = 40		

Table 2. ECOLOGY AND WATER QUALITY STUDENT POST-TEST 1991

Post-Test	Mean	Standard Deviation
2nd Hour	36.62	5.56
4th hour	36.24	4.69
Mean	36.43	5.17
Mean %	72.9%	
n = 41; df = 40		

Mean % Change = + 33% pre-test to post-test
t-test results comparing Tables 1 and 2
t = 9.1267 p = 0.001

With changes in methods and activities explained previously, it is also shown that there was an increase based on chapter one and chapter two student tests results from 1987 to 1990 compared to those of 1991 (Table 4). The mean percentage score for 1987-1990 was 67.5, while the mean percentage score for 1991 was 79 with a lower standard deviation (Table 5). This was a 17% increase from the combined average student test results of the previous four years.

I observed that the means are similar, but not correlated between the 1988 and 1991 mean with the ecology and water quality unit combined Chapter 1 and 2 (Table 5). By performing a t-test between the 32 student scores in 1988 and the 41 scores obtained in 1990, the calculated t-value of 1.5203 at 71 degrees of freedom indicates that there is no significant difference between those two groups. For more conclusive results, it would be necessary to continue with the improved teaching methods and activities to provide a greater future data base from which to make comparisons.

Table 3. ECOLOGY AND WATER QUALITY UNIT

Combined Student Test Results For The Years 1987-1990 and 1991

YEAR	1987-1990	1991
Mean %	67.5	79
S.Deviation	13.975	13
df = 41		

Mean % Change = + 11.5% from 1987- 1990 student test results compared to 1991 results.

t-test results comparing 1987 - 1990 to 1991.

t = 1.5203 = >10%

Table 4. ECOLOGY AND WATER QUALITY UNIT

Chapter 1 and 2

Student Test Results For 1987-1991

YEAR	1987		1988		1989		1990		1991	
Chapter	1	2	1	2	1	2	1	2	1	2
Mean %	65	65	76	73	66	68	60	68	79	79
S.Deviation	13.3	12.9	9.9	12.9	19.9	15.5	12.2	14.3	12.8	13.2

Table 5. ECOLOGY AND WATER QUALITY UNIT
Combined Chapter 1 AND 2
Student Test Results For 1987-1990 and 1991 (See Table 3)

YEAR	1987	1988	1989	1990	1991
Mean %	65.0	74.5	67.0	64.0	79
S.Deviation	13.1	11.9	17.7	13.2	13

Another method of illustrating the results of combined Chapters 1 and 2 student tests is graphically in figure 3. It is easily noted that 1991 scores were an improvement over any of the previous years.

ECOLOGY AND WATER QUALITY TEST RESULTS

Combined Chapters 1 and 2 Assessment 1987-1990 and 1991

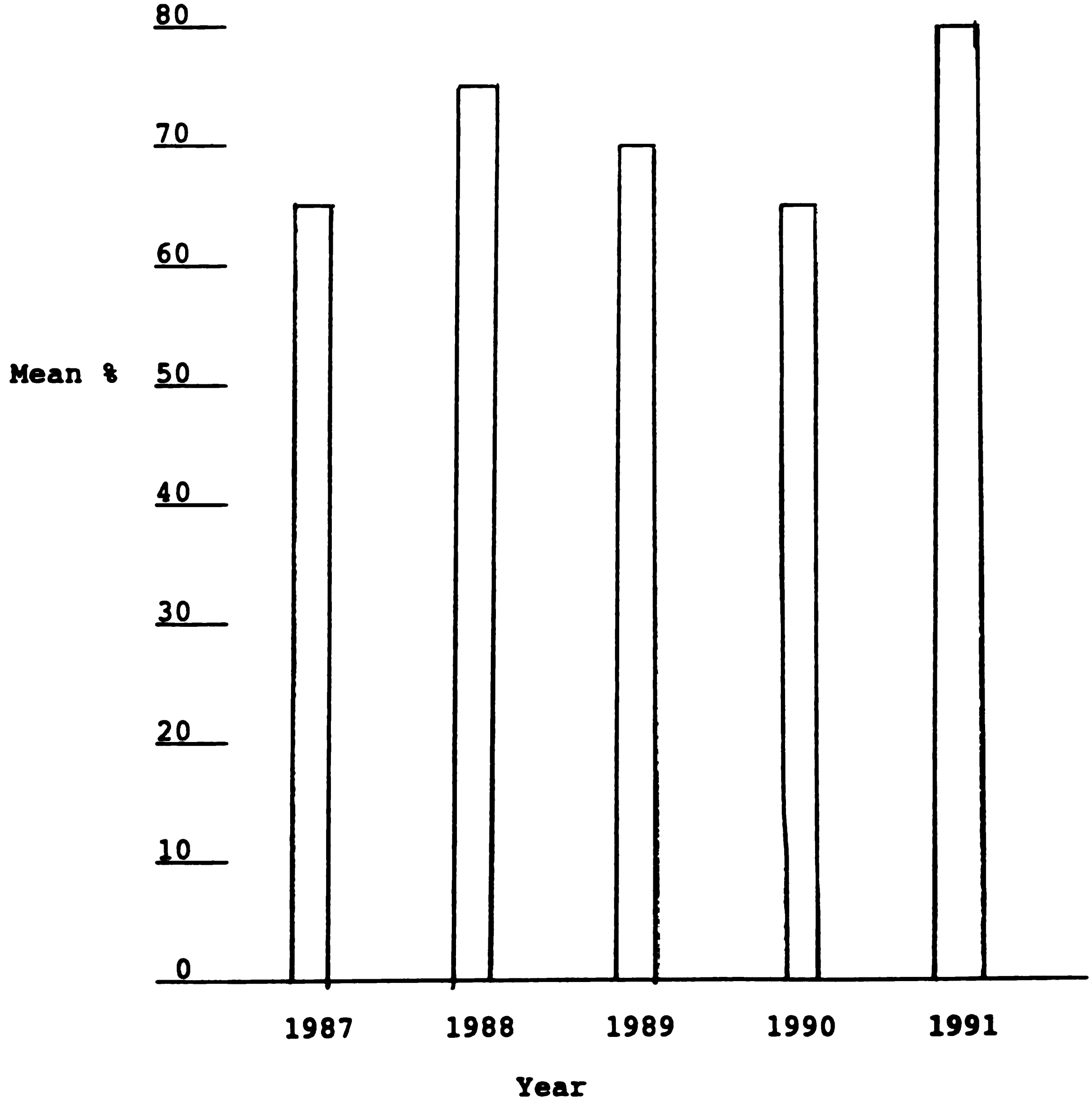

Figure 3.

CLINICAL INTERVIEW

Eleven students took part in the clinical interviews. There were four groups; female high achievers (4), female low achievers (3), male high achievers (2), and male low achievers (2). Our high school presently has a higher percent of female high achievers than male high achievers.

During clinical interviews with the students before the study I asked three questions. The first was, "Have you had any experiences with lakes, ponds or creeks for example, fishing, playing or exploring when you were younger?" (Table 6.)

Table 6. PREVIOUS EXPERIENCE WITH LAKES, PONDS OR CREEKS

	High Achievers	Low Achievers	Total
Yes	5	5	10
No	1	0	1

With the exception of one, all eleven students surveyed had at least some experience as a child with lake, pond or stream organisms. They either played with, observed or tried to take home and keep alive grubs on rocks, fish, clams, larvae nests, water bugs, leeches, insects, turtles, ducks and nests, crayfish, minnows, "slimy stuff", snakes, cat tails and muskrats.

Because one of the five water quality testing sites previously discussed was Huntoon Lake, it was necessary to ask the second question, "What difference would you expect to see in Huntoon Lake compared to Huntoon Creek? Why?" To help give the student more specific direction, I suggested categories of physical factors (bottom depth temperature, etc.), types of plant life (more, less, surface or submerged), and animal life (microscopic and macroscopic). The responses to these questions are summarized in Table 7.

Table 7. STUDENT CLINICAL INTERVIEW, PREVIOUS KNOWLEDGE, DIFFERENCES IN A LAKE AND CREEK ENVIRONMENT

FACTOR	LAKE	CREEK
Physical Factors	Deep Still Dirty Muck Warm Stagnant	Shallow Moving Clean No Muck Cold Sandy Clear CityPollution
Plant Life	More Surface Plants Lily Pads Bottom Plants Around the Edges None In Deep Water	Less Plants On Shore Algae, Bottom and Rocks No Plants
Animal Life	Insects and Bugs Fish More Decay and Dying Crayfish, Frogs, Turtles, Pike, Bass, Bluegills and Bullhead Larger	Bugs Less More Trout Smaller

In general, the students had difficulty explaining why the differences between moving/standing water existed. They are more familiar with lake or pond environments than with moving water environments.

The third question, "What are some differences you would <u>expect</u> to see in Huntoon Creek below the sewage treatment plant compared to above the plant discharge?" Responses are summarized in Table 8.

Table 8. STUDENT CLINICAL INTERVIEW, STUDENT SUGGESTED DIFFERENCES: ABOVE AND BELOW SEWAGE PLANT DISCHARGE

DISCHARGE ABOVE	BELOW
More vegetation	Effluent
More creatures	Less Creatures
Clean	Dirtier, Sewage Not Clean
More Life	More contaminants
	Chemicals
	More Microorganisms
	More Silt
	Cloudy Below
	O2 Lower
	Higher pH
	Coliform
	Faster Velocity

The data shows that the students have a strong negative opinion of what they expect to see below the sewage treatment discharge into Huntoon Creek.

POST UNIT INTERVIEWS/ANALYSIS

Seven months after the ecology and water quality unit, the same eleven students were asked questions about the interrelationships on a concept map (see Appendix D). The boxes were filled in and lines connected between them. Questions such as "What does photosynthesis produce?", and "What happens to the dissolved oxygen (D.O.) when the temperature increases?" were asked. The following six relationships were questioned. "What is the relationship between temperature and D.O.?" " What is the relationship between temperature and Biological Oxygen Demand (B.O.D.)?" " What is the relationship between CO2 and pH?" "What is the relationship between nitrates and phosphates?" "What is the relationship between photosynthesis and Total Suspended Solids (T.S.S.) and Total Dissolved Solids (T.D.S.)?" (see Table 9).

Table 9.

CLINICAL INTERVIEW AND CONCEPT MAP UNDERSTANDING RESULTS

CHEMICAL AND PHYSICAL ASPECTS OF WATER POLLUTION

Concept	Yes	No
Photosynthesis using CO2 and releasing O2 Respiration using O2 and releasing CO2	10	1

Temperature increase - D.O. Decrease Temperature decrease - D.O. Increase	5	6
Temperature Increase - B.O.D. Increase Temperature Decrease - B.O.D. Decrease	9	2
Increase CO2 - pH Decrease (More Acidity) Decrease CO2 - pH Increase (More Alkaline	5	6
Photosynthesis - Nitrates and Phosphates	1	10
Photosynthesis - T.S.S. and T.D.S.	3	8

Some of what I consider as basic concepts were well understood by my students and other concepts were not. 91% of those surveyed understood the relationship of photosynthesis and respiration concerning oxygen and carbon dioxide. 82% understood the relationship between temperature and B.O.D. On the other hand, the relationships between temperature and D.O. (46%), CO2 and pH (46%), photosynthesis and nitrates and phosphates (9%), and photosynthesis and T.S.S. and T.D.S. (27%) were not understood or retained well.

INTERVIEW CONCLUSIONS

SUBJECTIVE IMPRESSIONS

Students were asked what feeling or impressions they had about the ecology unit and what activities they will likely remember. The following are a sample of their replies.

* "Cool, nifty, summary booklet gave concrete results"
* "Stream - fun, neat"
* "Sewage treatment plant"
* "Testing at the creek, cold weather"
* "Ludington Power Plant trip, so cold, group and independent responsibility, team"
* "Treatment plant"
* "Outside hands-on chemical tests"
* "Ludington and stream"

IMPROVEMENTS (STUDENTS)

I asked the students what specific improvements they felt would be helpful to them concerning the creek water quality testing activity. The following were among their replies.

* More time at the test sites
* Rotate test responsibilities within the group

* Test at different time of the day
* Take the results to someone who can do something about improving the water quality
* Visit the test sites between testing and discuss progressive results at each site to get a "feel" for the difference
* Do testing during different seasons

IMPROVEMENTS (TEACHER)

The results of the student pre and post test clearly showed student improvement in understanding Chapters 1 and 2 as indicated by results and comparing scores with those of previous years. Therefore with the improved teaching methods and hands-on activities in the real world a positive student interest and understanding resulted. During informal discussions with the two classes, students felt that the Huntoon Creek study and the Ludington field trip increased their interest and broadened their knowledge of the environment and pollution. They also mentioned the sights, smells and sounds of the sewage treatment plant. Were it not for these extra effort activities, the interest level would certainly be lower.

I was satisfied with the students' understanding of photosynthesis and respiration, but dissatisfied with their understanding of temperature and D.O., pH and CO_2, Photosynthesis and nitrates and phosphates, and photosynthesis and T.S.S. and T.D.S. (see Appendix B, P. 118). Rather than making assumptions that these are understood, I will design an individual written assignment emphasizing these topics after the post test.

The on-site stream study was the core of the teaching module. Overhead projection notes, other laboratory experiences and activities were supportive of the core activity.

Some students preferred the concreteness and security of lecture, while others preferred to explore the unknown with investigations. This knowledge developed as a result of general observations and informally talking with the students.

The "Lorax" film was particularly interesting and effective, in part due to my expectations of notes and written response. One change would be to do the same with other films.

I would also change my method of using the concept map (Appendix D). I would begin with a blank map for the student and complete it with the interrelationships as the material was presented.

The ecosystem development and collage were very effective, especially when the results were displayed in the room (Appendix A-1, P. 41).

The students during informal discussions suggested improvements in the on-site stream analysis, listed previously.

In conclusion, this has been a very beneficial learning experience for me and will in turn have a positive impact on my students. This activity forces me, as it should all teachers, to analyze why and how the material is taught. Is communication and understanding happening? What is necessary to be effective in that communication?

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APPENDIX A-1

LABORATORIES AND ACTIVITIES

BIOLOGICAL SCIENCE RESEARCH REPORT

1. Select an article for review from a recent issue of an appropriate science journal in our library. To be on the safe side, have the instructor approve your choice of article before you write up the review. Choose an article on the assigned topic that you can read and understand. Settling for the first title you come across may make this assignment more difficult than intended. Here are a few resources for your use. Our library has several sources for research. Sirs (standing display): vertical file: National Geographic index and magazines 1947+: Abridged Readers Guide (red): Readers Guide (green): Articles not directly available are available by fax. In the biology room are a variety of American Biology Teacher and Biological Sciences Review.

2. Read the article you have selected. If it is appealing, make a photocopy to show to your instructor for approval. The photocopy will allow you to work on your article review at your convenience after you leave the library. The instructor may also request that a photocopy of the article be turned in with its review.

3. Write your review of the article in three parts:

Part A. Citation. Give a complete, correct, bibliographic citation at top of page one. Include these pieces of information in this journal, volume number and pages. Use punctuation and capitalization as shown the example below.

The format for writing a proper journal citation varies among journal editors. There is no universally correct way to write a citation. However for this class you must use the style illustrated above. There is no need to lose points for writing an incorrect citation. When you bring your article for my approval to write the review, I will pregrade and correct your citation if you ask me.

Part B. Summary. Summarize the major content of the article in terms of the author's purpose, methods, results, and conclusions. This should take up the remainder of page one following the citation when your review is typed. Do not copy the author's abstract in place of writing your own summary. Do not include your own thoughts, judgments or reactions to the article in this section of the review.

Part C. Analysis. Critically consider the article's content and evaluate its importance. Among the things which you might consider are the following: What is your reaction to the paper's findings? Why is your reaction favorable or unfavorable? How has the paper changed your previous thinking about this topic? What personal experiences make this topic relevant to you? Does this paper seem to have major applications for society or is it relatively unimportant? Why do you think so? Do you have experiences or knowledge which gives you a point of view which is different from the author's? Explain them. How well did the author use the scientific method? What questions does the paper bring to your mind? Are there alternate ways for solving the problem or dealing with the issue that the author failed to consider? Does the paper suggest possible new research for you or other scientists?

You must provide evidence that you have critically examined the author's work. Simply saying that the paper is well done, or that you liked reading it, or that you agree with the author, learned a lot and found it interesting is not going to convince me you've really tried to deal with the topic or a particular author's way of approaching it.

The analysis should take up a full page of your typed review.

4. Type your review. Include your name in the upper right hand corner of each page. The citation should be single line spaced. The remainder of the paper should be double line spaced with one inch margins. The review should be at least two complete pages of 8 1/2 X 11 inch paper. You will not be penalized for less than two pages.

5. Write down the topic and due date as the instructor makes the assignment for your class.

Topic: Environmental Problems **Due Date:** 10/21/91

Grading: Maximum credit is 35 points awarded as follows: citation (5), adequate summary (10), adequate analysis (10), writing mechanics (10), and evidence of critical thinking.

ECOSYSTEM COLLAGE

ACTIVITY

Purpose:

To create a collage of a natural ecosystem on a sheet of 12 X 18 inch construction paper and write a one page explanation describing the various interrelationships.

Materials:

12 X 18 inch construction paper

magazines such as National Wildlife, National Geographic, Natural History, American Forests, Defenders, etc.

scissors

glue

Procedure:

1. Decide on the type of natural ecosystem that you wish to create. Ex. forest, ocean, desert, pond, etc.

2. Collect as many pictures as possible illustrating that system. Remember the abiotic as well as the biotic. Ex. air, water, soil, rock, sun.

3. Remember the more complex the system is the more stable it will be. (Possibly a better grade)

4. Arrange the pictures according to what you think is the most reasonable.

5. Write a one page explanation describing the various interrelationships of your ecosystem. Ex. autotrophs, heterotrophs, food chains, food webs, energy pathways, abiotic factors, etc.

Classroom Aids

LAKES: A LESSON UNIT
Robert Christman

Introduction

Most students are familiar with lakes. However, they probably have not thought much about lakes. Some questions are:

1. How do lakes originate?
2. Why do lakes occur where they do?
3. What controls the size of the lake?
4. What controls the level of high water of a lake?
5. With time, do lakes become bigger, stay the same size or become smaller?

The purpose of the unit is to answer some of these questions. In finding the answers, some geological principles about lakes can be taught. The study will be done by observing a demonstration, involving the students in discussion by asking questions and by doing a short activity.

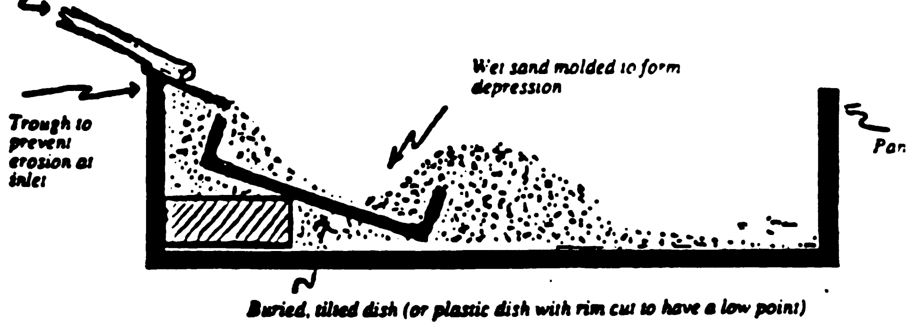
Demonstration

The diagram below shows how to set up the demonstration. The water will fill the depression to the lowest point, then it will flow out and rapidly erode an outlet.

Perform the demonstration with little explanation. Tell the students to observe what happens and to be prepared to answer some questions.

Questions/Answers for a Classroom Discussion

1. As shown by the demonstration, what two things are needed for a lake to form?
   a. Supply of water and
   b. Depression to hold the water.
2. In nature, where does the water come from?
   a. Precipitation, as rain , snow, or hail,
   b. Rivers, streams, creeks and surface wash flowing into the lake,
   c. Springs, groundwater flow beneath the surface.
3. If water is continually accumulating, why don't lakes get bigger and bigger?
   a. Water may evaporate. This is only important in hot areas,
   b. Water spills out.



Activity, Part One: Three Lakes

Blue Lake

Distribute the maps of Blue Lake (on blue paper) and a colored pencil or crayon. Let's suppose the land, as shown on the map, has no water.

1. If water begins to flow down White River, where will the water go?
   (It will accumulate in the lowest spot-the area inside the 110-meter contour line.)
2. Color the area occupied by the water if the level of the water reaches 110 meters.
3. If water continues to flow down White River to fill the depression to an elevation of 120 meters, color the area now occupied by the water.
4. If the water reaches the level of 130 meters, color the map to show the size of the lake.
5. If the water reaches the level of 140 meters, color the map to show the size of the lake. At this point the students will encounter a problem. What happens when the level of the water reaches about 139 meters?
   (It will spill out and flow to the north and down the slope towards the 130-meter contour line. It is not possible for the water to reach the 140-meter level. Like a bathtub, the water will flow out when the water level reaches the lowest point of the rim which holds the water in.)
6. With a rising lake level, the water will flow out when it reaches the lowest point of the land surrounding the lake. What is this place called?
   (An outlet. The majority of lakes in the world have an outlet.)
7. What is the maximum elevation (height in meters) that the water can reach in Blue Lake?
   (Some value slightly less than 140 meters.)

Green Lake

Distribute the maps of Green Lake (on green paper). Following the same procedure, color the areas inside the successive contour lines to show the sizes of the lake as more and more water is added.

1. What is the maximum level (height in meters) possible for the water in Green Lake?
   (Some value slightly less than 150 meters.)

Yellow Lake

Distribute the maps of Yellow Lake (on yellow paper). Following the same procedure, color the areas inside the successive contour lines to show the sizes of the lake as more and more water is added.

1. What is the maximum elevation possible of water which is possible for Yellow Lake?
   (Some value less than 160 meters, but larger than 150 meters. The answer could be about 155 meters.)

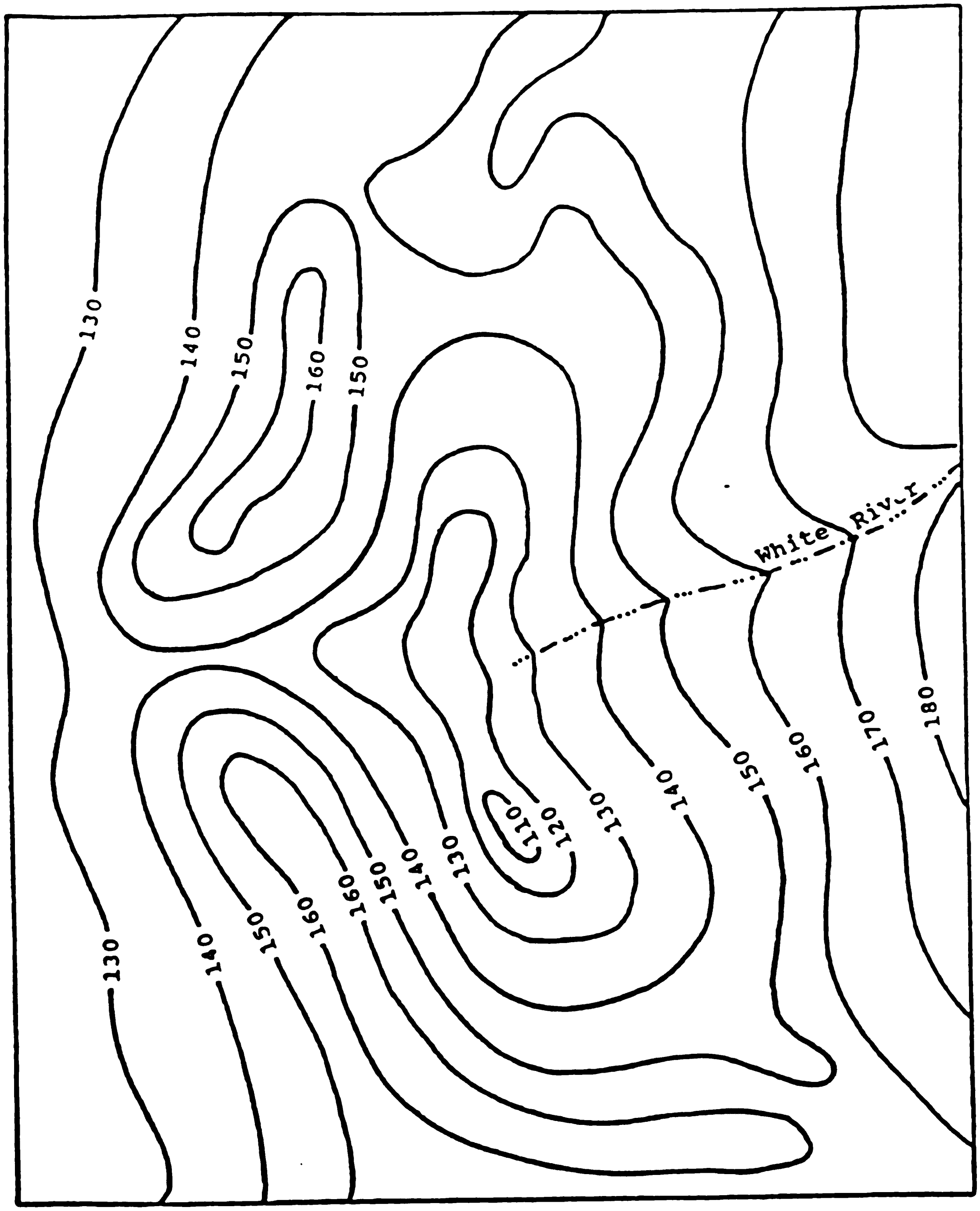


Figure 1 Blue Lake (contour interval = 10 meters)

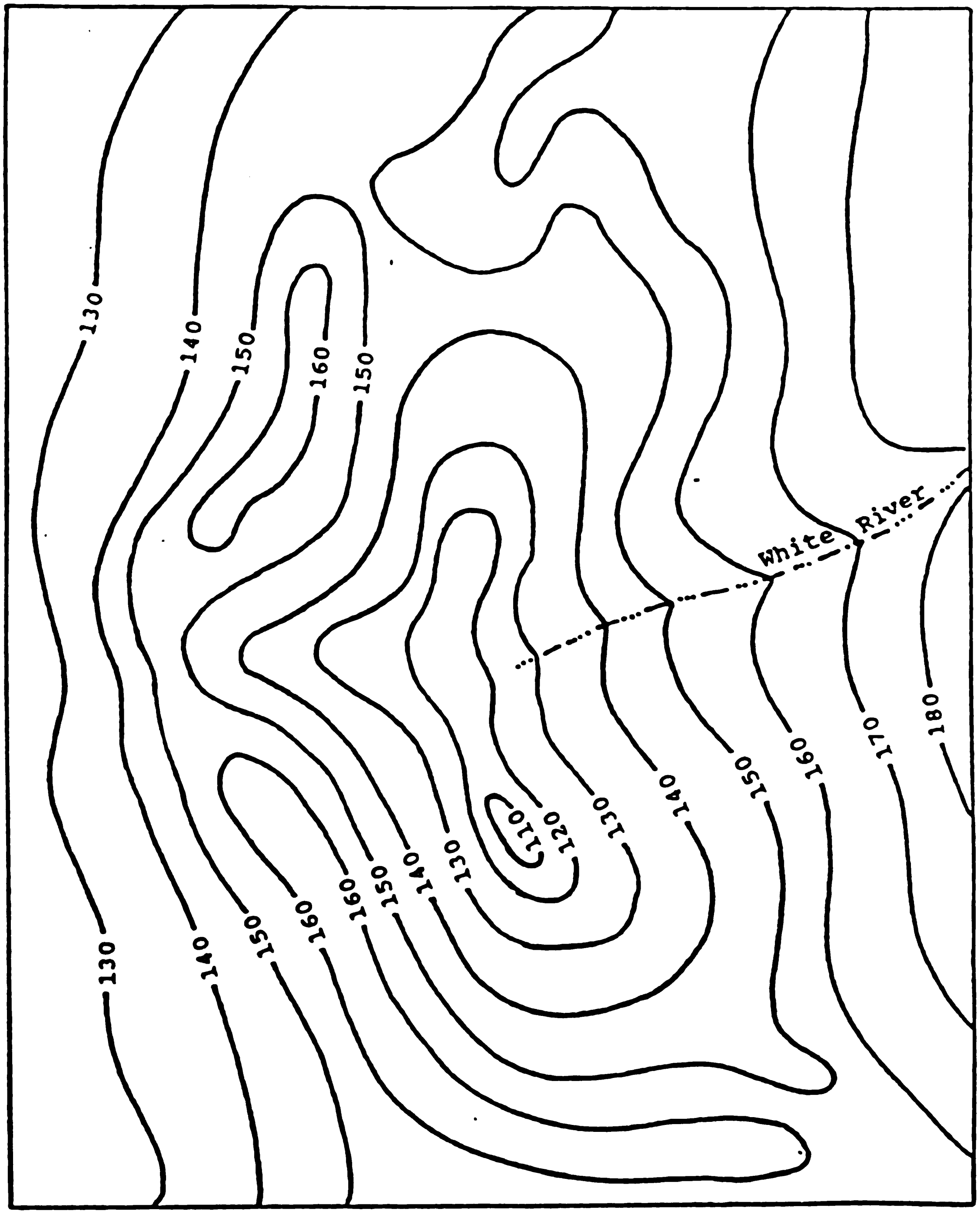


Figure 2 Green Lake (contour interval = 10 meters)

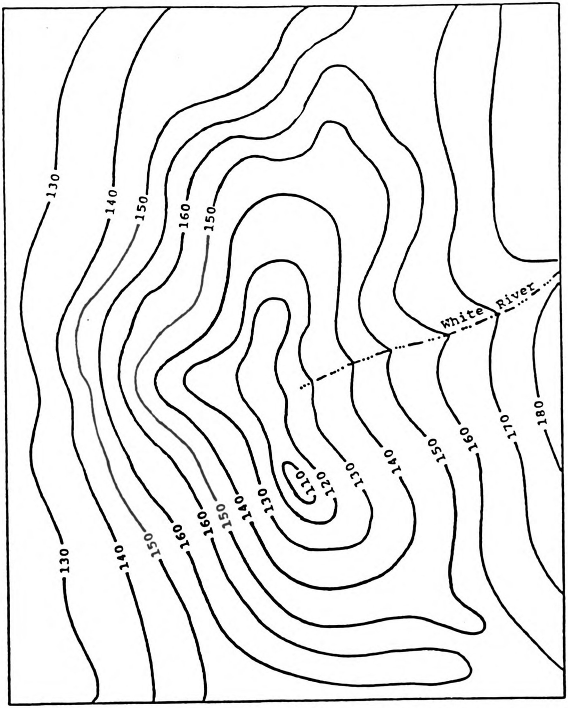


Figure 3 Yellow Lake (contour interval = 10 meters)

FRESHWATER ECOSYSTEMS IN YOUR AREA

PROBLEM: What freshwater ecosystems occur in your area?

What are they like and what are they used for?

MATERIALS: topographic map(s) camera (optional)

aerial photographs binoculars (optional)

PROCEDURE:

1. Form a group with three or four students.
2. Get a topographic map.
3. Make a full-page copy of the following

TYPE of ECOSYSTEM	SIZE	LOCATION	SURROUNDINGS
Lake SAMPLE	1.5 Km l. 0.5 Km w.	N. of town Right Rd.	homes N.side woods etc. ...

4. Complete the table for three freshwater ecosystems on the map.
5. Answer the discussion questions for each ecosystems.
6. Aerial photographs may help.
7. A visit to the area will help to answer some of the questions.

FRESHWATER ECOSYSTEM IN YOUR AREA

Discussion Questions

1. If the ecosystem is a stream,

   a. what stream order is the stream?
   b. what is the origin of the stream?
   c. where does it end?
   d. what factors along its path may affect the water quality of the stream? In what ways?
   e. does the future look good or bad for the stream? Explain your answer.
   f. what is the stream used for? Which uses may change in the future?
   g. who has jurisdiction over the stream? Is it in private property or is it in property administered by some level of government?

2. If the ecosystem is a lake, pond, or wetland,

   a. from where does this ecosystem get its water?
   b. where does the water go when it leaves this ecosystem?
   c. what is the lake or pond used for? Which uses may change in the future?
   d. how good is the water quality of the ecosystem? (Try asking people who may know.)
   e. what factors affect the water quality of the ecosystem?
   f. does the future look good or bad for the ecosystem? Explain your answer.
   g. what species of wildlife use the ecosystem? (You may need to drive by and observe using binoculars.)

MICROSCOPIC MEASUREMENTS OF PLANT AND ANIMAL CELLS

BACKGROUND:

Ever since the first microscope was used, biologists have been interested in studying the cellular organization of all living things. After hundreds of years of observations by many biologists, the cell theory was developed. The cell theory states that the cell is the structural and functional unit of living things. Cells contain structures called organelles that carry out life processes. Cells are classified by the types of organelles they contain. In plant and animal cells, similarities and differences exist because of varied life functions. In this investigation you will demonstrate how to measure the field of view of a microscope. You also will observe plant and animal cells through a microscope.

OBJECTIVES:

After completion of this investigation, you will be able to

* Measure the diameter of the field of view in microns under low and high power.
* Calculate the area of the field of view in square millimeters under low and high power.
* Demonstrate the use of a simple stain to enhance the observation of certain organelles.
* Compare and contrast characteristics of plant and animal cells.
* Estimate the size of a cell in microns.

MATERIALS (per 2 students):

Prelab

* compound light microscope
* clear plastic metric ruler

Part A

* compound light microscope
* glass slide and coverslip
* Methylene blue in dropper bottle
* paper towels
* forceps
* dropper
* toothpick

Part B

* compound light microscope
* Lugol's iodine solution in dropper bottle
* onion soaked in water
* glass slide and coverslip
* forceps
* dropper

PROCEDURE:

Prelab: Technique--Measuring the Microscopes Field of View

1. Review pages 59 to 67 in your text.

2. Adjust the microscope for viewing under low power. Place a clear plastic metric ruler on the microscope stage. Position the edge of the ruler over the hole in the stage as shown in Figure 7-1.

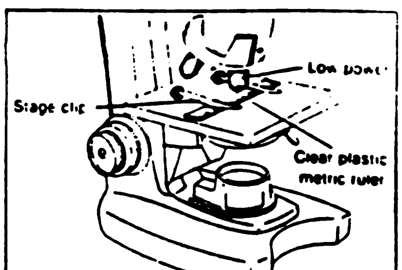


Fig 7-1

3. Looking through the eyepiece, bring the lines of the ruler into focus. Adjust the position of the ruler so that the edges cross the field of view at the midpoint.

4. Move the ruler sideways so that a scale line is just visible at the left as shown in Figure 7-2. The distance between two scale lines is 1 mm. NOTE: Only a portion of a millimeter will appear on the right. Estimate this part of a millimeter as a decimal to the nearest 0.1 mm. Answer question 1 on the Answer Sheet.

5. Microscopic measurements are often given in microns, or u, instead of millimeters. One micron equals 1000 mm. To convert the measurement of the diameter in millimeters to microns, use the following equation:

$$\text{diameter in mm} \times 1000 = \text{number of u}$$

Answer question 2 on the Answer Sheet.

6. The diameter of the high-power field of view cannot be measured with a ruler. The diameter is calculated mathematically by the following equation:

$$\frac{\text{magnification of low-power objective} \times \text{low-power field of view in mm}}{\text{Magnification of high-power objective}} = \text{Diameter of high-power field of view in mm.}$$

Answer question 3 on Answer Sheet.

7. Calculate the diameter of the high-power field of view in microns (μ). Answer question 4 on the Answer Sheet.

8. The area of the circular field of view can be calculated with the following equation:
$\pi r2$ = area Where = 3.14
and r = one half the diameter.

For example, a field of view with r = 1 mm has an area of 3.14 mm2 or 3.14 X 1mm2 = 3.14 mm2. Calculate the circular field of view in mm2 for both the low power and the high power. Answer questions 5 and 6 on the Answer Sheet.

9. Complete Table 7-1 on the Answer Sheet.

10. Answer questions 7 through 10 on the Answer Sheet.

Investigation

Part A: Examining Cheek Cells Through a microscope

1. Place a drop of water in the center of a clean glass slide.
2. With the blunt end of a toothpick, gently scrape the inner lining of your cheek. **CAUTION: Do not use force when scraping. Only a few cells are needed.** The end of the toothpick will have several cheek cells stuck to it even though you may see nothing by a drop of saliva.
3. Swish the end of the toothpick with cheek cells in the drop of water on the slide. Throw the toothpick in a waste basket.
4. Focus the slide under low power. The cells will appear as transparent and grainy clumps. **NOTE: You will need to reduce the amount of light with the diaphragm to see the cells more clearly.** Move the slide around until you find a couple of isolated cells. Switch to high power. Use the fine adjustment to focus on the single cheek cell.
5. You probably noticed that the transparent, colorless cell was difficult to observe. The addition to the slide of a simple stain such as methylene blue makes certain organelles of the cell easier to see. Remove the slide from the microscope and place it on a piece of paper towel. Place one drop of methylene blue next to the coverslip.
   CAUTION: Use care when working with methylene blue and other stains to avoid staining hands and clothing. With forceps, hold a piece of paper towel at the opposite side of the coverslip. The paper towel helps to draw the stain under the coverslip to the opposite side. Observe the stained cheek cells under low power and high power of the microscope.
6. To estimate the size of a cheek cell, determine how many cheek cells would fit across the diameter of the field of view. Divide the diameter of the field of view by the number of cells to determine the size of the cell.

$$\frac{\text{diameter of field of view (in } \mu)}{\text{number of cells across diameter}} = \text{size of cell (in } \mu)$$

Complete number 1 on the Answer Sheet.

Part B: Examining Onion Cells Through a Microscope

1. Place a drop of water in the center of a clean glass slide.
2. Remove one of the fleshy leaves from a piece of onion that has been soaking in water. Bend the piece of onion against the curve until it snaps. With forceps, carefully remove the thin layer of epidermis from the inside of the curved piece of onion.
3. Spread the epidermis in the drop of water on the slide

as smoothly as possible. **NOTE:** If the epidermis becomes folded on the slide, use a probe to gently flatten and unfold it.

4. Place a drop of Lugol's iodine solution on the onion tissue. **CAUTION:** Use care when working with iodine to avoid staining hands and clothing. Add a coverslip.
5. Focus the slide under low power. Center a few cells and switch to high power. With the fine adjustment, carefully focus on one onion cell. Complete number 1 on the Answer Sheet.
6. Under low power, position the slide with a reasonably straight row of onion cells across the diameter of the field of view as shown in Figure 7-6. Count the number of cell lengths lying along the diameter. Record this number in Table 7-2 on the Answer Sheet.

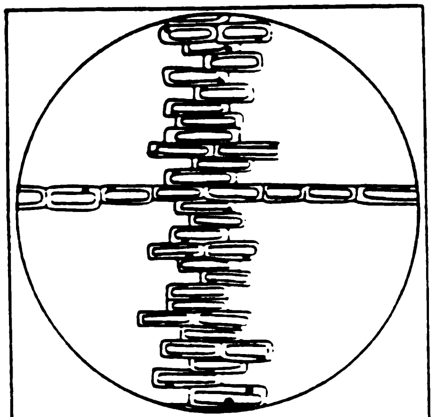


Fig 7-6

7. Calculate the average length in microns of the onion cells on your slide. Record this number in Table 7-2 on the Answer Sheet.
8. Count the number of cell widths lying perpendicular to the row just counted as shown in Figure 7-6. Record this number in Table 7-2 of the Answer Sheet.
9. Calculate the average width in microns of the onion cells on your slide. Record this number in Table 7-2 on the Answer Sheet.
10. Carefully switch to high power and repeat steps 6 through 9. Complete the "High Power" column of Table 7-2 on the Answer Sheet. Complete numbers 2 through 5 on the Answer Sheet.

FURTHER INVESTIGATIONS

1. Ask your teacher for prepared slides of different types of cells, such as blood cells, sperm cells, plant cells, and algae cells. Estimate their sizes in the same way you did for the onion cells. Organize the measurements of each cell type into a wall chart that could be displayed in your lab room.
2. Remove the skin from other fruits and vegetables, such as tomatoes and apples. Prepare wet mounts of these cells and observe them under low and high power of your microscope.

Name________________________________Class__________Date_________

What are some of the characteristics of plant and animal cells?

ANSWER SHEET
Prelab

1. What is the diameter of the field of view in millimeters (mm)?____

2. What is the diameter of the field of view in microns (u)? ____

3. What is the diameter of the high-power field of view in millimeters (mm)? ____

4. What is the diameter of the high-power field of view in microns? (µ)?____

5. What is the area of the circular field of view for the low-power view?____

6. What is the area of the circular field of view for the high-power view?____

Fill in the Table below:

Table 7-1	LOW POWER	HIGH POWER
Power of eyepiece	________	________
Power of objective	________	________
Total magnification	________	________
Diameter of field of view in millimeters (mm)	________	________
Diameter of field of view in microns (µ)	________	________
Area of the circular field of view in square mm	________	________

7. Why do you think it is not possible to measure the high-power field of view with a ruler?____

8. Why do you think that microscopic measurements are often given in microns instead of millimeters?__________

9. Why is it helpful to view an object under low power before switching to high power?______________________________
____

10. What is the relationship between changing the magnification and its effect on the size of the field of view?____
____

Table 7-2

	Low Power	High Power
Field diameter in microns	_________	__________
Number of cells-horizontal	_________	__________
Number of cells-vertical	_________	__________
Average cell length	_________	__________
Average cell width	_________	__________

2. Were the dimensions of your onion cells the same under low and high power? _____ Should they be?_____

Explain.

MAKING A MODEL ECOSYSTEM

NAME________________________

Problem:

What are the basic parts of an Aquatic Ecosystem?

What changes occur over an extended time period in an Aquatic Ecosystem?

Materials:

2 1/2 Gal. fish bowl	strands of aquatic plants
light source	sand, gravel, or mud
small plant eating fish	snails
khuli loach etc.	clear cover material

Procedure:

1. Place the bottom material to a depth of 3 to 5 cm.
2. Carefully fill the bowl 1/2 full with lake, pond, or stream water.
3. Add the aquatic plants.
4. Add the snails and fish.
5. Fill the remainder of the bowl to within 6 cm. of the top.
6. Complete the following data sheets. (Attached)
7. Write a one page paper explaining the changes that happened over the duration of the experiment.

ECOSYSTEM TANK LAB

NAME ____________________

WATER COLUMN		DATE	TEMP.	pH	LIGHT	ORGANISMS
Near surface	1.		X			(see) (attached)
	2.		X			
	3.		X			
	4.		X			
Middle	1.			X	X	
	2.			X	X	
	3.			X	X	
	4.			X	X	
Near bottom	1.		X	X		
	2.		X	X		
	3.		X	X		
	4.		X	X		
In bottom	1.		X	X	X	
	2.		X	X	X	
	3.		X	X	X	
	4.		X	X	X	

OBSERVATION OF ORGANISMS

Name________________

Using a microscope or stereoscope draw and label the various organisms found in your tank. Indicate the approximate size, quantity, and location of each type.

1. 2.

3. 4.

Part A THE PRODUCTION OF CARBOHYDRATES BY PRODUCERS

MATERIALS

a) 150 ml beaker
b) 600 ml beaker
c) hot plate
d) forceps or crucible tongs
e) glass plate
f) ethyl or isopropyl alcohol
g) geranium plant that has been under a light for 24 hours
h) geranium plant that has ben in the dark for 24 hours

PROCEDURE

a) Remove a leaf from each geranium plant.
b) Immerse the leaves in a beaker of boiling water for a few seconds. Remove them as soon as they become limp.
c) Transfer the leaves to a beaker containing boiling alcohol. Use a hot plate or place a small beaker of alcohol in a larger beaker partly full of boiling water. DO NOT HEAT THE ALCOHOL WITH AN OPEN FLAME. IT WILL IGNITE.
d) When the leaves are white, remove them from the alcohol. Soften them by dipping them in boiling water for one or two seconds.
e) Spread the leaves on a glass plate and cover them with iodine solution.
f) Record your observations.

DISCUSSION

What do these observations tell you about the role of geranium plants in the ecosystem in which they are found?

Repeat the experiment using the leaves of corn seedlings, bean seedlings, and other plants. What do these observations tell you about the role of producers in ecosystems?

Part B CHLOROPHYLL AND PHOTOSYNTHESIS

Is chlorophyll necessary for photosynthesis? Many plants have leaves that contain chlorophyll in some regions and not in others. Examples are variegated geraniums and some coleus plants. Obtain one of these plants and design an experiment to answer the question. You will require many of the materials and procedures of part A.

Part C LIGHT AND PHOTOSYNTHESIS

Is light required for photosynthesis? You may think that this question was answered in part A. However, you used two different plants in that experiment. A scientist would say that you did not have very good controls in the experiment. The different results with each plant could be entirely due to the fact that they were different plants. To eliminate this possibility, you should use only one plant or, preferably, one leaf of the plant. See if you can design such an experiment. Again, you will require many of the materials and procedures of part A.

What do these results tell you about the role of producers in ecosystems?

Part D CARBON DIOXIDE AND PHOTOSYNTHESIS

Does a green plant use carbon dioxide during photosynthesis?

MATERIALS

a) bromthymol blue
b) carbon dioxide
c) glass tube or soda straw
d) Elodea
e) test tubes
f) light source

PROCEDURE

a) Bromthymol blue is an acid-base indicator. find out what color it turns in an acidic solution: put 3 or 4 drops of bromthymol blue in a test tube of water that contains a few drops of acid. Perform a similar experiment to find out what color bromthymol blue turns in a basic solution.
b) What is formed when carbon dioxide comes in contact with water? (See Section 2.2.) Confirm this by bubbling carbon dioxide from a gas cylinder or from your breath into a neutral solution of bromthymol blue.
c) Design an experiment to show whether or not green plants use carbon dioxide during photosynthesis. You will need all of the materials listed above. Don't forget that a control is necessary.
d) What do these results tell you about the role of producers in ecosystems?

Part E OXYGEN AND PHOTOSYNTHESES

MATERIALS

a) 2 test tubes
b) 2 1000 ml beakers
c) 2 funnels
d) Elodea
e) sodium bicarbonate

PROCEDURE

a) Set up the apparatus shown in Figure 6-1. The water must contain carbon dioxide during the entire experiment. to insure this, add 2 or 3 pinches of sodium bicarbonate to the water. Insert the cut ends of the Elodea sprigs into the stem of the funnel. The funnel should be deep in the beaker of water. The test tube and funnel must be full of water at the beginning of the experiment. You figure out how to fill them.
b) Set up a control experiment.
c) Shine a bright light on the entire setup for several days. Watch for a product. If one appears, confirm its identity with a suitable test.
d) What does this experiment tell you about the role of producers in ecosystems?

Part F CARBON DIOXIDE AND RESPIRATION

Do green plants produce carbon dioxide? Green plants, like all living organisms, respire. Was there any evidence in the experiment of part D that green plants give off carbon dioxide? Account for your answer.

Design an experiment to show that a green plan produces carbon dioxide. A simple modification of part D should be sufficient. Again, don't forget to set up a control.

What does this experiment tell you about the role of producers in ecosystems?

APPENDIX A-2

LABORATORIES AND ACTIVITIES

SOLUBILITY OF OXYGEN IN WATER

Problem:

How much oxygen will be dissolved in water at 10 degrees C. and at 30 degrees C.?

Materials: (class)

2 containers (5 Gal. aquariums)
2 air pumps
1 aquarium heater
D.O. water test kit (Hach, etc.)
refrigerator

Procedure: (groups of 2 or 3)

1. Measure the temperature (C) in each container.
2. Follow the D.O. test directions to determine the oxygen concentration in each container.
3. Record your results in the table below.
4. Record the results of the other groups in the space provided.
5. Calculate the mean for container 1 and container 2.

CONTAINER 1		CONTAINER 2	
TEMP.	D.O.	TEMP.	D.O.
MEAN			

ALKALINITY

Problem:

How can a substance have a high alkalinity and not be highly alkaline?

Materials:

0.1M Sodium Hydroxide
0.1M Sodium Bicarbonate
0.1M Hydrochloric Acid
pipet or 15cc syringe
graduated cylinder
250 ml beaker
Alkacid test paper

Procedure: (group of 2 or 3) Follow SAFETY rules.

1. Place 25 ml of 0.1M Sodium Hydroxide in a 250 ml beaker.
2. Determine the pH of the solution.
3. Add 2 ml of 0.1M Hydrochloric Acid to the beaker at a time and mix the solution.
4. Test for pH each time.
5. Record the number of ml of HCL to change the solution to an acid (pH = 6).
6. Repeat steps 1 - 5 using 0.1M Sodium Bicarbonate.
7. Obtain results from other groups and record.

Sodium Hydroxide #ml HCL	Sodium Bicarbonate #ml HCL
MEAN	

HARDNESS

Problem:

What are the effects of hardness on surface water?

Materials:

distilled water	4 test tubes
tap water	10 ml syringe
$CaCl_2$ solution	soap solution
$MgSO_4$ solution	bunsen burner
$Ca(HCO_3)_2$ solution	test tube rack
test tube holder	marking pencil
water bath (room temp.)	

Procedure: (group of 2 or 3) Follow SAFETY Rules

1. Place 10 ml of the materials listed in the table below into each of 5 test tubes.
2. To each add soap solution drop by drop, shaking after every 2 or 3 drops. Counting the drops, continue to do so until a permanent lather of 1/2 inch in depth forms on top of the solution.
3. Repeat step 1 and 2 with the following change: Heat the material to boiling. Keep it at that temperature for one minute. Then cool to room temperature and proceed with the addition of the soap. (Place the test tubes in a water bath at room temperature to decrease the cooling time).
4. Record all information in the table below from your experiment and the other groups.

	Dist. water	Tap water	$CaCl_2$	$MgSO_4$	$Ca(HCO_3)_2$
	Number of soap drops with NO heating				
Mean					
	Number of soap drops AFTER heating				
Mean					

UPSETTING THE NUTRIENT BALANCE IN AN ECOSYSTEM

Problem:

How will lawn fertilizer affect the balance in an ecosystem?

Materials:

2 wide-mouthed jars, with a capacity of a least 1 L

Pond water

Pond snails

Strands of aquatic plants 10 - 20 cm long

Fertilizer

Procedure:

1. Fill both jars with pond water.
2. Add 1/2 of the plants to each jar.
3. Add 3 pond snails to each jar.
4. Label one jar "control" and one "experimental" jar.
5. Add a very small pinch of lawn fertilizer to the experimental jar.
6. Place both jars in a bright location.
7. Observe the jars each day for 2-3 weeks, making notes on changes.

Discussion:

1. What are the producers in your ecosystem?

2. What are the consumers in your ecosystem?

3. a) What important microorganisms are in your ecosystem?

   b) Explain these changes.

4. What is the purpose of the control?

5. Why are the jars placed side by side?

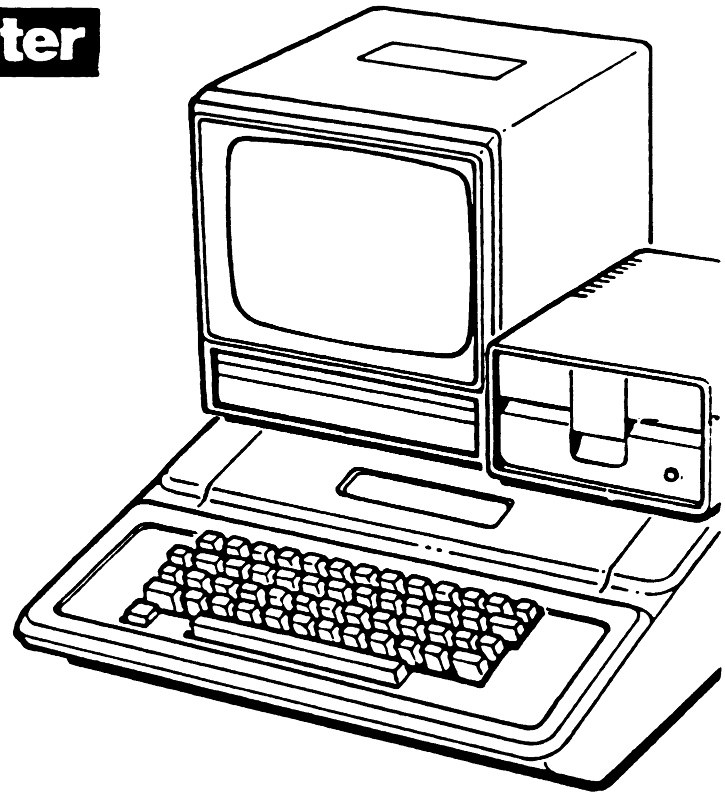
6. a) Describe the changes the fertilizer caused in your ecosystem?

   b) Explain these changes.

7. Explain why sewage can cause plant and algal growth in lakes.

E.M.E

microcomputer program



WATER POLLUTION

Programmed
by
Michael Harmon
Irvington High School
Irvington, New York

EDUCATIONAL MATERIALS AND EQUIPMENT COMPANY
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OVERVIEW

WATER POLLUTION is an interactive computer simulation consisting of two parts:

1. Introduction -- reviews the basics of water pollution including physical properties of water, factors affecting dissolved oxygen levels, types of water pollution, fish-kills, biochemical oxygen demand, primary and secondary water treatment.

2. Experiment Mode -- setting up and running water pollution experiments.

In the Experiment Mode, students manipulate the variable which influences water quality. Results are displayed in tables and graphs. A student lab booklet provides basic activities to acquaint all students with various aspects of water pollution, as well as advanced activities to challenge brighter students. If possible, run the program in advance to see what your students will encounter. Prior coverage of water pollution topics reviewed in the program's introduction is recommended.

OBJECTIVES

The WATER POLLUTION Program will help students to:

1. Understand the variables that improve and degrade water quality.
2. Determine the impact of water pollution on aquatic populations.
3. Predict the effects of manipulating one or more variables.
4. Improve data interpretation, problem-solving skills and graphing skills.
5. Evaluate hypotheses in light of experimental results.
6. Design experiments and plan a research project.

BACKGROUND

Water is a most precious resource. Living things, themselves about 70% water, depend upon water as a medium and reactant for biochemical reactions, for support and for circulation. In addition, humans use this natural resource for industrial and home use, sanitation, agriculture, recreation and to produce power.

Water is a stable molecule composed of two atoms of hydrogen to every one atom of oxygen. At sea level it vaporized at 100 C (212 F) and freezes at 0 C (32 F). Water is most dense at 4 C (39.2 F). During the spring and fall, as water approaches this temperature, it displaces water at lower levels. This mixes the body of water, aerating it and bringing nutrients to the surface. In the winter colder but less dense ice forms at the surface protecting organism overwintering in the bottom waters.

Many useful substances such as oxygen, carbon dioxide and minerals, as well as potentially harmful industrial chemicals and pesticides, dissolve in water. Dissolved oxygen in water results from the photosynthesis reaction in aquatic plants as well as water-surface/atmosphere interactions. Generally, the more turbulent the water, the more dissolved oxygen it can capture from the atmosphere. Cooler water temperatures also increase the levels of dissolved oxygen in a body of water.

Dissolved oxygen levels are also dependent on the rate of decomposition of organic material. As bacteria break organic material into a stable, inorganic form, they use up dissolved oxygen. The amount of oxygen needed for decomposition is called the Biochemical Oxygen Demand (B.O.D.) and is used as an indicator of the "health" of a body of water. A high B.O.D. indicates a high level of organic matter and an "unhealthy" condition. When dissolved oxygen levels become very low, decomposition may occur anaerobically (without oxygen). Noxious gases such as hydrogen sulfide and methane, as well as a foul appearance are characteristic of this condition.

Humans use waterways for disposal of their sewage and industrial wastes, generally reducing dissolved oxygen levels. As the levels approach 5 ppm at about 10 C (50 F), most game fish begin to suffer respiratory distress. Fish will tend to increase their respiratory rate (using up dissolved O2 faster), while getting 5-10% less oxygen as water passes through their gills at the faster rate. When dissolved oxygen levels drop below 5 ppm a fishkill results.

Water treatments are used to keep B.O.D. levels low and dissolved oxygen at levels adequate to support aquatic communities. Primary water treatment involves passing water through a coarse screen, a grit chamber and a sedimentation tank to remove heavy, solid waste. This process alone reduces B.O.D. by 35-40%. Secondary water treatment destroys harmful organisms and removes some dissolved materials. This can be done in one of two ways. The Trickling Filter Method passes water over crushed stone (1.5m deep), which captures a film of microorganisms. The film combines with oxygen and changes harmful substances into a form that can be filtered out in a sedimentation tank. Addition of chlorine further purifies the water. Remaining sludge is treated and can be recycled as fertilizer, but more frequently is dumped into the ocean. The Activated Sludge Method of secondary water treatment uses bacteria which, together with oxygen, destroys harmful microorganisms. Primary and secondary treatment combined can reduce B.O.D. by 80-90%.

Name ________________________________ Student Lab Booklet

WATER POLLUTION

1. This program concerns the effects of water pollution on aquatic life. To begin, run the INTRODUCTION for an explanation of the factors that affect water quality.

2. The EXPERIMENTAL MODE section allows you to set up simulated experiments on the computer. You can investigate the effects of changing these variables:

   A) Body of water (pond, lake, slow/fast river)

   B) Temperature (1 -32 C)

   C) Type of pollution (industrial, sewage)

   D) Dumping rate (0-14 ppm/day)

   E) Type of treatment (none, primary, secondary)

   F) Number of days (2-30)

Activity 1

The Ketone Chemical plant is situated on a slow river whose year-round temperature remains about 18 C. The plant dumps untreated industrial waste into the river at an average rate of 12 parts per million (ppm) per day. Run this experiment for 30 days to determine:

A) What happens to the concentration of waste over time?

B) On what day does the waste concentration start to level off?

C) What happens to the concentration of dissolved oxygen over time?

D) Does a fishkill occur? __________ If so, when? _____

Why?

E) Compare the pollution discharged by the chemical plant to that of a town dumping 12 ppm/day of untreated sewage into the same river. Which type of waste reduces the dissolved O2 most rapidly?

Which pollutant is decomposed to a greater extent?

_______________ Why?

Activity 2

The Flexy-Plastic Company is investigating four possible sites for a new plant: along a 14 C fast-flowing river; along a 14 C slow-flowing river; on a 14 C quiet lake; on a 14 C pond. Flexy-Plastic will dispose of an average of 12 ppm/day of untreated industrial waste directly into the water.

A) How many days does it take for the dissolved O2 level to fall below 5 ppm for:

fast river _____ slow river ____ lake ____ pond ____

B) Which body of water retains the highest levels of dissolved O2 for the longest period of time? Why?

C) Which plant location would be the least damaging to the environment? ________________________ Why?

D) List two measures the company can take to prevent a fishkill while the plant is in operation.

1)________________________ 2)____________________

E) Does decomposition of the plant's waste continue after the dissolved O2 level drops to zero? ____________

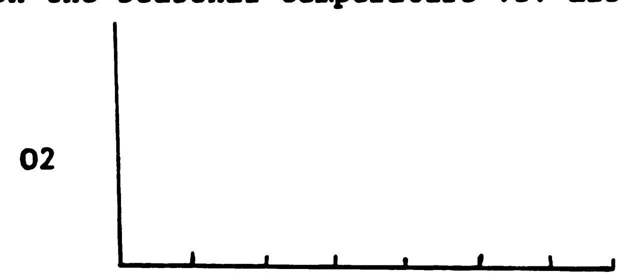
Explain your answer.

Activity 3

Average seasonal temperatures of Peach Lake are:

Winter 1°C, Spring 11°C., Summer 26°C, Fall 16°C.

A) Graph the seasonal temperature vs. dissolved O2.



B) Describe the relation between dissolved O2 and water temperature.

C) Which season would you choose to dump 10 ppm/day of untreated industrial waste to cause the least environmental damage? ____________________

D) Describe the interactions between water temperature, dissolved O2 and waste decomposition.

Activity 4

Testing the industrial waste discharge of Slick Oil Refinery for 5 days shows 12 ppm/day entering the 18 C waters of a slow river.

A) Will a fishkill occur?______________________ If so, predict which day ________________________________

B) Is water treatment necessary to protect the fish life?

____

Activity 5

Bacteria and fungi use dissolved O2 to decompose organic pollutants. The amount of O2 needed by these decomposers is called Biochemical Oxygen Demand (B.O.D.). The Department of xFish and Game wants to stock fish in several fast rivers. These fish cannot tolerate a dissolved oxygen level of less than 5 ppm.

Blue River receive 8 ppm/day of secondary treated sewage. It maintains a year-round temperature of 10 C.

Tepid River receives 3 ppm/day of primary treated industrial waste. It maintains a year-round temperature of 22 C.

Narrow River receives 6 ppm/day of untreated sewage. It has a year-round temperature of 21 C.

A) Which river has the highest BOD values?

B) Which river maintains the lowest concentration of waste?

C) Which rivers can be stocked with fish?

Advanced Activities

1. A paper mill of Sedge pond dumps 14 ppm/day of untreated

waste directly into the 10°C pond causing a fishkill. The County is requiring the mill either to close (putting many people out of work) or to change its waste discharge so the levels of dissolved O_2 in the pond do not fall below 5 ppm. What measures can management take to meet the County's requirement? Will the mill have to close?

2. A sewage plant situated on a slow river with a temperature of 7°C produces 12 ppm/day of waste that is given primary treatment. Downriver, a dam regulating the rate at which water enters a 15°C pond reduces the concentration of this waste to 2 ppm/day by secondary treatment.

A) Which body of water has the higher BOD?

B) Which of these environments can support a game fish population that requires a minimum of 5 ppm of dissolved O_2?

C) If the dam were removed, the pond would receive the full 12 ppm/day of untreated sewage. What would be the effect on the pond's dissolved O_2 levels if this occurred?

GLOSSARY

Biochemical Oxygen Demand (BOD): the amount of oxygen required to decomposed the organic waste content of a body of water.

Decomposition: the biochemical breakdown of organic materials into stable, inorganic compounds by bacteria and fungi. This process may be done aerobically (with oxygen) or anaerobically (without oxygen).

Fishkill: less than 5 ppm of dissolved oxygen at 10 C (50 F) results in the death of large numbers of game fish such as trout.

Industrial waste: from factories, mines, research facilities, etc.; includes salts, acids, oils, tars, greases and heavy metals.

Pollution: the undesirable alteration of the environment through human activities.

Primary Waste Treatment: removes heavy, solid waste materials through filtering; this process reduces the BOD by 35-40%.

Secondary Waste Treatment: destroys harmful microorganisms and removes certain dissolved materials by means of bacterial action. Reduces BOD by 80-90% when coupled with primary waste treatment.

Sewage: organic plant, animal, and human wastes.

Sludge: semiliquid waste resulting from sewage purification.

Solubility: the ability to dissolve.

EFFECT OF A LARGE TOWN ON A RIVER

The river in this study is 10 miles long and drains into a lake of moderate size. Situated on it is a town of about 15,000 people. A biological and chemical survey was per ormed to determine the effect of the town on the water quality of the river.

Five stations were set up along the river (Fig. 8-1). Station A was located about 0.5 mile above the town. Here the river is about 25 feet wide and 4 feet deep. Station B was located 0.5 mile downstream from the town. Here the river is also about 25 feet wide and 4 feet deep. Station C was located 1 mile further downstream. Station D was located 1.5 miles from C. The river at both C and D is about 20 feet wide and 3.5-4 feet deep. Station E was located two miles from D. The river is 18 feet wide and 3 feet deep there. The velocity of flow at all sampling stations was about 2.5 feet per second. The town has no sewage treatment plants. Its sewage is dumped untreated into the river. The results of the survey are tabulated in Tables 1 and 2.

Figure 1.

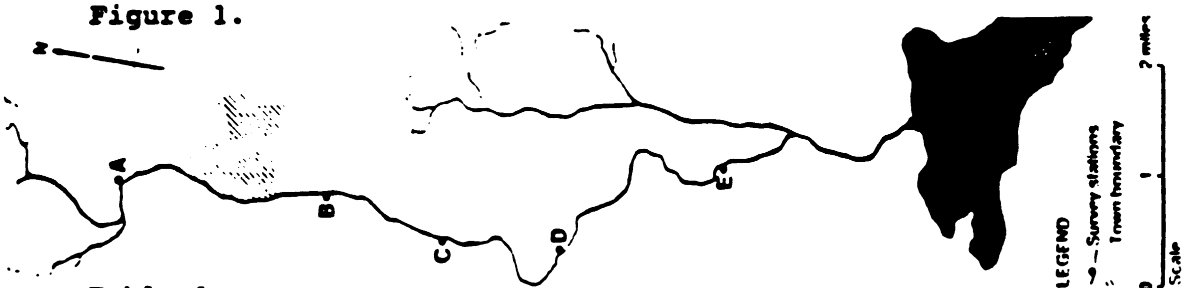


Table 1.

BOTTOM FAUNA PER SQUARE FOOT

	A	B	C	D	E
Mayfly nymphs	20	4	28	15	23
Stonefly nymphs	12	3	5	10	14
Caddisly larvae	15	0	1	6	18
Asellus	7	5	6	8	7
Chironomus	2	26	24	21	6
Tubifex	1	37	36	24	8

EFFECT OF A LARGE TOWN ON A RIVER

The river in this study is 10 miles long and drains into a lake of moderate size. Situated on it is a town of about 15,000 people. A biological and chemical survey was per ormed to determine the effect of the town on the water quality of the river.

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Figure 1.

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Chironomus	2	26	24	21	6
Tubifex	1	37	36	24	8

Table 2 .

CHEMICAL ANALYSIS

	A	B	C	D	E
Suspended solids (ppm)	10	19	17	14	12
Phosphate (ppm)	0.37	0.75	0.61	0.43	0.41
B.O.D. (ppm)	1.8	3.2	3.1	2.6	2.1
Dissolved oxygen (ppm)	6.5	2.1	2.2	3.4	4.9
Nitrogen (ppm)	0.22	2.13	1.27	1.02	0.59
Coliforms per 100 ml	0	180	170	121	87

Questions

1. Account for the changes in the bottom fauna of the river.
2. Account for the high B.O.D. reading at station B.
3. What do the coliform counts tell you about the sanitary quality of the river?
4. What would you expect the relative populations of algae and zooplankon to be at the five stations?
5. Downstream from the town, the sensitive bottom fauna increase in numbers and the tolerant fauna decrease in numbers. Account for this change.
6. Use the chemical and biological data to predict the types of fish, if any, that might be found at each station.

EFFECT OF AN AGRICULTURAL AREA ON A RIVER

The river in this study passes through a relatively large agricultural area. A survey was made to determine the effects, if any, that agricultural practices have on the water quality of the river.

Five stations were set up along he river and one in the lake (Fig. 8-2) A chemical and biological analysis of the water was made at each station. Bottom fauna were studied; the results were tabulated in number per square foot. A relative study of the algae was also make at each station. The results are shown in Tables 3, 4 and 5.b-

The only significant algae present at stations B-E were

Cladophora, Spirogyra, and a small quantity of Ulothrix. They were found only along the banks of the river. No significant quantities of phytoplankton were observed in the river. However, at station F there was a bloom of Microcystis. Also present, but in lesser quantities were Navicula, Anabaena, Closterium, and Chlorella.

Figure 2.

Table 1. PHYSICAL CHARACTERISTICS

	A	B	C	D	E	F
Width (ft)	15	20	12	12	15	--
Depth (ft)	2	2.5	2	2	2.5	12
Velocity of flow	3	1.5	2	2	2.5	--

Table 2. CHEMICAL ANALYSIS

	A	B	C	D	E	F
Suspended solids (ppm)	22	28	36	61	62	21
Phosphate (ppm)	0.04	0.09	0.16	0.75	1.1	2.9
B.O.D. (ppm)	1.9	2.2	2.0	1.8	1.9	2.8
Dissolved oxygen (ppm)	6.5	6.3	6.1	6.6	6.2	5.7
Nitrogen (ppm)	0.22	0.61	0.83	1.01	1.73	1.21

Table 3. BOTTOM FAUNA PER SQUARE FOOT

	A	B	C	D	E	F
Mayfly Nymphs	16	12	13	7	1	0
Stonefly nymphs	9	8	6	2	0	0
Caddisfly larvae	13	11	7	1	4	1
Aesllus	2	0	1	1	2	1
Chironomus	1	0	2	5	17	15
Tubifex	0	0	1	4	15	21

Questions

1. In general, how has the agricultural area affected the water quality of the river passing through it?
2. Account for the biological changes along the course of the river.

APPENDIX A-3

LABORATORIES AND ACTIVITIES

ANALYZING AN UNKNOWN WATER SAMPLE

The aquarium for this activity contains water with certain chemical properties. It also has certain forms of life in it. As you know, the chemical factors (non-living) interact with the organisms. That is, the chemical factors and the organisms affect one another. Can you find out how?

Problem:

How do chemical and biological factors interact in the aquarium?

Materials:

Hach water test kit
D.O., CO2, pH, total hardness, phosphate, nitrate, B.O.D.
coliform
thermometer
light meter
aquarium tank

Procedure:

1. Obtain the necessary materials for a specific test. (See the direction sheet.) Do one of the tests listed on the STUDENT DATA SHEET and record the results. For tests marked with trial 1 and trial 2 do the test twice and get an average. Complete the first table.
2. Make careful notes on other non-living properties of the aquarium ecosystem. These should include clarity of the water, presence or absence of aeration, and the nature of any debris on the bottom.
3. Make careful notes on the biological properties of the aquarium ecosystem. These should include a description of the types and abundance of organisms present (fish, snails, plants, algae, and small animals).

Discussion:

1. Account for the results of each test. For example, if you obtained an oxygen concentration of 8 ppm, explain why it was that way.
2. Explain the effects of each result on living organisms. For example, if you obtained a pH of 9, what effect will that pH have on living organisms? Can the aquarium support a wide range of fish species?
3. Make an overall judgement on the quality of the water in the aquarium. will it support a wide range of species of organisms? Is it polluted?

ANALYZING AN UNKNOWN WATER SAMPLE

STUDENT DATA SHEET

Factor	Trial 1	Trial 2	Average
dissolved oxygen	______	______	______
carbon dioxide	______	______	______
pH	______	______	______
total hardness	______	______	______
phosphate	______	______	______
nitrate	______	______	______
B.O.D.	______	xxxxxxx	______
coliform	______	xxxxxxx	______
water temp.	______	______	______
surface light	______	______	______

Procedure (Notes #2) ____

____

Procedure (Notes #3) ____

____

____

____

#1. Discussion results:

D.O. ____

CO2 ____

pH ____

T. hardness ____

phosphate ____

nitrate ____

B.O.D. ______________________________

coliform ______________________________

w. temp. ______________________________

s. light ______________________________

#2. Discussion results:

D.O. ______________________________

CO2 ______________________________

pH ______________________________

T. hardness ______________________________

phosphate ______________________________

nitrate ______________________________

B.O.D. ______________________________

coliform ______________________________

w. temp. ______________________________

s. light ______________________________

#3. Discussion results:

____

____

____

____

HUNTOON CREEK STUDY
METHOD

1. Familiarization with topographic map of the study area.
2. Develop research teams of four to five students each. Teams are heterogenous in make-up based on the students academic grades.
3. Parent letter detailing activities and transportation.
4. Physically survey the test sites and surrounding land forms that may have an impact on the water quality of the creek. Use a video camera for class discussion later.
5. Begin the study of chapter two, Chemical and Physical Aspects of Water Pollution. Background material will be studied and discussed when the research teams are not out in the field.
6. Before testing in the field, there will be an analysis of an unknown water sample using Hach Water Test Kits for: D.O., CO2, pH, total hardness, phosphate, nitrate, and B.O.D.
7. Familiarize students with all materials, testing equipment, and safety practices. Determine specific student responsibilities within each team.
8. Do a practice trip to each test site by the respective teams doing all tests and collection the data.
9. Discussion and problem solving from the practice trip.
10. Take tests weekly from each site according to the schedule and complete the composite data base sheets.
11. Data analysis and graphing of the various parameters.
12. Compile the research teams booklet.

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LELAND WHEATON, *Principal*
RONALD BEEGLE, *Assistant Principal/Athletic Director*

Dear Parent, Sept. 25, 1991

This year in Advanced Biology we are doing an analysis of the water and life in Huntoon Creek and the shore of Huntoon Lake. This makes it necessary to divide the class into research teams with a student driver and an alternate student driver. The follwing dates have been selected for testing: Sept. 26; Oct. 2, 9, 16, 23. Second hour will be out from 9:00-10:00 and fourth hour from 11:30-12:30. If you have any questions or concerns or are interested in coming along please call me at school, 589-8294, or at home, 589-9678.

I have stressed safety to the students both with driving and the water. No student will be in a boat at Huntoon Lake. They will have waders at the shoreline and the creek is two feet deep or less where we are testing.

Below is a list of research teams with the driver(*) and alternate(alt.) driver shown.

Wayne Miller

Second hour	Fourth hour
A. Christensen	E. Luke
(alt)J. Hensley	D. Allard
* B. Bradish	A. Carr
A. Ekins	D. Cowing
C. Quillin	* M. Johnson
(alt)J. Poleski	(alt) J. Scofield
K. Morton	S. Gulvas
* D. Evans	M. Hanson
C. Puckett	* D. Glyn
* L. Mullins	S. Hartenburg
A. Beltran	(alt) R. Demon
S. Angell	M. Angell
J. Sweet	* B. Cradock
* G. Tidd	L. Slates
(alt)C. Martin	(alt) J. Gibbs
B. Chenault	C. Cradock
H. Patrick	* M. Beaman
(alt)A. Lance	(alt) J .Benson
A. Smally	M. Hendershot
D. Creisher	J. Sartin
* T. Feazel	* O. Martin

PHYSICAL STREAM STATISTICAL CALCULATIONS

Average Depth

Materials:

rope marked in equal increments (long enough to span the width of the stream).

meter stick, pencil, paper, calculator

Procedure:

1. Stretch the rope across the width of the stream.
2. Measure and record the water depth at each marked increment on the rope.
3. Calculate the average depth by finding the sum of the depth measurements and dividing by the number of measurements.

Velocity of Flow

Materials:

stop watch, known length of string (meters)

buoyant object (orange, wood block, ball)

Procedure:

1. Stand near the center of the stream.
2. Set stop watch.
3. Holding your hand with the end of the string near the surface of the water, place the object up stream from your hand. When the object is even with your hand start the stop watch. When the string is at full length stop the watch. Record the time elapsed.
4. Repeat step 3, 3 or 4 times to get an average.
5. Compute the velocity of flow in meters per second.

Volume of Flow

With the velocity of flow calculated above use the following formula:

$$r=wdav$$

r = rate or volume of flow

w = average width in meters of the stream section

d = average depth in meters of the stream section

a = a constant of 0.8 if the stream bed is quite smooth (sand, silt, bedrock).

v = velocity of flow from above.

WATER ANALYSIS
STUDENT DATA SHEET

1. Test Site (Circle one) Research Team______________
   - A. Huntoon Lake ______________
   - B. Race St. Bridge ______________
   - C. Walk Bridge ______________
   - D. After sewage discharge ______________
   - E. Olds Rd. ______________

   Date______________
   Time______________

2. Nature of Shore______________________ Weather-wind speed__
   -wind dir.___
3. Nature of Bottom_____________________ -sky__________

4. Appearance of Water_________________ Air Temp.____________

5. Width of Stream________meters. Water Temp.__________

6. Average Depth__________meters. (Calculate on the back.)

7. Velocity of Flow_______meters/sec. (Test p. 189)

8. Volume of Flow_________cu. meters/sec. (Text p. 190)

9. Materials

Hach water test kits	boots
1 float (wood block/string)	5 zip lock bags
1 thermometer	2 B.O.D. bottles
3 plastic containers	tape measure
1 meter stick	1 500 ml. flask
1 timer (watch)	1 waste water container
1 marked rope	

10. Chemistry

TEST	RESULT	ACCEPTABLE LEVELS
DISSOLVED OXYGEN	______	__________________
CARBON DIOXIDE	______	__________________
pH	______	__________________
TOTAL HARDNESS	______	__________________
PHOSPHATE	______	__________________
NITRATE	______	__________________
B.O.D.	______	__________________
COLIFORM	______	__________________

WATER ANALYSIS COMPOSITE

DATA BASE

ACTIVITY						Mean
Time	____	____	____	____	____	____
Site	____	____	____	____	____	____
Wind Speed	____	____	____	____	____	____
Wind dir.	____	____	____	____	____	____
Sky	____	____	____	____	____	____
Air temp.	____	____	____	____	____	____
Water temp.	____	____	____	____	____	____
Water app.	____	____	____	____	____	____
Volume f.	____	____	____	____	____	____
D.O.	____	____	____	____	____	____
C.O.2	____	____	____	____	____	____
pH	____	____	____	____	____	____
T.H.	____	____	____	____	____	____
Phos.	____	____	____	____	____	____
Nitrate	____	____	____	____	____	____
B.O.D.	____	____	____	____	____	____
Coliform	____	____	____	____	____	____
Index	____	____	____	____	____	____
Sediment	____	____	____	____	____	____
Nutrient	____	____	____	____	____	____

Leslie High School Water Study
A Chemical and Biological Analysis of Huntoon Lake and Creek Report

TABLE OF CONTENTS

APPENDIX B

LESSON PLANS

ECOLOGY AND WATER QUALITY

ENTRY CONCEPTS

NAME___________________________

Given the following information, write a one + page paper explaining as much as you can about the interrelationships and changes that may occur in a stream.

* type of bottom where the water is moving fast/slow.
* temperature of the water as the air temperature rises.
* amount of dissolved oxygen and carbon dioxide

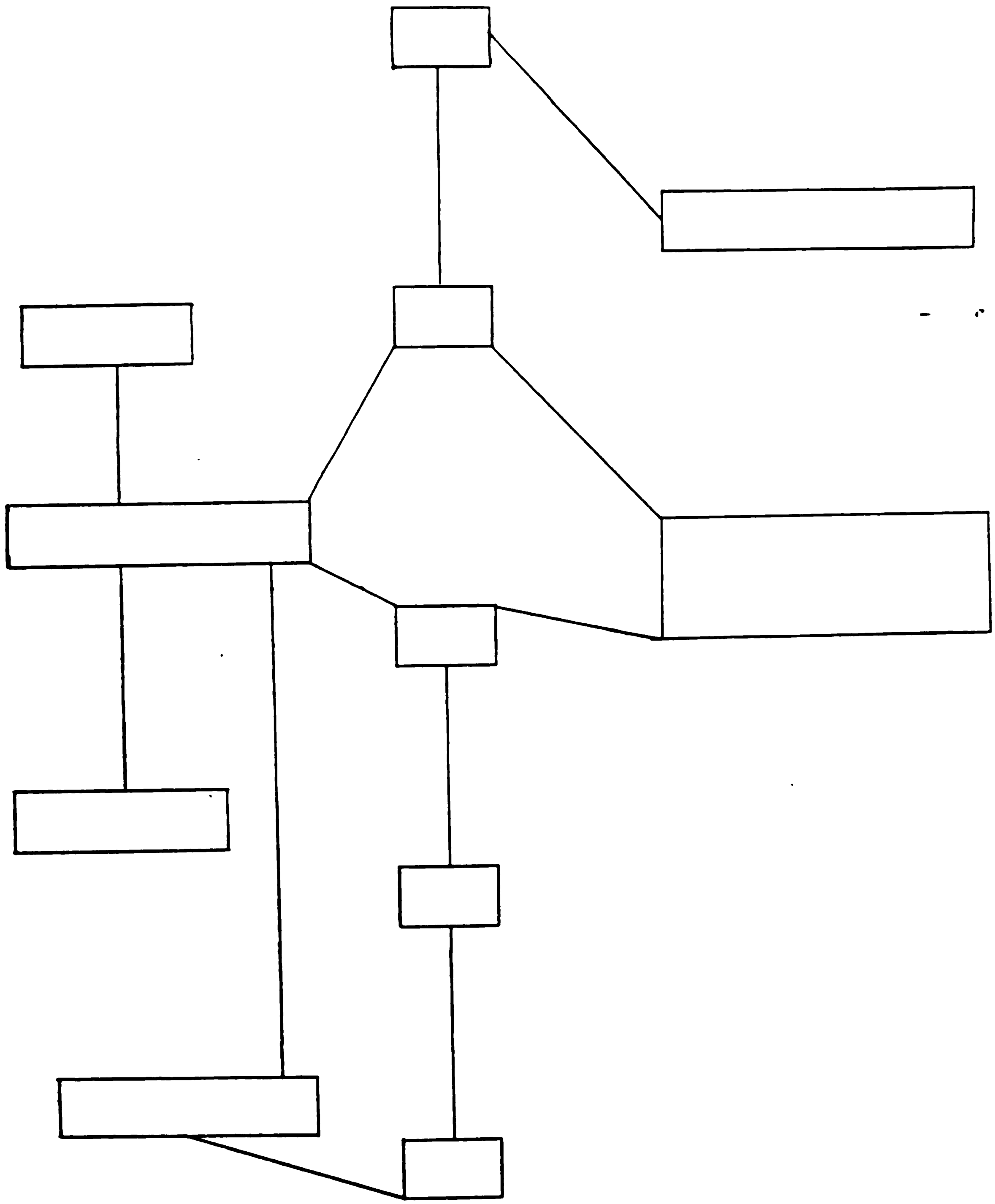
  as the temperature rises

  as the amount of decomposers increase

  as the amount of plants increase
* since nitrogen and phosphorus compounds act as a fertilizer on farm fields, what effect may they have as runoff into a stream?
* similar or different types of organisms in a small lake compared to a stream, explain.
* since coliform bacteria are an indication of sewage in a stream and yet this provides food for microorganisms, what effect may this cause in relation to: turbidity, photosynthesis, various organisms, $O2$, and $CO2$ (be careful)

THINK! THINK! THINK!

Chapter 2 CONCEPT MAP



ENVIRONMENTAL POLLUTION

TERMS

Ecology - A branch of science concerned with the interrelationships of organisms and their environment.

Population - A group of individuals in time and space.

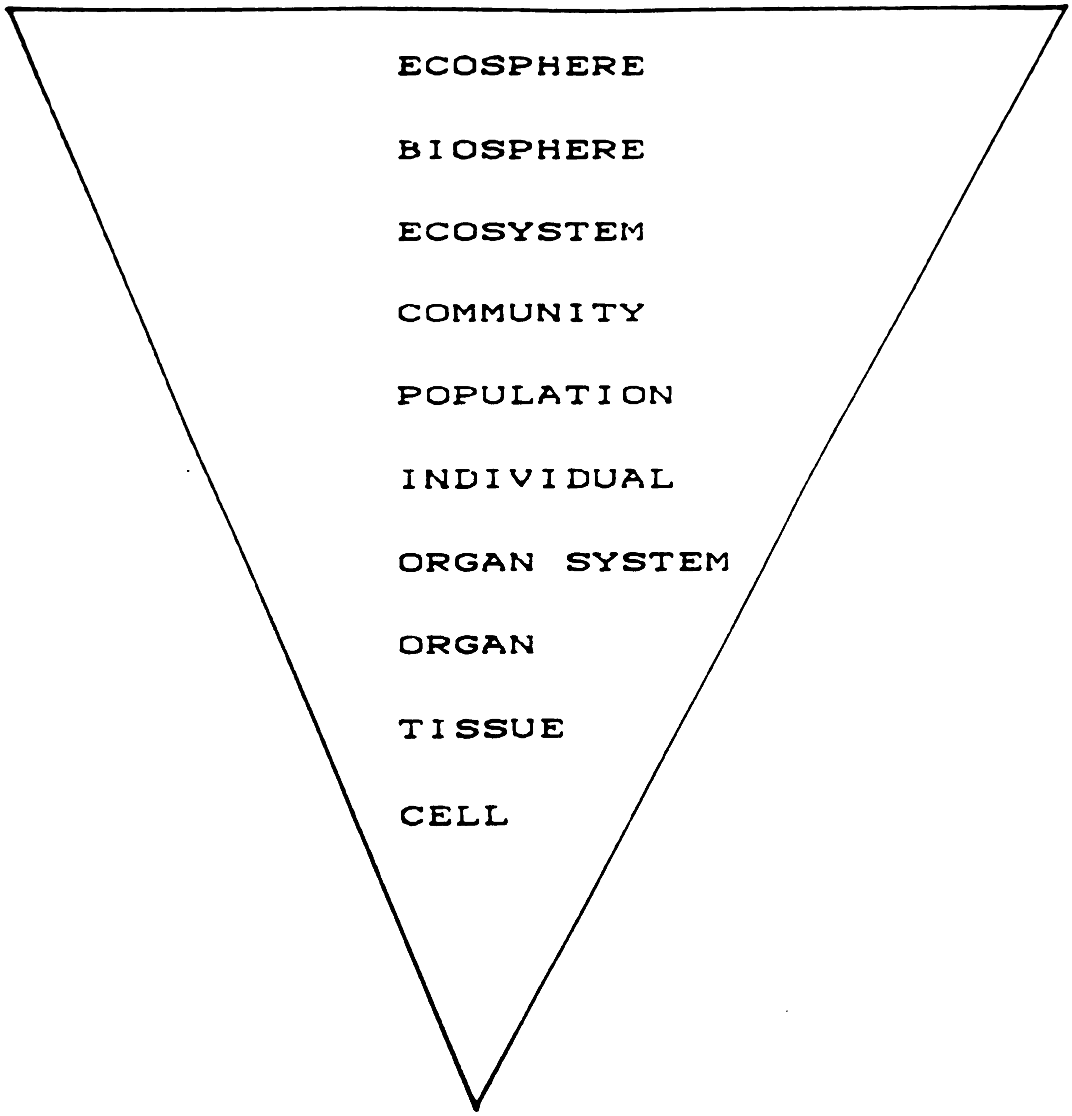
Community - All of the species populations that naturally inhabit a given area.

Ecosystem - A community and its physical environment as a single interacting system (biotic - living & abiotic - non-living).

Biosphere - Sum total of all life on our planet.

Ecosphere - Sum total of all the ecosystems on the earth.

LEVELS OF ORGANIZATION



TYPES of FRESHWATER

ECOSYSTEMS

Standing Waters

Name	Description
Pond	- shallow - light can reach bottom in most places - considerable vegetation, mostly submerged
Lake	- deeper than a pond - light cannot reach bottom in many places - no vegetation in deeper areas
Marsh	- very shallow - no open expanses of water - contains "islands" of soggy land - dominated by cattails, - bulrushes, reeds, and grasses

Name	Description
Carr	- very shallow - drier "islands" of land - dominated by shrubs
Swamp	- like a carr, except - "islands" of land have trees on them
Bog	- waterlogged spongy area (peat) - contains acidic water - dominated by sphagnum moss
Fen	- waterlogged spongy area (peat) - contains neutral or basic water - dominated by sedges, grasses and mosses
Slough or pothole	- small lake or pond - nutrient-rich - in low areas of prairies

TYPES of FLOWING WATERS

How do we tell the difference between a Brook, Creek, Stream, and River?

STREAM ORDERS

Fig. 1-3 A typical river system has many stream orders. What orders are a, b, c, and d?

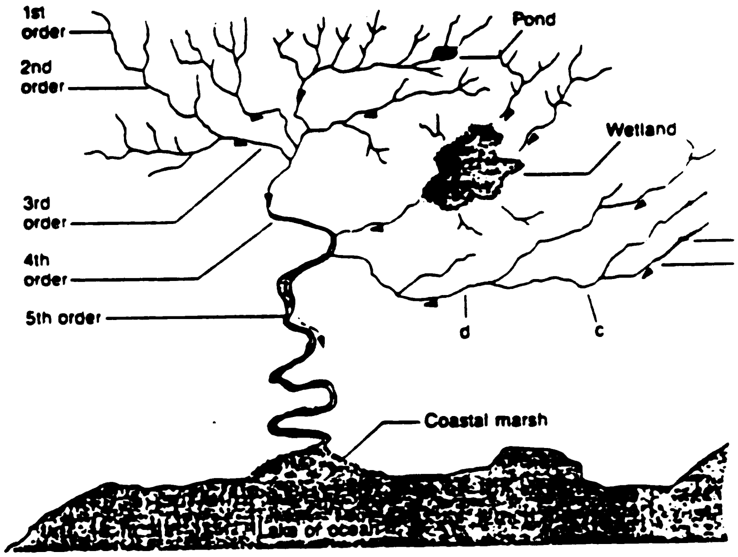
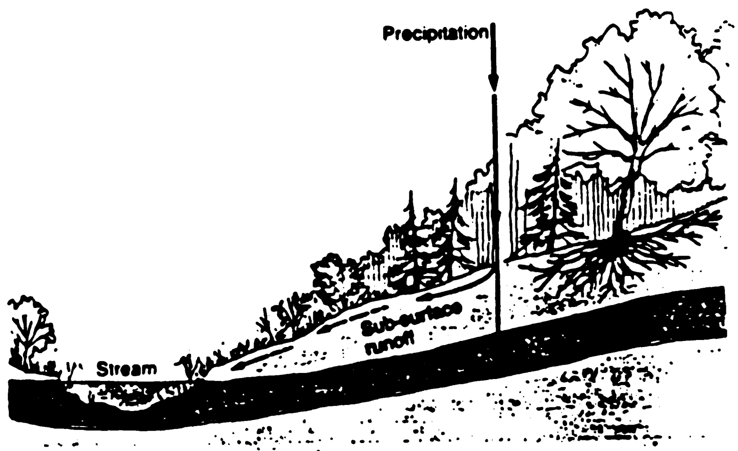


Fig. 1-4 Cool water often enters streams from such sources as sub-surface runoff and the water table.



Two main things usually happen as the stream order increases.

1. The water becomes warmer.
2. The stream speed decreases.

LAKE FORMATION ACTIVITY

FRESHWATER ECOSYSTEM IN OUR AREA

Type of Eco.	Size	Location	Surround.

ANSWER DISCUSSION QUESTIONS 1 & 2

FRESHWATER ECOSYSTEM IN YOUR AREA

Discussion Questions

1. If the ecosystem is a stream,

    a. what stream order is the stream?
    b. what is the origin of the stream?
    c. where does it end?
    d. what factors along its path may affect the water quality of the stream? In what ways?
    e. does the future look good or bad for the stream? Explain your answer.
    f. what is the stream used for? Which uses may change in the future?
    g. who has jurisdiction over the stream? Is it in private property or is it in property administered by some level of government?

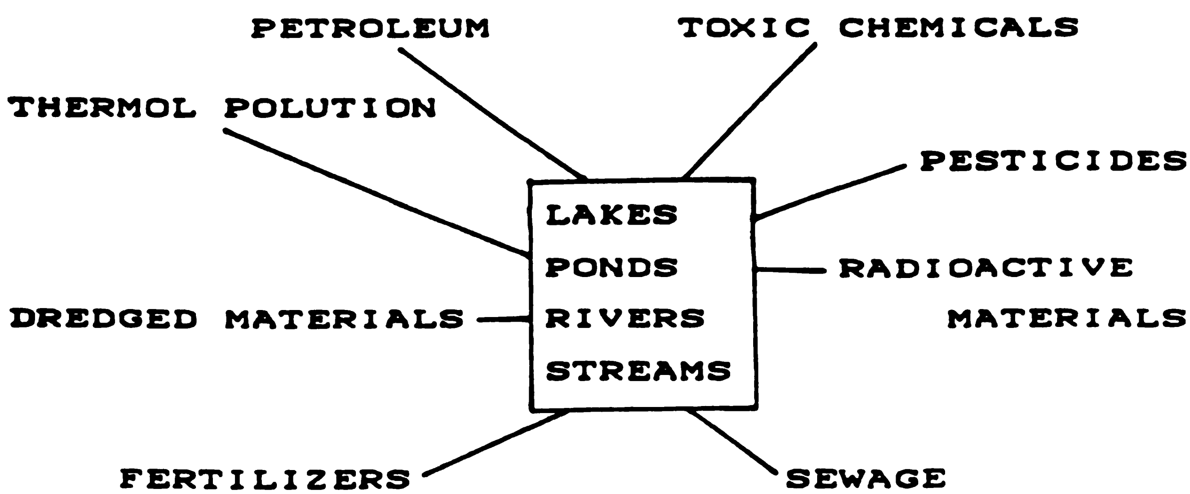
2. If the ecosystem is a lake, pond, or wetland,

    a. from where does this ecosystem get its water?
    b. where does the water go when it leaves this ecosystem?
    c. what is the lake or pond used for? Which uses may change in the future?
    d. how good is the water quality of the ecosystem? (Try asking people who may know.)
    e. what factors affect the water quality of the ecosystem?
    f. does the future look good or bad for the ecosystem? Explain your answer.
    g. what species of wildlife use the ecosystem? (You may need to drive by and observe using binoculars.)

POLLUTION - Undesirable change in the physical, chemical, or biological characteristics of an ecosystem.

Explain and give examples of how pollution may effect each of the various levels in the above chart. (discussion)

Explain how pollution is a/an
- Health problem -
- Economic problem -
- Problem in conservation of natural resources -
- Aesthetic problem -



WETLANDS (Filmstrip and worksheet)

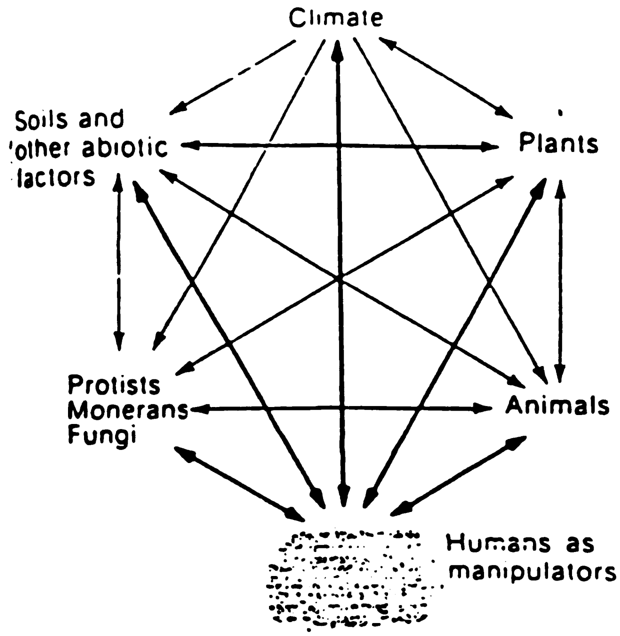
ECOSYSTEM CONCEPT and STRUCTURE

Biotic components - plants, animals, protists, and monerans.

Abiotic components - water, carbon dioxide organic and inorganic substances in the soil, and such physical factors as wind, moisture, light, and temperature.

The most important thing about an ecosystem is that its various components are highly interrlated.

Give specific examples of the following chart.



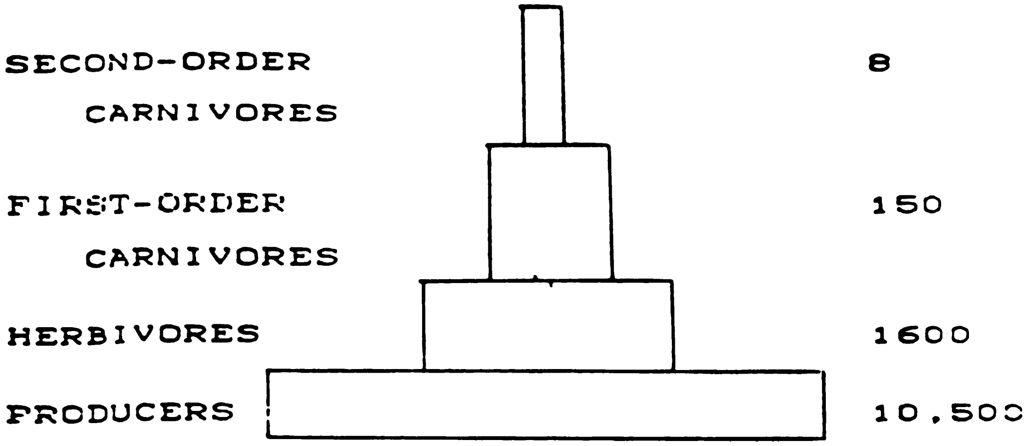
Make an aquatic model ecosystem.

PYRAMID of ENERGY

This represents the total energy flow at that level.

Energy Flow Factors

1. Energy is lost into the environment at each successive level. WHY?



2. Energy flow is one-way, no recycling. A continual supply of energy is necessary in all ecosystems

NUTRIENT CYCLES

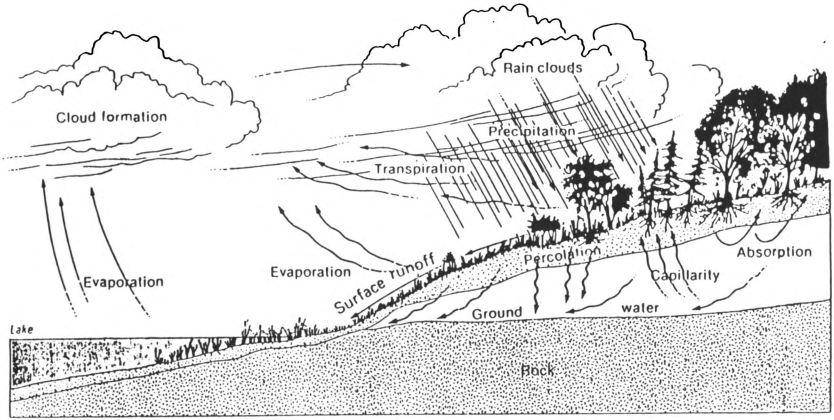
WATER

CARBON

NITROGEN

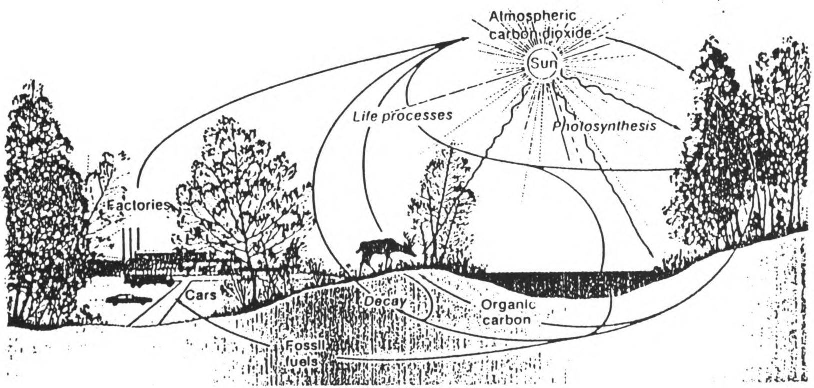
PHOSPHORUS

WATER CYCLE



Rain clouds
Cloud formation
Precipitation
Transpiration
Evaporation
Evaporation
Surface runoff
Percolation
Absorption
Capillarity
Ground water
Rock
Lake

CARBON CYCLE



Biotic (living)

- Trophic (feeding) levels
  - Primary producers (green plants)
    - Autotrophic - self feeders
      - energy source - sun
      - chlorophyl
      - photosynthesis
      - $6CO_2 + 6H_2O$ + light $\longrightarrow C_6H_{12}O_6 + 6H_2O$
  - Consumers
    - Heterotrophic - other feeders
      - respiration
      - $C_6H_{12}O_6 + 6O_2 \longrightarrow$ energy $+ 6CO_2 + 6H_2O$
      - primary
      - secondary
      - tertiary
      - (slide set)

Food Chain

producers -- herbivores -- carnivores -- higher order carnivores

Write an example of a natural food chain making it as long as possible.

Food Web

It is impossible to draw parallel food chains in an ecosystem. Cross-linkes create a food web.

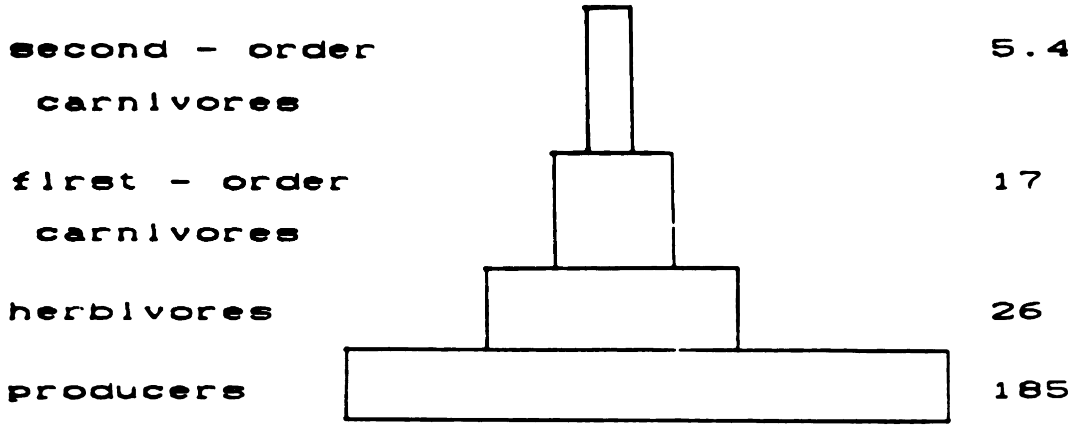
Write two different food chains from the food web on p.8.

Make a picture collage of an ecosystem of your choice with as much diversity as possible.Write a paragraph of explanation.

PYRAMID of BIOMAS <greater importance>

The total mass per unit area of each organism in a particular food chain.

seed --- mouse --- hawk



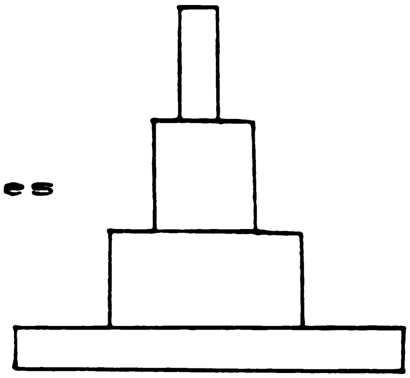
<Problem> No allowance is made for differences in calorie or energy releasing ability. One gram of organism provides the same amount of energy as one gram of any other organism.

This is not true.

1 to 4, 1 to 5, 1 to 7 or 8 in migrating birds or hibernating animals

Ecological Pyramids

The number of organisms decrease as the size of the organisms increase creating a PYRAMID of NUMBERS



moles, birds 2

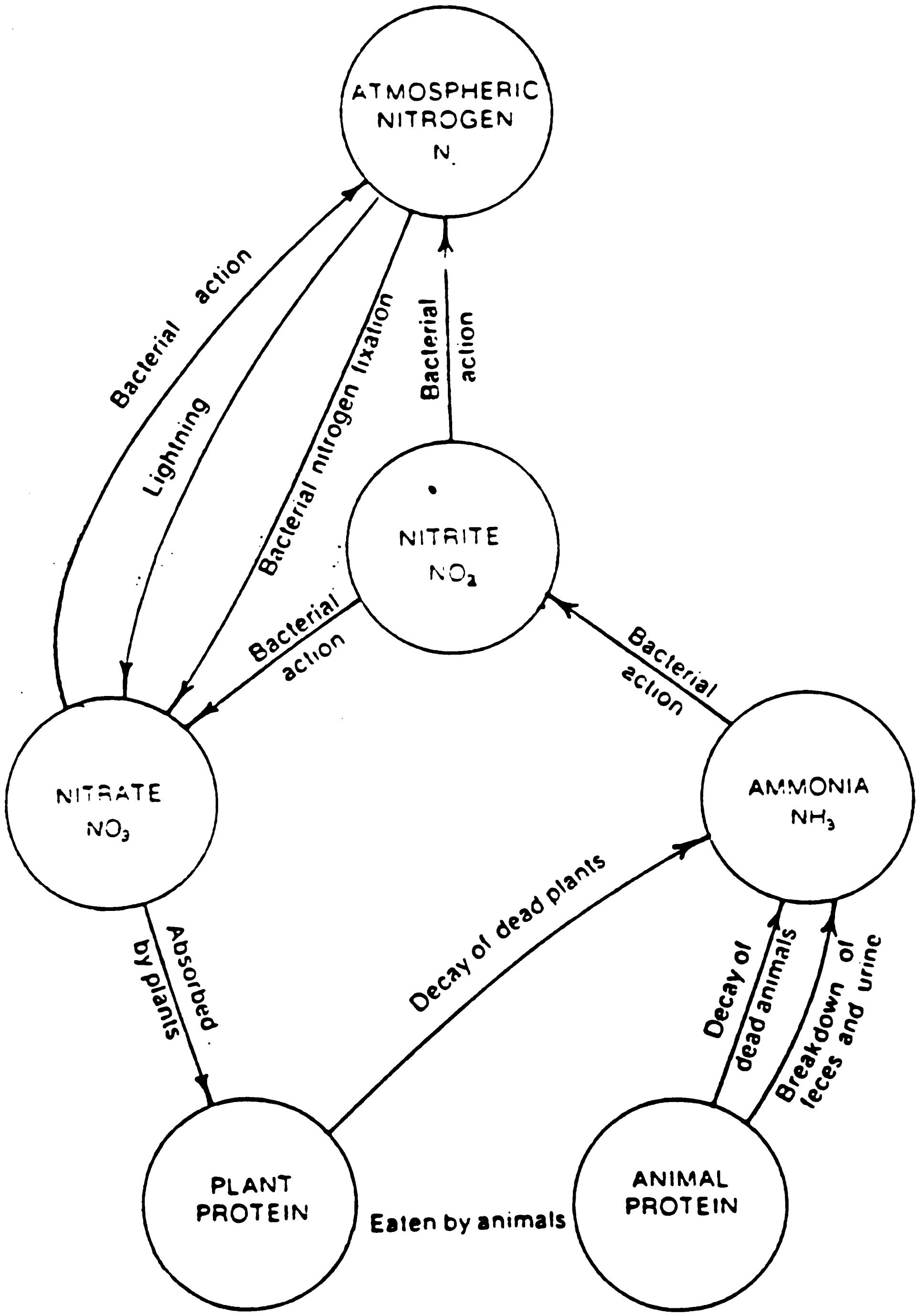
spiders
carnivorous beetles 17000

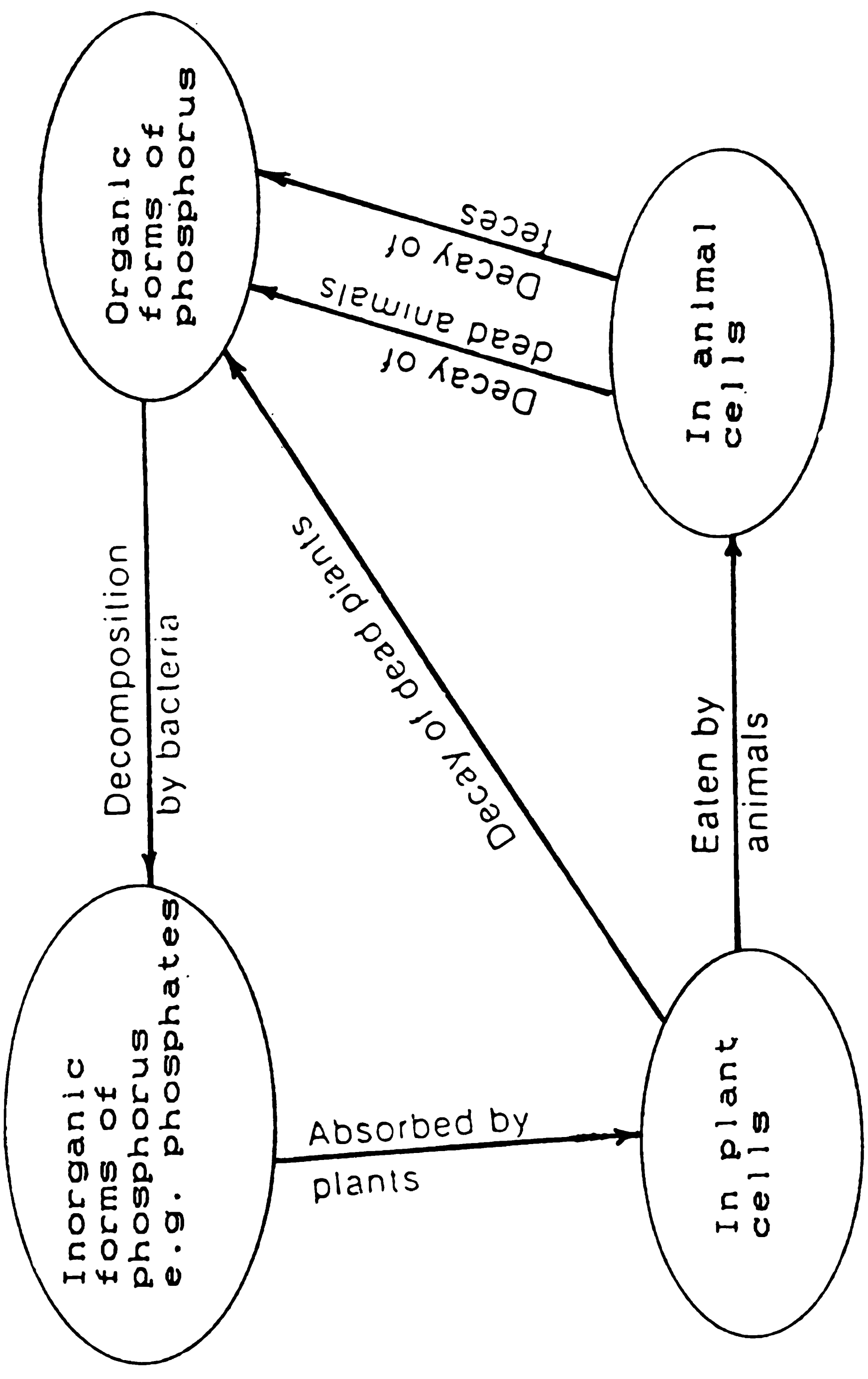
mostly insects 320000

green plants 2500000

(makes no allowance for difference in sizes of the organisms)

NITROGEN CYCLE





PHOSPHORUS CYCLE

Summary of the structure and fuctioning of ecosystems.

1. Most ecosystems have the same three biotic parts: producers, consumers, and decomposers. The actual species will differ from ecosystem to ecosystem.
2. A highly interdependent relationship exists between the biotic and abiotic parts of an ecosystem.
3. Energy flow in ecosystems is one-way. Energy is gradually lost along food chains. Little or none is recycled to producers. Therefore energy must always enter the ecosystem from the sun.
4. Most ecosystems need the same 20 or so nutrients. These nutrients are recycled within each ecosystem.

Upsetting the nutrient balance in an ecosystem. (lab).

CARBON DIOXIDE

In water - the amount is related to the water temperature. (example)

A. CO_2 mixes with water by diffusion (very slowly)

B. Wave action helps

C. Spring and fall overturn

LAKE TEMPERATURE LAYERING

SUMMER

upper layer, warm 65-75 F.

less dense

floats on middle layer

middle layer, rapid drop 45-65°F

bottom layer, colder, 39.2-45° F.

low light in middle & lower layer, no photosynthesis

no mixing

Decomposition of organic debris in the lower layer, increase in CO_2 decrease in O_2

Most fish live in the upper layer where food & O_2 are plentiful

FALL

Upper layer cools to temp. of the middle layer, the two mix (fall overturn)

WINTER

Upper & middle cool to temp. of the lower layer, dense water sinks & they mix. Less animal activity in winter.

In Rain Water

A. Obsorbed by the drops as they fall (.6 ppm)

B. Reacts with water to form carbonic acid

$CO_2 + H_2O$ <------> $H_2 + CO_2$

C. Rain water on land

1. collects more CO_2 through air spaces in the soil
2. becomes more concentrated
3. forms calcium bicarbonate upon contact with limestone
4. this passes through the soil to bodies of water as a result of runoff

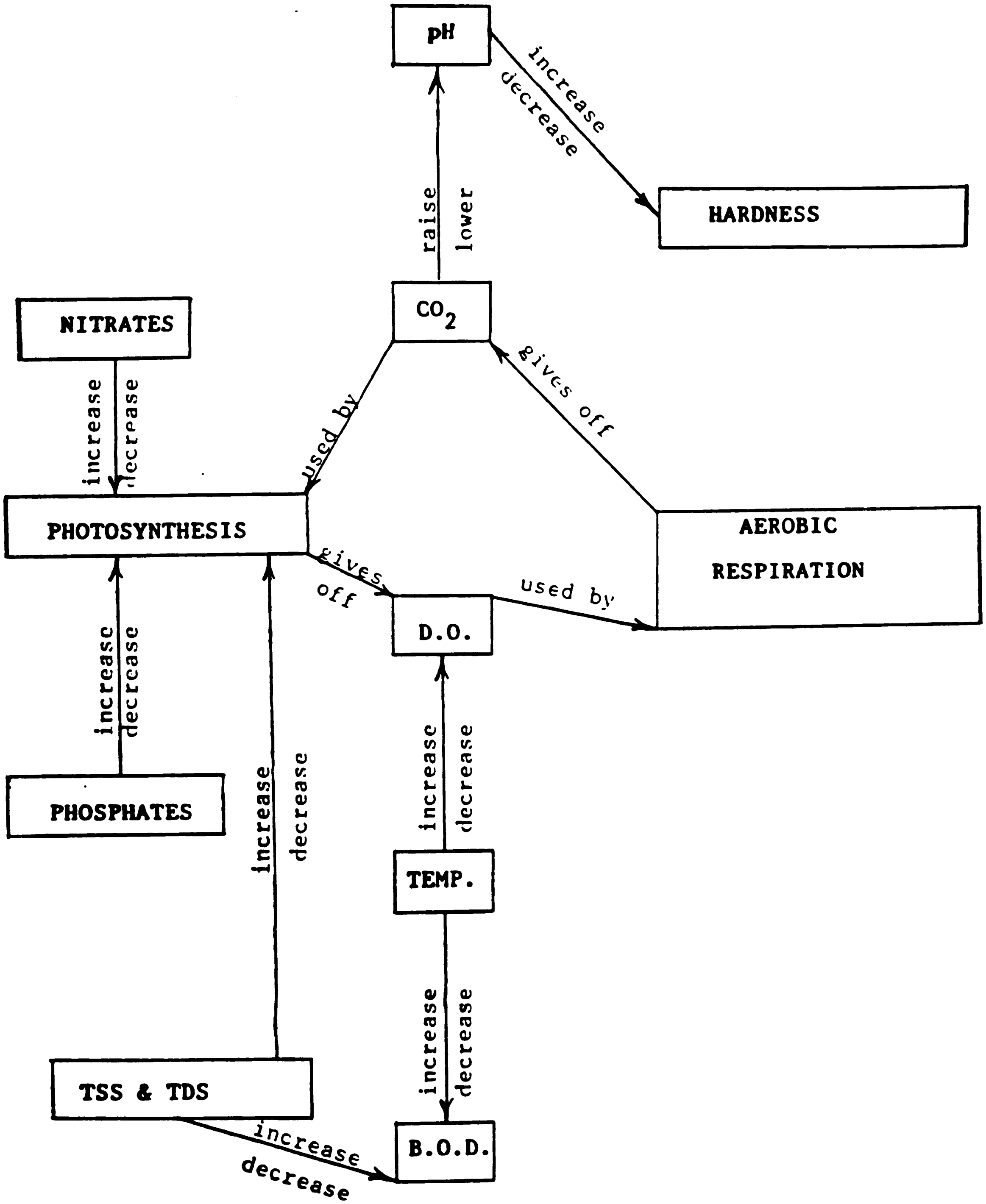
CO_2 FROM METABOLISM

(see table)

There is a close relationship between D.O. content and free CO_2 in the environment.

Water testing for pollution would be

Chapter 2 CONCEPT MAP



CH. 2 WATER ANALYSIS

1. Dissoloved oxygen (D.O.)

   This is the most significant test to measure water quality in a stream, pond, or lake.

   Acceptable level

   No less than 5 ppm of oxygen (5mg/liter of H_2O)

2. D.O. concentration of a body of water depends on:

   A. temperature

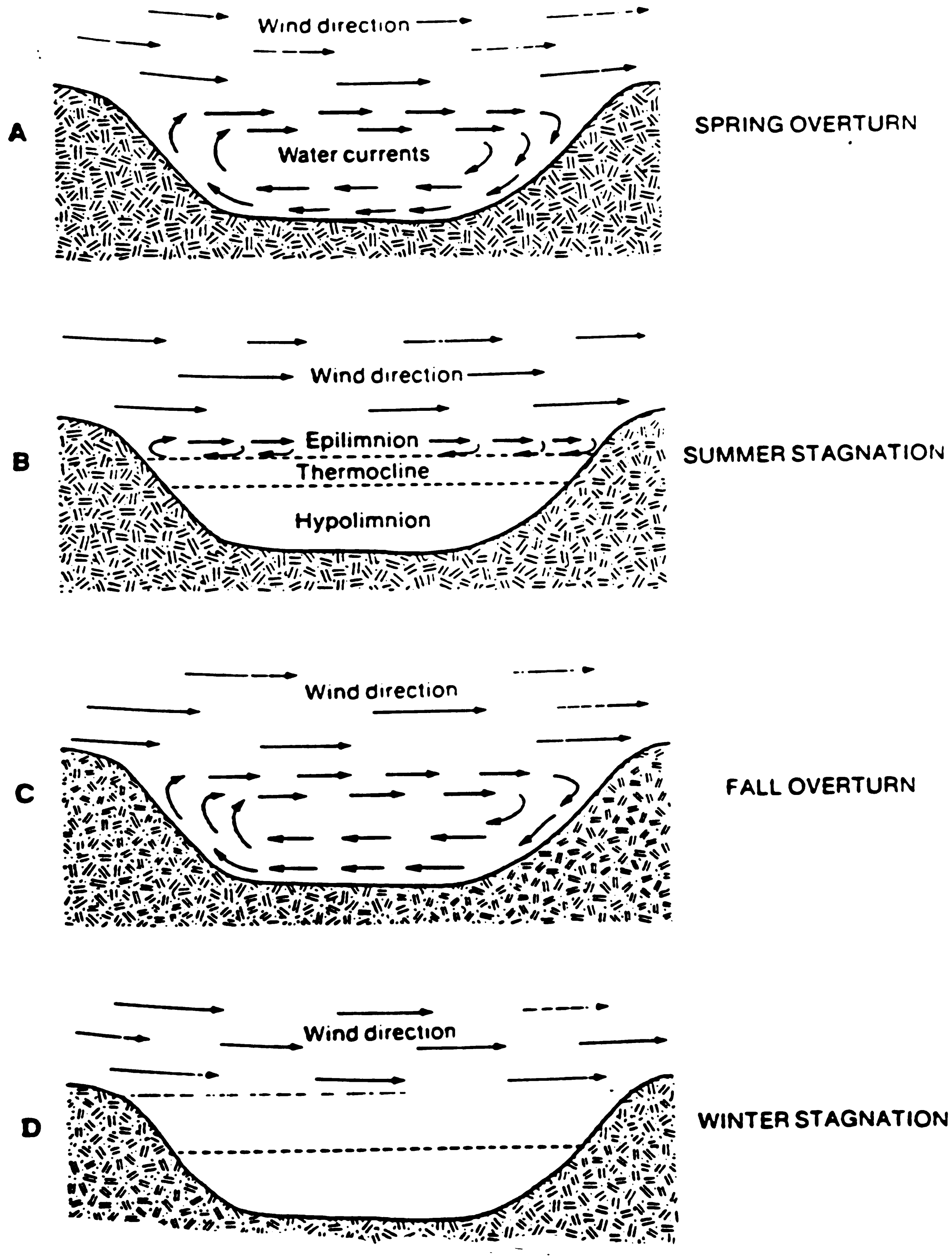
   B. The presence or absence of photosynthetic plants (microscopic & macroscopic)

   C. The degree of light penetration (dependent upon depth & turbidity)

   D. The degree of turbulance in the water

   E. Amount of organic matter being decomposed in the water (sewage dead algae, industrial wastes)

OVERTURN


Wind direction
A
Water currents
SPRING OVERTURN
Wind direction
B
Epilimnion
Thermocline
Hypolimnion
SUMMER STAGNATION
Wind direction
C
FALL OVERTURN
Wind direction
D
WINTER STAGNATION

simple if this were all. Four other substances must be considered.

1. pH The pH of an aqueous sloution representes the concentration of hydrogen ions in solution. It is on a scale of 0 to 14. (see chart)

pH SCALE

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

<--acedic--> ! <--basic-->

Water having a pH range from 6.7 to 8.6 will support a good fish population The pH of a body of water usually drops as the body of water ages. It is basic when young and becomes more acedic with time. The cause relates to organic material build up and decomposition releasing CO_2 into the water. The presence or absence of nutrients has a distinct impact on plant and animal life and protists.

2. ALKALINITY - A body of waters capacity to neutralize acid. This is caused by bases and basic salts in the water. Common bases are hydroxides of sodium, calcium and magnesium

A solution can have a high alkalinity without being highly alkaline (having a high pH). Alkalinity is expressed in ppm of $CaCO_3$. 50ppm is low, 200 is high, sewage has a slightly higher alkalinity than general water.

3. ACIDITY A solution can also have a high acidity and not be highly acedic Def.- ability to neutralize bases. Typical weak acids - carbonic, acetic

4. HARDNESS - caused by calcium & magnisuim ions. In most natural waters hardness is mostly due to bicarbonates. Hardness is not desirable for economic reasons. Use of soap. When heated it causes a scale on boilers and hot water heaters. TEMPORARY HARDNESS AND PERMANT HARDNESS = TOTAL HARDNESS

SOFT ---------------- 0 -60

MODERATELY HARD ---- 61 - 120

HARD -------------- 121 - 180

VERY HARD -------- OVER - 180

T.H. values below 250 ppm are acceptable for drinking. T.H. above 500 could be hazardous. Geology is sometimes the cause of hard water.

NUTRIENTS

NITROGEN PHOSPHORUS POTASSIUM
SULFUR CALCIUM MAGNESIUM

Most important nutrient - Nitrogen present in all proteins.

Three main reservoirs of nitrogen

1. Atmospheric nitrogen 78%
2. Inorganic nitrogen compounds
3. Organic nitrogen compounds

Expectation of nitrogen in water

1. Dissolved nitrogen gas
2. Inorganic nitrogen compounds, nitrates, nitrites, ammonium, & ammonia .
3. Organic compounds - proteins of living & dead organisms & their metabolism (urea,uric acid)

The inorganic nitrogen compounds are the nost convenient indicators of nitrogen pollution.

A. Ammonia - A by-prodict of decay of plant & animal protein & of fecal matter. Presence is an indication of sewage entering the water. Also possible fertilizer farm runoff.

B. Nitrates - Formed when ammonia is converted to nitrates by bacteria.

Indicates possible <u>industrial pollution</u>. Nitrites are often used in <u>boiler water</u> to prevent corrosion Sometimes this is <u>released</u> into water systems.

C. Nitrates - formed chiefly by <u>electrical</u> stormes, nitrogen-fixing <u>organisms</u>, & the action of <u>bacteria</u> on ammonia. All the above occur <u>independently</u> of man.

Other causes of a rise in nitrates.

1. Man <u>discharging sewage</u> in a body of water.
2. farm <u>runoff</u> (fertilizers)
3. Natural <u>decay</u> of dead plants & animals.
4. Industrial <u>effluents</u> & animal <u>excreta</u>.

Effects of high nitrates in a body of water.

1. Increase in the <u>aging</u> of a lake.
2. Increase of <u>phytoplankton</u> & other plants.
3. lowering of <u>D.O</u>.
4. Change in <u>fish</u> population.
5. <u>Foul</u> odors, <u>disagreeable</u> taste, <u>low</u> recreational value.

Acceptable levels (see p.40)

PHOSPHORUS

Importance - A T P of cells

Three forms of phosphorus in an aquatic ecosystem.

1. Inorganic phosphorus compounds, phosphates
2. Organic molecules in the protoplasm of living & dead organisms.
3. Dissolved organic molecules from decomposition of dead organisms & of waste from living organisms.

Path of phosphorus through a typical aquatic ecosystem.

1. Water normally contains inorganic phophorus.
2. Phytoplankton & other plants absorb phosphates to synthesize ATP
3. Herbivores eat plants to obtain phosphorus.
4. When plants & animals die & decompose, phosphorus returns to water, organic phosphorus

5. Organic phosphorus is converted to inorganic phosphorus by bacteria & the cycle continues again.

LIMITING FACTOR

The amount of phosphorus seems to be a controling factor of lake eutrophication (high productivity) oligotrophic (low productivity)

Source of phosphorus pollution, sewage industrial effluents, agricultural run-off, animal waste, decay plant & animal matter.

Control of phosphorus pollution

1. Ban on phosphates in detergents (eliminates 300,000,000#/yr.) (still have 700,000,000#/yr.) from human & animal feces

2. Water treatment - can remove 90-95% cost of $.05/1000 gal. of water

ACCEPTABLE LEVELS

"well balanced lake" should not have an inorganic phosphorus content above .015 ppm at the time of spring overturn Any above this will cause algal blooms.

TOTAL SUSPENDED & DISSOLOVED SOLIDS

This is in refference to particles of soil & various colors of water throughout the year.

TOTAL SUSPENDED SOLIDS (T.S.S.)

Chiefly - living & dead phytoplankton & zooplankton, silt, human sewage, animal excrement, portions of decaying plants & animals and industrial waste.

Def. - Amount of material by wt. that is suspended in a given volume of water (mg/L or ppm, mg/L = ppm)

Since measurement is time consuming turbidity estimates are used.

Turbidimeter. Amount of light that passes through the sample.

ACCEPTABLE LEVELS

Establish a norm for a body of water, any deviation would be unacceptable.

TOTAL DISSOLVED SOLIDS (T.D.S.)

Method of measure

1. Filter T.S.S. out of known volume of water & evaporate the water. (weigh what is left)
2. Impurities conduct electricity, pass a known current through the water sample.

ACCEPTABLE LEVELS

Below 100 ppm = oligotrophic

LAKE	T.D.S.
Superior	60
Huron	110
Michigan	150
Ontario	185
Erie	180

TRANSPARENCY & COLOR

Low transparency usually high productivity

PHYSICAL FACTORS

Temperature - Abnormal change of 5 C. will disrupt a fishes life. They can detect a .05 C. change. An increase in temperature usually causes an increase in the toxic effects of chemical pollutants in the water.

Other factors (physical)

- Streams & rivers
  - vloume of flow
  - nature of bottom
  - nature of banks
- Ponds & lakes
  - inflow & outflow
  - depth profile
  - nature of bottom
  - nature of shoreline

B.O.D. (5 DAY TEST)

General condition of water	B.O.D.
very clean	1 ppm
clean	2 ppm
moderately clean	3 ppm
doubtful cleanliness	4 ppm
poor	5 ppm

(example p.55)

CHEMICAL OXYGEN DEMAND (C.O.D.)

Test of C.O.D. takes into account three things

1. Biodegradable organic matter that would normally decompose in a 5-day B.O.D. test.
2. Biodegradable organic matter that does not decompose in 5 days but would eventually decompose & affect water quality.
3. Organic compounds that are not biodegradable.

DETERGENTS - TWO TYPES

Hard - nonbiodegradable (A.B.S.)

Soft - biodegradable (L.A.S.)

Both exert a harmful effect on fish at low levels. A.B.S. at 5 ppm destroys the effectiveness of the gills of trout (raw muncipal sewage contains 10 ppm) .5 ppm will destroy the taste buds of certain fish species in 3 to 4 weeks. A concentration of 10 ppm will do it in 1 day. This effects the eating habits of the fish. (read p. 57)

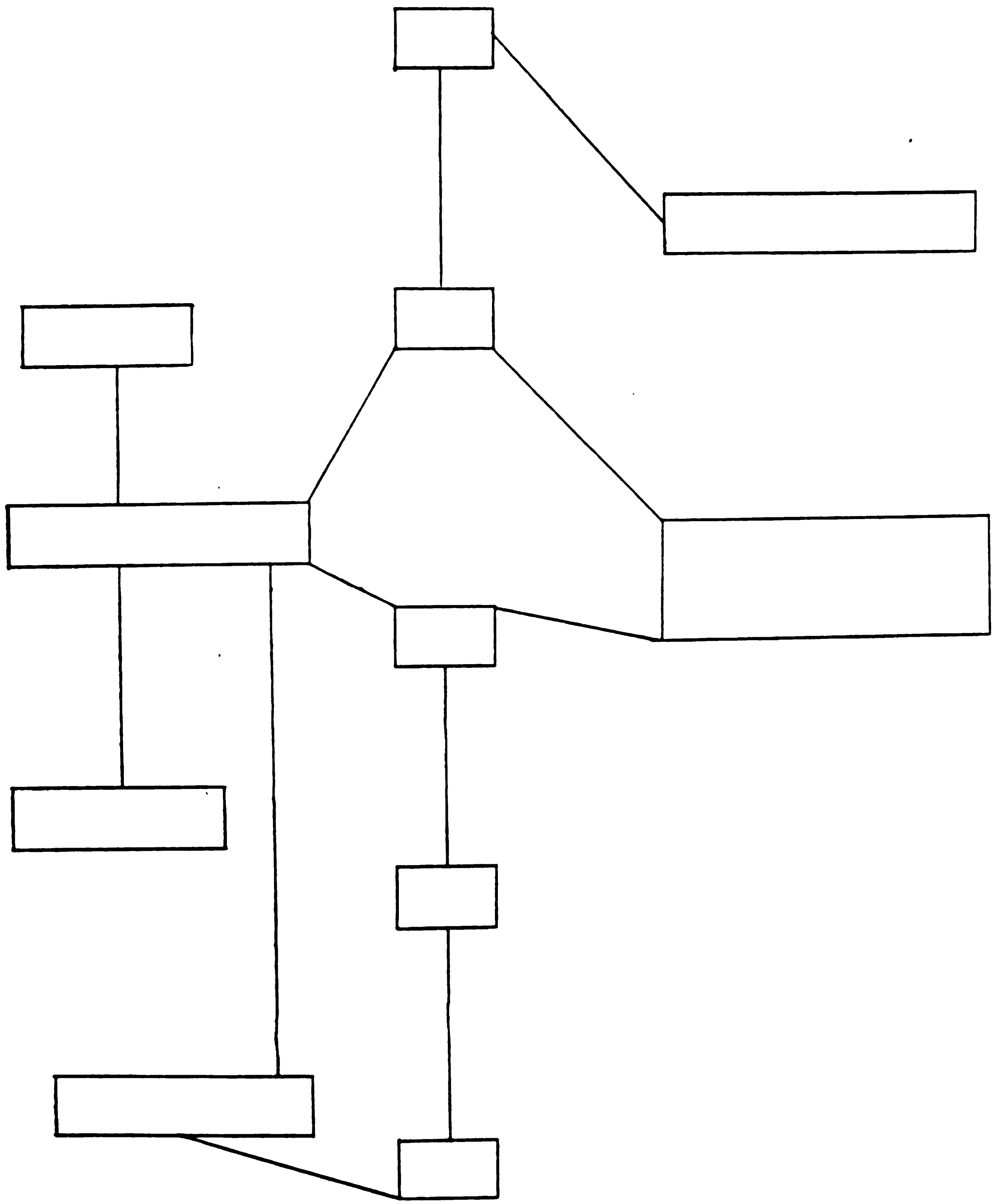
ACCEPTABLE LEVELS

1 ppm drinking water. Detergent industries are switching from hard to soft detergents. Soft detergents do not get broken down completely as they pass through the soil. (decomposition takes place only in the top 1" or 2" of soil.

SOLUTION

1. Replace hard with soft detergents
2. Proper advanced water treatment removes 90%.

Chapter 2 CONCEPT MAP



Chapter 2
Water Analysis

Name_______________

1. Dissolved oxygen ________________.

   a) This is the most significant test to measure water quality in a ________, ________, ________.

   b) Acceptable level:
      1) No less than __________ of oxygen (5mg/liter of H_2O)

2. D.O. concentration of a body of water depends on:

   a) ____________________________________

   b) The presence or absence of__________________________ (microscopic and macroscopic);

   c) The degree of light penetration (dependent upon ________ __________________.

   d) The degree of __________________ in water;

   e) Amount of organic matter being decomposed in the water (_______, ________, and ______________.)

<u>CARBON DIOXIDE</u>
In water - the amount is related to the water temperature.

   a) CO_2 mixes with water by __________________ (very slow)

   b) _______ ___________________ helps.

   c) Spring and fall _________________________.

<u>LAKE TEMPERATURE LAYERING</u>

Summer

upper layer__________________________.

less dense
   floats on middle layer.

middle layer, ______________________________.

bottom layer, ______________________________.

_______ light in ___________________________ layer, No ______________________________________

No ______________________________________

Decomposition of organic debris in the ______ layer, Increase in ______, Decrease in ______.

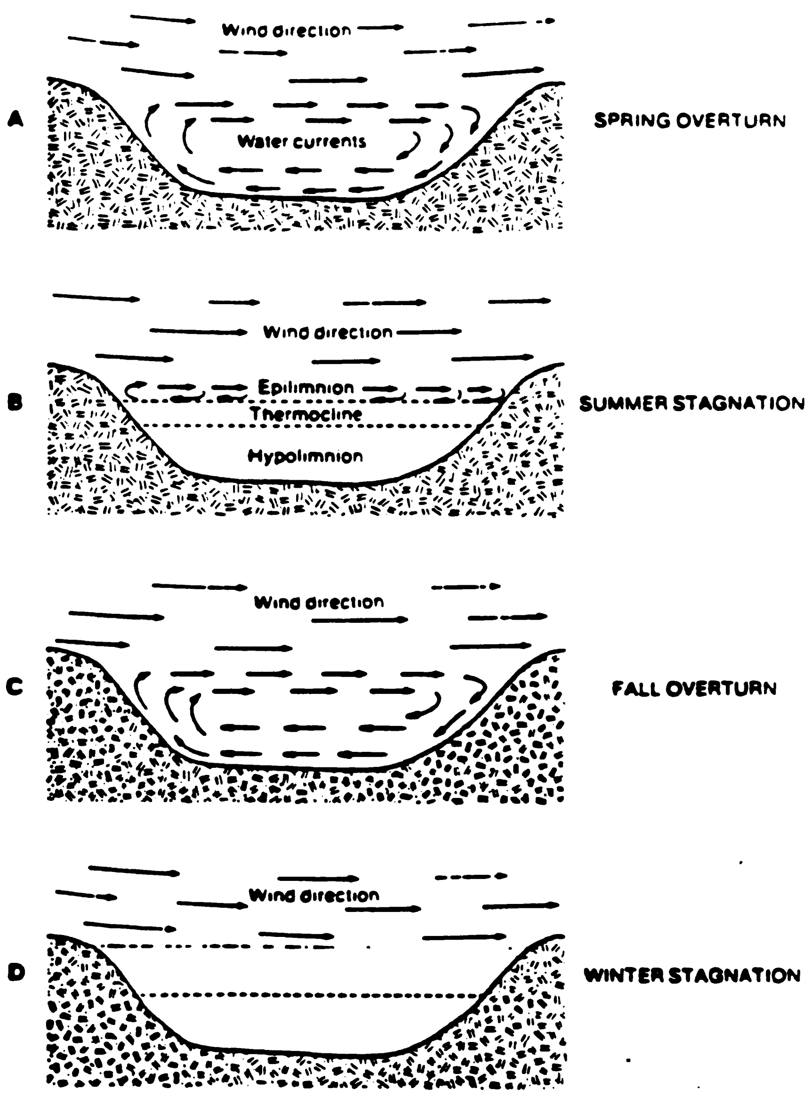
Most fish live in the upper layer where food and O2 is plentiful.

Fall

Upper layer __________ to temperature of the middle layer; the two ____________. (Fall overturn)

Winter

Upper and middle ______ to temperature of the ________ layer; _____________ water sinks and they mix. Less animal activity in winter.



In Rain Water:

a) Absorbed by the drops as they__________. (.6ppm)

b) Reacts with water to form ______________________.

c) Rain water on land

1) Collects more ___________ through air spaces in the soil.

2) Becomes more ________________________________

3) Forms calcium bicarbonate upon contact with ______________________.

4) This passes through the soil to bodies of water as a result of ______________________.

CO_2 from metabolism
(see table)

There is a close interrelationship between _____ content and free ________ in the environment.

Water testing for pollution would be simple is this were all. Four other substances must be considered.

1. pH. The pH of an aqueous solution represents the concentration of hydrogen ions in solution. It is on a scale of ________________ (see chart).

pH SCALE

Water having a pH range from ___________ _____ _______ will support a __________ ____________ population.

The pH of a body of water usually ______________ as the body of water ages. It is ____________ when young and becomes _______ ____________ with time. The cause relates to ______ ________ ___________ ___________ and releasing ______________ into the water.

The _______________ of or ______________ of nutrients has a distinct impact on ____________ and ____ ______ and ________.

2. <u>Alkalinity</u> - A body of waters capacity to neutralize __________. This is caused by ________ and ____ _________ in the water. Common bases are hydroxides of
   Sodium
   Calcium
   Magnesium

A solution can have a ___________ _________________ with out being ______________ ___________________ (having a high pH). Alkalinity is expressed in __________ ________ ______________.

50 ppm is _____
200 ppm is _____

Sewage has a __________ _____________ alkalinity than general water.

3. Acidity - A solution can also have a __________ _______ and not be _____________ __________. Def. - ability to neutralize bases.

Typical weak acids:

____

___________ ________________

4. <u>Hardness</u> - caused by __________ and _______ ions. In most natural water hardness is mostly due to _________.

   Hardness is _____ desirable for economic reasons. Use of soap. When heated it causes a scale on boilers and hot water heaters. ___________________ hardness and _____________ hardness = ____________________ hardness T.H.

   soft ____________________ppm

   moderately hard ____________________ppm

   Hard ____________________ppm

   Very hard ____________________ppm

   T.H. values below 250 ppm is _________________ for drinking. T.H. above 500 could be ____________________.

   ______________________ is sometimes the cause of hard water.

Nutrients

Nitrogen
Phosphorus
Potassium
Sulfur
Calcium
Magnesium

Most important nutrient - _________________ present in all proteins.

Three main reservoirs of nitrogen

1. ________________nitrogen

2. ________________nitrogen compounds

3. ________________nitrogen compounds

Expectation of nitrogen in H2O

1. ________________nitrogen gas

2. ________________nitrogen compounds nitrates, nitrites, ammonion, and ammonia

3. __________________________ - proteins of living and dead organisms and the products of their metabolism (urea, uric acid).

The ____ compounds are the most convenient indicators of nitrogen pollution.

A. Ammonia - a by-product of ________ of plant and animal protein and of fecal matter. Presence is an indication of ________________ entering the water. Also possible ____________________ runoff.

B. Nitrites - formed when ammonia is converted to nitrates by _______________. Indicates possible __ __________. Nitrites are often used in ___________ ________ to prevent corrosion. Sometimes this is _ ________________ into water systems.

C. Nitrates - formed chiefly by 1. _______ storms, 2. Nitrogen-fixing __________, and the 3. Action of _________ on Ammonia.

All the above occur ______________ of man.

Other causes of a rise in Nitrates
1. Man __________________ in a body of water.

2. Farm ______________ (fertilizers)

3. Natural ___________ of dead plants and animals.

4. Industrial __________ and animal _______________.

Effects of high Nitrates in a body of water

1. Increase in the _____ of a lake.

2. Increase of ___________________ and other plants.

3. Lowering of ____________________.

4. Change in __________ population.

5. ___________ odors, _____________ tastes, __________ recreational value

Acceptable Levels

(see ditto)

PHOSPHORUS

Importance - __________ of cells

Three forms of Phosphorus in an aquatic ecosystem:

1. __________________ phosphorus compounds phosphates po43-.

2. _________ molecules in the protoplasm of living and dead organisms.

3. ___________________________ molecules from decomposition of dead organisms and or waste from living organisms.

PATH OF PHOSPHORUS THROUGH A TYPICAL AQUATIC ECOSYSTEM.

1. Water normally contains ___________________ phosphorus.

2. Phytoplankton and other plants absorb _____________ to synthesize __________________.

3. Herbivores eat plant to obtain ____________________.

4. When plant and animals _____ and ________________, phosphorus returns to the water, ________________ ________________________________.

5. Organic phosphorus is converted inorganic phosphorus by ________________ and the cycle continues again.

Limiting Factor

The amount of phosphorus seems to be a controlling factor of _____________ ____________________. (High productivity) ________________ (Low productivity).

Source of Phosphorus Pollution

Sewage, industrial ________________, agricultural ________________________, animal ________________, decay plant and animal ___________________________.

Control of Phosphorus Pollution

1. Ban on phosphates in _______________ (eliminate 300,000,000 #/yr.)
   (still have 700,000,000 #/yr.)
   From _______ feces and __________________ feces

2. Water Treatment - can remove_____________ at a __________ of $.05/1000 Gal. of water.

ACCEPTABLE LEVELS

________ ______________ ________________ should not have an inorganic phosphorus content above ___________ at the time of ______________ overturn.
Any above this will cause __________ ______________.

Total Suspnded and Dissolved Solids

This is in reference to particles of ___________ and various _________ of water throughout the year.

Total Suspended Solids _________________________
Chiefly - ____________________&____________________
phytoplankton and zooplankton, silt, human sewage, animal excrement, portions of decaying plants and animals, and industrial waste.

DEFF. Amount of material by wt. that is suspended in a given volume of water. mg/L. or ppm
____

Since measurement is _____________________ turbidity estimates are used. Turbidimeter - amount of light that passes through the sample.

ACCEPTABLE LEVELS

Below 100 ppm = Oligotrophic

LAKE	T.D.S.
Superior	______
Huron	______
Michigan	______
Ontario	______
Erie	______

Transparency and Color

Low Transparency usually high ________________________.

PHYSICAL FACTORS

Temperature

Abnormal change of ______ will disrupt a fishes life. They can detect a _________ change, an ___________ in temperature usually causes an __________ in the toxic effects of _______________ ________________ in water.

Other Factors (Physical)

Streams and Rivers

Volume of ________

Nature of ________

Nature of ________

Ponds and Lakes

Inflow & ________   Nature of ________

Depth ________   Nature of ________

B.O.D. (5 day test)

General condition of water	B.O.D.
Very clean	___ ppm
Clean	___ ppm
Moderately clean	___ ppm
Doubtful cleanliness	___ ppm
Poor	___ ppm

Chemical Oxygen Demand ______________________

Test of C.O.D. takes into account ______ things.

1. Biodegradable organic matter that would _____________________ decompose in a _______ __________ test.

2. __________________________ organic matter that does _____ decompose in 5 days but, would eventually ________________ and affect water quality.

3. Organic compounds that are ____ biodegradeable.

DETERGENTS

Two types

Hard - ____________________ (A.B.S.)

Soft - ____________________ (L.A.S.)

Both exert a harmful effect on fish at low levels

A.B.S. at _______________ destroys the effectiveness of the ________________ of trout.
(Raw municipal sewage contains _________________)

__________________ will destroy the _____ _________ of certain fish species in _____ to _____ weeks. A concentration of _____ ppm will do it in ___ day. This effects the eating habits of the fish.
(read p. 57)

ACCEPTABLE LEVELS

___ ppm drinking water

Detergent industries are switching from _____ to _____ detergents.

Soft detergents do not get broken down completely as they pass through the soil. (Decomposition takes place only in the top ___________________ of soil)

SOLUTION

1. Replace ________________ with __________ detergents

2. Proper advances ________________________ removes ______ ____________.

APPENDIX C

PRE AND POST TEST

ECOLOGY AND STREAM WATER QUALITY

PRE-POST TEST

1. _____ A branch of science concerned with the interrelationships of organisms and their environment.

   a. community   b. ecosystem
   c. ecology   d. biology

2. _____ A community and its physical environment as a single interacting system (biotic - living and abiotic - non-living).

   a. population   b. ecosystem
   c. biosphere   d. ecosphere

3. _____ What is the central unit in the level of organization?

   a. organ   b. population
   b. community   d. individual

4. _____ What type of standing water is shallow, light can reach the bottom in most places, and considerable vegetation mostly submerged?

   a. marsh   b. pond
   c. lake   d. bog

5. _____ How do we tell the difference between a brook, stream, creek or river?

   a. stream order   b. type of bottom
   b. width   d. volume of water

6. _____ What type of ecosystems are in the Leslie area?

   a. river   b. lake
   c. marsh   d. all of the above

7. _____ Where does Huntoon Creek end?

   a. Huntoon Lake   b. Grand River
   c. Pleasant Lake   d. none of the above

8. ____ An undesirable change in the physical, chemical, or biological characteristics of an ecosystem is:

   a. pollution   b. desirable
   c. expected   d. contamination

9. _____ Is pollution a:

a. health problem
b. economic problem
c. aesthetic problem
d. all of the above

10. _____ Wetlands are very important to our community and state.

a. true
b. false

11. _____ An abiotic component of an ecosystem is:

a. plant
b. protist
c. water
d. animal

12. _____ In trophic levels, the green plants are:

a. consumers
b. heterotrophic
c. autotrophic
d. tertiary

13. _____ A food web is made up of many food chains.

a. true
b. false

14. _____ In ecological pyramids, the pyramid of _____ shows the best relationship of the organisms.

a. numbers
b. biomas
c. energy
d. liter

15. _____ In the water cycle, ground water and surface water are the same.

a. true
b. false

16. _____ For the most part we are using the same water that has been recycled through plants, animals, ecological systems for hundreds of years.

a. true
b. false

17. _____ Where does the carbon dioxide in the atmosphere come from?

a. plants
b. animals
c. decomposers
d. all of the above

18. _____ When fertilizers are put on farm fields and sometimes runs off into streams, the result is:

a. killing animal organisms
b. killing plants
c. stimulate plant growth
d. no effect

19. _____ Bacterial action plays a minor role in nitrogen transfer.

    a. true   b. false

20. _____ The niche of an organism is its role in the community.

    a. true   b. false

21. _____ Most ecosystems have the same three biotic parts: producers, consumers, and decomposers.

    a. true   b. false

22. Interdependence is not an important relationship between the biotic and abiotic parts of an ecosystem.

    a. true   b. false

23. _____ Energy flow in an ecosystem is _____

    a. two-way   b. one-way
    c. recycled   d. not necessary

24. _____ Most ecosystems need the same 20 or so nutrients recycling within the system.

    a. true   b. false

25. _____ What is the most significant test to measure water quality?

    a. CO2   b. D.O.
    c. 4 ppm   d. TSS

26. _____ What level of dissolved oxygen is considered to be unacceptable?

    a. 10 ppm   b. 7 ppm
    c. 4 ppm   d. 20 ppm

27. _____ What is the relationship between photosynthetic plants and dissolved oxygen in a shallow lake?

    a. they cause it to increase during the day
    b. they cause it to decrease during the day
    c. they have no effect on D.O.
    d. b & c only

28. _____ What will happen to the temperature as you progress from the surface to the bottom of an oligatrophic lake?

    a. the temperature will increase
    b. the temperature will decrease
    c. no change
    d. I don't know, don't pick this one

29. _____ What is the cause of fall overturn in a lake?

    a. The cooling of surface water by the air
    b. warm water rising
    c. boats mixing the water
    d. cold water is less dense than warm water

30. _____ What would be the difference in carbon dioxide consumption of photosynthetic plants at the bottom of a deep lake compared to the margin of the same lake?

    a. same
    b. greater at the bottom of the lake
    c. greater at the margin of the lake
    d. lesser at the margin of the lake

31. _____ What pH range will support a good fish population in a lake or stream?

    a. 1 - 4   b. 4 - 6
    c. 6 - 8   d. 9 - 12

32. _____ What happens to the pH of a body of water as it becomes more eutrophic?

    a. stays the same   b. goes up
    c. goes down   d. this is not the one

33. _____ The type of geological substrate that water in a stream flow over has a strong effect on how hard or how soft the water will be.

    a. true   b. false

34. _____ Which is not one of the three main reservoirs of nitrogen?

    a. lakes   b. atmosphere
    c. inorganic compounds   d. organic compounds

35. _____ The natural decay of plants and animals will cause a rise in nitrates and have an effect on the type of fish population.

    a. true   b. false

36. _____ In a body of water, the nutrient present in the lowest amount determines the degree of plant growth.

a. true b. false

37. _____ The main source of phosphorus is the decay of organic matter (plant & animal). What will increases of phosphorus in a stream cause?

a. plant death b. agal bloom
c. no change d. fish growth

38. _____ What effect will TSS and TDS have on the photosynthetic rate in a body of water?

a. increased plant growth b. decreased plant growth
c. none d. a & b

39. _____ Volume of flow, nature of the bottom, and nature of the banks are considerations that are also important to a stream study.

a. true b. false

40. _____ What does a B.O.D. test show about a body of water?

a. how much oxygen is in the water
b. how much oxygen is used in a 5 day test
c. how much oxygen is released out of the water
d. it has nothing to do with dissolved oxygen

41. _____ What structures in a fish do low levels of hard and soft phosphates effect?

a. kidney b. stomach
c. taste buds d. ovaries

42. _____ When a body of water becomes polluted there is a greater variety of species.

a. true b. false

43. _____ Species present in polluted water are considered to be index species.

a. true b. false

44. _____ Different animals can tolerate different concentrations of a particular substance due to their varying abilities to metabolize or otherwise deal with the substance. The toxicity of a substance also depends on other factors such as temperature, dissolved oxygen, and a pH.

a. true b. false

45. _____ As effluent moves down stream it becomes:

a. more concentrated b. less concentrated
c. neutral d. solid

46. _____ Heated effluent will have a _____ on a stream.

a. positive effect b. negative effect
c. neutral effect d. not this one

47. _____ Coliform bacteria are indicators of:

a. industrial waste b. inorganic waste
c. human waste d. temperature drop

48. _____ Phytoplankton and zooplankton are pollution indicators.

a. true b. false

49. _____ Aquatic insect larvae are not effected by water pollution.

a. true b. false

50. _____ Certain fish species are tolerant of low oxygen concentrations.

a. true b. false

APPENDIX D

CLINICAL INTERVIEW

CLINICAL INTERVIEW

ECOLOGY AND STREAM WATER QUALITY

BEFORE Name ______________________

1. Have you had any experiences with lakes, ponds or creeks. For example, fishing, playing, or exploring when you were younger? Explain. ______________________________________

____

____

2. What differences would you expect to see in Huntoon Lake compared to Huntoon Creek? Why?

   Physical factors?______________________________________

   ____

   Plant life?____

   ____

   Animal life?____

   ____

3. What are some differences you would expect to see in Huntoon Creek below the sewage treatment plant compared to above the plant discharge? ______________________________

____

AFTER

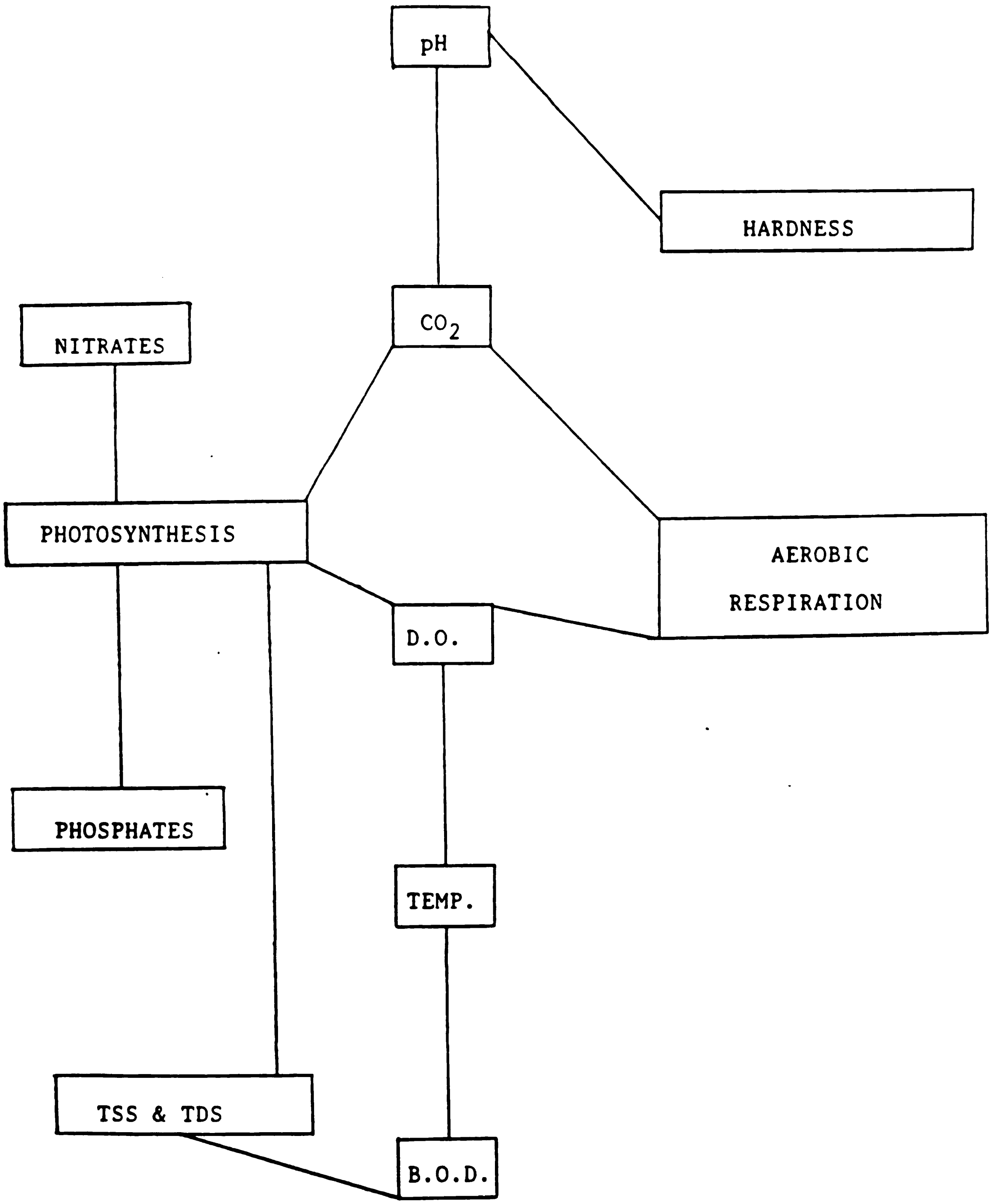
1. Some things you learn in class make a lasting impression. Why is that true while other things are quickly forgotten?

____

____

____

Chapter 2 CONCEPT MAP



APPENDIX E

FIELD TRIPS

(Student Reports)

THE LUDINGTON PUMPED STORAGE HYDROELECTRIC PLANT

The plant is cooperatively owned by Consumers Power Company and Detroit Edison. (Only CPC workers have operated the plant.) Though the building process started in July of 1969, the plant didn't start making electricity on a large scale until 1973. The building cost was $315 million.

LPSP is located on the eastern shore of Lake Michigan, a little south of Ludington. The plant has an electric generating capacity of 1,872 megawatts! When all six units are generating a flow of 34 million gallons per minute is produced.

Most pumped storage plants, like Ludington, have two reservoirs connected by penstocks with a reversible pump turbine. Electricity is only produced when water is coming from the reservoir. At night water from the lake returns to the reservoir, where it is held until it is needed again to produce electricity.

The problem is that fish get sucked up in the turbines when the water is drawn from the lake, and get chopped up. The only solution was to use something that would allow the water to go through, but not the fish. Therefore, a two mile long net was placed around the breakwater in front of the plant. So far it has worked effectively. Year by year the effectiveness rises, with continual work on the net. The "Net Project" has only one more year left. If it turns out well, there could be an installation of a permanent net. The environmental impacts of a hydroelectric facility should not be taken for granted.

THE WEIR

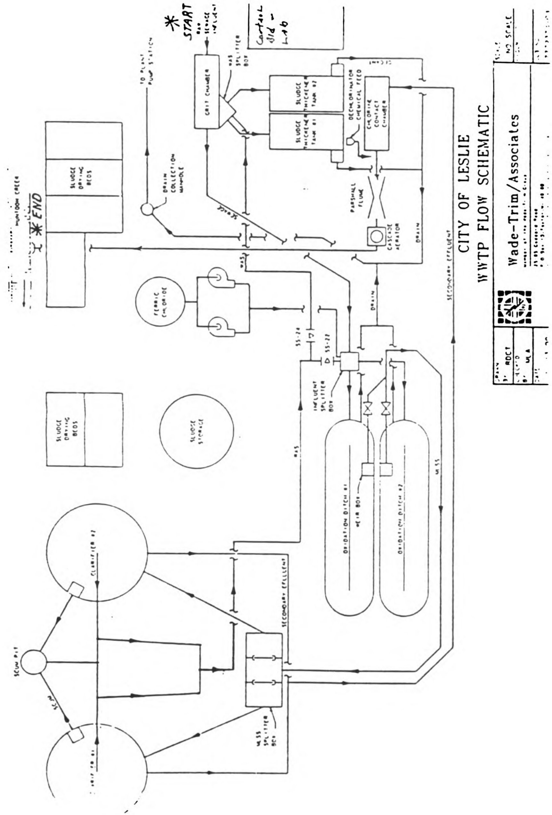
The Manistee weir, which is located on the Little Manistee River, is a remarkably interesting place. The weir generally estimates taking from 14 to 16 million eggs per year from the Coho and Chinook salmon, brown trout and steelhead. The fish swim up ladders that are in the water, thinking they are going upstream to spawn. The males and females are then separated. On the average, 2 or 3 million eggs per day are taken from the fish. The weir ships around a million eggs per day to various locations, such as restaurants and fish bait shops. The eggs are shipped all over - from Illinois to the New York, but most are shipped to the Platte River Hatchery.

To get the eggs, they hang the fish on hooks and blow oxygen to their insides. This allows easy access to them without hurting the bodies of the fish. The eggs are soaked in water with the sperm, then measured into quarts. After sorting out those with bacterial kidney disease, the eggs are ready for shipping.

SEWAGE TREATMENT PLANT

The sewage treatment plant is located in Leslie Michigan. The plant takes in 350,000 gallons of water each day. In the sewage treatment plant the sewage flows by gravity. The grit chamber is used to slow the velocity of water so solids get to the bottom. The oxidation ditches keep the water mixed and it adds oxygen to the water. This makes the proper environment for microorganisms, there is enough food and water for them. They eat the solids, which breaks down the solids. In the final clarifier the water flows from the inside to the outside and the solids settle to the bottom. The solids on the bottom of the clarifiers are taken through the system again if the solids were not broke down enough. The clear water flows over and out to the next step. This water is called effluent. The splitter divides up the water to go to the clarifiers. The waste conected on the bottom of the tanks goes into the scum pit. From there it will sometimes goes to the sluge drying beds. When the sluge drying beds are full then they have to shovel it into a big pail, and the farmers sometimes pay for the sluge to put onto their fields. They are only used as a backup. Sluge settling tanks concentrate the sluge.

Chlorine tanks disinfect the water. The aerators add oxygen to the effluent. When the water leaves, there must be at least 5 ppm of oxygen in the water. Finally the chemicals are added to take the chlorine out before going to the creek. An oxygen test is done daily to check for the proper oxygen level. About 98% of impurities are removed by this type of sewage treatment. The clarifiers were completed in January of 1991 and the oxidation ditches were built in 1985. The city has spent over $2 million on the sewage treatment plant in the last few years.


START
GRIT CHAMBER
SLUDGE THICKENER TANK #1
SLUDGE THICKENER TANK #2
DECHLORINATOR CHEMICAL FEED
CHLORINE CONTACT CHAMBER
PARSHALL FLUME
CASCADE AERATOR
DRAIN
SECONDARY EFFLUENT
SLUDGE DRYING BEDS
END
DRAIN COLLECTION MANHOLE
TO PLANT PUMP STATION
FERRIC CHLORIDE
WAS
RAS
MLSS
SS-24
SS-22
INFLUENT SPLITTER BOX
SLUDGE STORAGE
OXIDATION DITCH #1
OXIDATION DITCH #2
WEIR BOX
SCUM PIT
MLSS SPLITTER BOX
CITY OF LESLIE
WWTP FLOW SCHEMATIC
Wade-Trim/Associates
NO SCALE