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ABSTRACT

This environmental unit is one of a series designed for integration within an existing curriculum. It is self-contained and students are encouraged to work at their own speed. The philosophy behind the series is based on an experience-oriented process that promotes independent student work. This particular unit explores the concept of succession in communities. The activities included develop the major concept by requiring students to set up small aquaria and to observe the changes that take place in these small communities. Sampling and population prediction techniques are included in the activities. Teacher information concerning background information, materials, and additional topics is given. This unit is designed for students, grades 5-9. A short bibliography is included. (MA)

edited and published by

NATIONAL WILDLIFE FEDERATION

written by

MINNESOTA ENVIRONMENTAL SCIENCES FOUNDATION, INC.

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THE ENVIRONMENTAL UNITS

This is one of a group of Environmental Units written by the Environmental Science Center and published by the National Wildlife Federation.

In both theory and practice education is the essential base for long-range local, regional and national programs to improve and maintain the quality of environment necessary for man's welfare and survival. Citizens must be aware of ecological relationships in order to recognize, appreciate and fulfill constructive roles in society. This awareness should be launched through the existing educational process—in classroom and related school activities. No special courses on ecology can replace the need to integrate ecological learning throughout the existing curricula of our school systems. Furthermore, the life-styles and value-systems necessary for rational environmental decisions can best be acquired through repeated exposure to ecological learning which pervades the total educational experience.

It was with these thoughts that we developed these curriculum materials. They were designed for the classroom teacher to use with a minimal amount of preparation. They are meant to be part of the existing curriculum—to complement and enhance what students are already experiencing. Each unit is complete in itself, containing easy-to-follow descriptions of objectives and methods, as well as lists of simple materials.

The underlying philosophy throughout these units is that learning about the environment is not a memorization process, but rather an experience-oriented, experiment-observation-conclusion sort of learning. We are confident that students at all levels will arrive at intelligent ecological conclusions if given the proper opportunities to do so, and if not forced into "right" answers and precisely "accurate" names for their observations. If followed in principle by the teacher, these units will result in meaningful environmental education.

In the process of development, these units have been used and tested by classroom teachers, after which they have undergone evaluations, revisions and adaptations. Further constructive comments from classroom teachers are encouraged in the hope that we may make even more improvements.

A list of units in this group appears on the inside back cover.

About the National Wildlife Federation—1412 Sixteenth Street, N.W., Washington, D.C. 20036

Founded in 1936, the National Wildlife Federation has the largest membership of any conservation organization in the world and has affiliated groups in each of the 50 states, Guam, and the Virgin Islands. It is a non-profit, non-governmental organization devoted to the improvement of the environment and proper use of all natural resources. NWF distributes almost one million copies of free and inexpensive educational materials each year to youngsters, educators and concerned citizens. Educational activities are financed through contributions for Wildlife Conservation Stamps.

About the Environmental Science Center—5400 Glenwood Avenue, Minneapolis, Minnesota 55422

The Environmental Science Center, established in 1967 under Title III of the Elementary and Secondary Education Act is now the environmental education unit of the Minnesota Environmental Sciences Foundation, Inc. The Center works toward the establishment of environmental equilibrium through education—education in a fashion that will develop a conscience which guides man in making rational judgments regarding the environmental consequences of his actions. To this end the Environmental Science Center is continuing to develop and test a wide variety of instructional materials and programs for adults who work with youngsters.

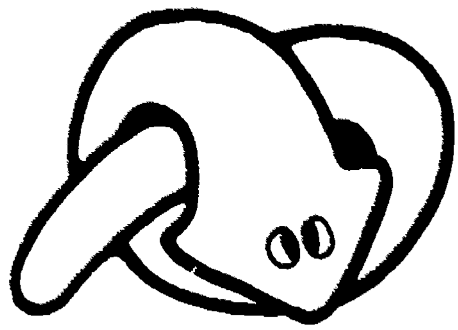
Change in a Small Ecosystem

An Environmental Investigation

BY

NATIONAL WILDLIFE FEDERATION

MINNESOTA ENVIRONMENTAL SCIENCES FOUNDATION, INC.



Design and Illustrations
by
JAN BLYLER

The natural and the man-made worlds are divided into relatively distinct units called **communities.** All communities have features which set them apart from each other. It is easy, for instance, to distinguish between a prairie and a forest, a pond and a stream. But communities are rarely stable entities. With time, they undergo a variety of changes and sometimes transform into completely different units. At times, even short-term changes—day to night, seasonal, etc.—can be detected.

A *patterned sequence of change* in a community is called **succession.** In a sense, the development of a village into a town into a city into a big city is similar to succession in a natural community. Ordinarily, growth in a population center like a village or town is a self-perpetuating process. The same is true of natural communities. For example, certain patterns of events occur which cause a pond to become a marsh. In time, the marsh may be transformed into a prairie or forest.

As the features of a community undergo change, so do its members. A pond may have once contained a sizeable number of fish, but as it is transformed into a marsh, the kinds of fish it can support will change. Eventually all fish will disappear and new life forms will appear in the marsh. Deer may now rest in or near it instead of being only transient visitors.

This unit is about communities and succession. The implications of the unit can be far-reaching. We hope the activities provided will help your students grasp the concept of succession and that gaining this understanding will, in turn, help them appreciate how change affects all environmental neighbors.

Table of Contents

INTRODUCTION

Studies of succession are usually carried on over periods of years because community change is a slow process. However, **Change in a Small Ecosystem** describes a method for investigating community changes which may occur in a short period of time. The unit has the class consider changes in small aquariums created from water samples of a nearby water source. In this case, the aquariums are actually jars of quart size and smaller.

In the unit, students will collect and periodically examine water samples. Over a period of time there will be changes in the numbers and types of organisms in the water. Exactly what will happen cannot be predicted because it will depend upon the contents of the original source of water and upon conditions in the aquarium. In general, though, certain organisms may at first be abundant and then appear to die off. A different type of organism may become evident in large numbers only to disappear in time. The children may also observe that one or more organisms are always present in large numbers while others seem to disappear and reappear every so often. There is no guarantee, of course, that what happens in one micro-aquarium will happen in another.

The activity which children observe in their small aquariums will be *representative* of activity which would take place in the larger body of water from which their samples were drawn. But conditions in an aquarium are not the same as those in a pond, stream, or water-filled ditch. As changes occur in the aquariums, you will want to caution the children against drawing exact parallels between their micro-communities and the natural community.

Although specific events and relationships are unpredictable, the general pattern of events will not be haphazard. Through observation and discussion, the children should come to realize that a kind of pattern does exist among the various events occurring in the aquariums. While the activities of this unit are primarily directed toward investigating those particular events, the materials should lend themselves to a wide variety of related investigations. In the back of this unit there are some suggestions for further activities.

MATERIALS

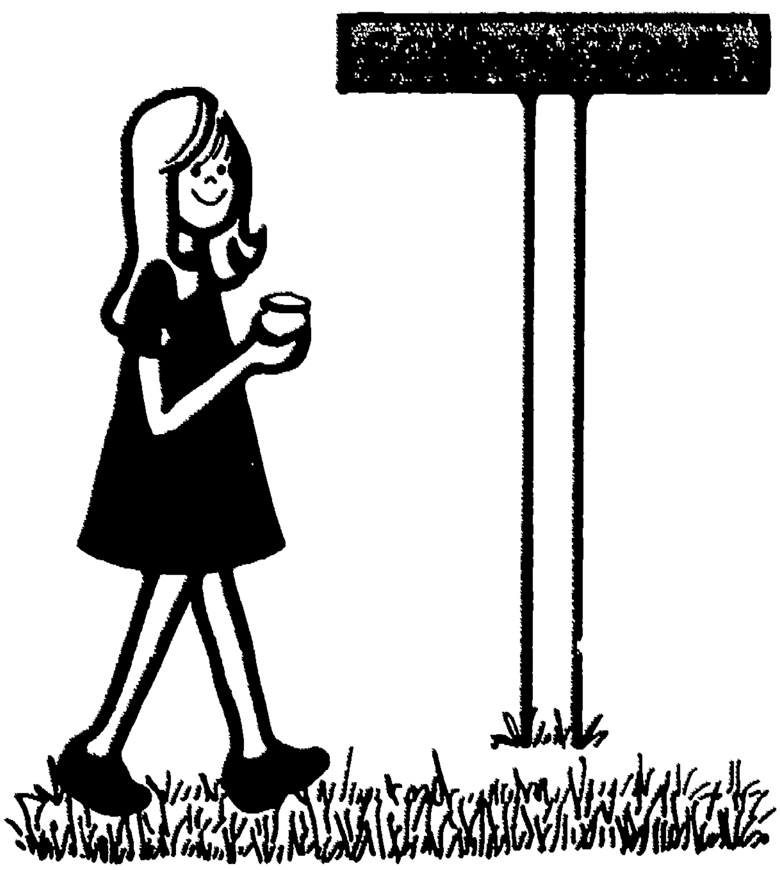
- quart jars & lids—mayonnaise, peanut butter, etc., smaller jars with lids
- water
- microscopes
- hand lens—10x & 15x type
- microscope slides and cover slips
- methyl cellulose (optional)
- soda straws
- cotton
- plastic bucket
- plastic bags
- thermometers
- brewer's yeast or flakes of uncooked cereal
- rubber bands

Change in a Small Ecosystem

Pre-Field Trip

Before the students begin the field trip you might want to select and investigate a nearby source of water. Check for small but visible living material in the water. A pond, water-filled ditch, a marsh or a swamp area are all excellent sources of water rich in microorganisms. Estimate the time needed to get to the area and back so that you may plan your field trip schedule. In selecting the site also consider its accessibility for the children, the depth of the water source and the ownership of the property.

Several days before the field trip, ask each child to bring to class a container which could be used as an aquarium. Peanut butter, mayonnaise, or baby-food jars are all suitable for use as small individual aquariums. Each jar should be labeled with its owner's name and set aside for the time being. You will also want to have jar lids or other covering material available to use later on to prevent evaporation. Make sure you have all the equipment you will need (see Materials list on previous page) so that the children may begin their observations immediately when they return from the field. Before going to the field site, you will also want to duplicate the water sample collection card in the back of the book, page 12, and hand out a copy to each student.



Field Trip

MATERIALS

plastic bags, *nets*, *rubber bands*, *buckets*, *thermometers*

The students should wear clothing appropriate for the field: old shoes, jackets, boots, etc. Discuss what special safety precautions will be necessary if the water is deep.

Each student should be given a plastic bag, a rubber band, and a water sample collection card. Additional materials such as thermometers, nets and buckets may be distributed among the students so they can help carry these to the field site.

When the students reach the site, remind them to be careful while they are collecting samples. If the body of water is large enough, students should each select a site along the bank or shore which offers easy access to the water and where there is no danger of their falling in. Plastic bags should be dipped into the water and half filled. Each student can also collect a small handful of debris such as mud, leaves, and sticks and place it in his water sample. (Many organisms cling to such debris, so collecting it will provide a rich sample of various organisms. The nets should be handy for collecting the debris.)

Have each student take the temperature of the water at the spot where he has taken his water sample. As the students take the temperatures, have them record the readings on their collection cards. At this time, you will also want to have them take an air temperature reading for their cards. They should also take note of other characteristics of the pond or stream which they will want to include in their descriptive data.

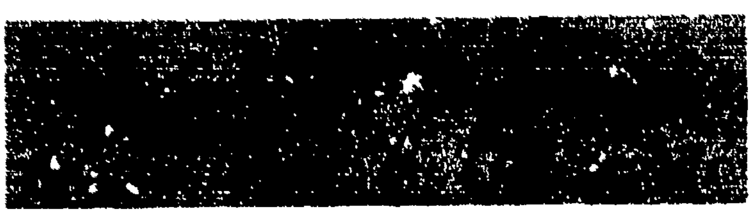
When each student has taken a sample, have him close his bag with a rubber band. Then he should take a few minutes to complete his collection card describing the site, weather, and so forth. If time permits, you will probably want the students to return to the classroom immediately in order to begin examining the water.

Water Sample Collection Card

Student Name Susan S.
Date of Collection April 23
Collection Site Description Small pond behind school, short grass and shallow water, sample taken near edge, gathered sticks + leaves
Weather Air temp. 75° overcast rained yesterday.
Condition of Water Clear to slightly cloudy, no odor, temp 60°

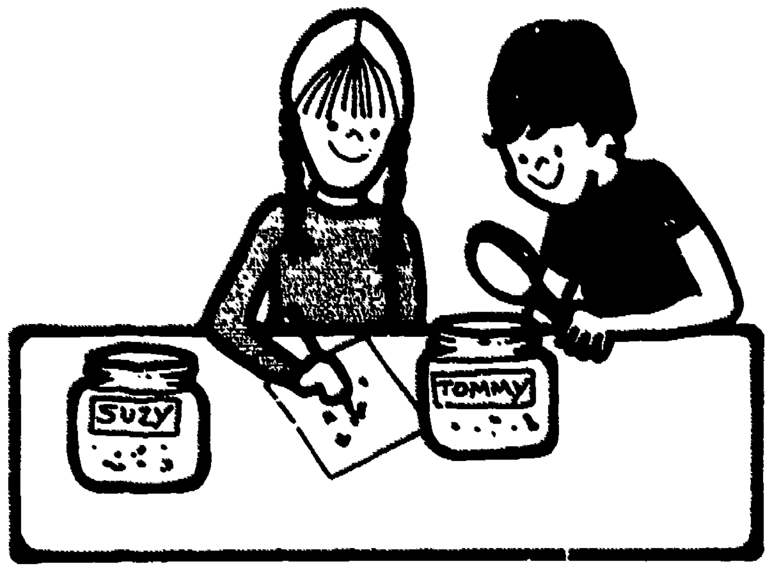
Just before leaving the field site, collect one or two buckets of water for yourself. Be sure to include some mud, sticks, stones, etc. You can use this water to fill an aquarium or some gallon jugs which can serve as larger samples for classroom observations.

Classroom Activities



I. Preliminary Observations

As soon as the students return to the classroom, have them transfer their samples to their jars. (Make sure all the jars have been labeled with the names of the owners.) The students should have the opportunity to make general examinations of their samples. Distribute hand lenses and paper to each student. Suggest that they draw or describe in words some of the things they see. Some students may become so involved in observing that they will not, at this time, want to stop and make records. If such an assignment seems to interfere with their natural inclinations to "just look," it would be best not to press them. Eventually you will want them to collect their observations in a notebook for reference purposes, but if they appear to be enjoying the act of observing, they could start their notebooks on the next day.



The students may expect you to be able to identify everything they see. Very few biologists, however, know the names or can recognize all of the organisms in a sample of pond water, so don't feel badly if you can't do that either. (The bibliography in the back of the book will give some help if you wish to follow up the identification.) Make it clear to the student who questions you that a name does not change the organism, nor does it make the organism any more understandable or any easier to observe. In fact, a name rarely has anything to do with what is important and unique about an organism. The students may want to make up temporary, descriptive names for some of the things seen in their aquariums. If they do decide to assign names, you will want to point out the need to be consistent. They must always use the agreed upon name when referring to a given organism. You will also want to remind the students that these names are for their current study only and that the organisms have other names generally agreed upon by the scientific community. For the interested students, you may make available some of the reference materials listed in the bibliography.

When the students have completed their initial observations, they should cap their aquariums loosely or place pieces of construction paper over the jars to prevent evaporation. When the materials are put away, encourage the students to share their observations with one another. They might enjoy describing what they saw or perhaps they could draw some of the organisms on the board for others to see. Eventually the students must come to a point of agreement among themselves about what they see. This means that each student must be able to recognize an organism as being of the same *type* that other class members have seen.

II. Continued Observation

At this point you might want to have the students inspect their samples under microscopes as well as with hand lenses. Parts of several days should be spent in casual observations of the water. During this time the students will become familiar with their samples, will begin to recognize organisms they have seen before, and will accustom themselves to the use of the microscope and magnifying glass as observation aids. Encourage them to make large drawings of what they see, especially of the forms which they find commonly from day to day.

Proper use of the microscope should become a class goal during this period. Your own familiarity with a microscope will be helpful to those who cannot seem to get the "knack" of it. It would be a good idea for you to spend some time making your own observations in order to anticipate problems the students might encounter with the microscopes.

Often students have difficulty distinguishing between air bubbles, scratches on a slide or cover slip, and living organisms. Remind them that few living organisms are perfectly round (as opposed to air bubbles) or perfectly straight (as with some scratches).

Learning to use microscopes involves caring for them properly. Students should clean them before and after use, learn to carry them properly, and should not abuse them.

In addition to learning the use of the microscope for purposes of observation, the students should be introduced to some other useful techniques. In surveying the water for smaller organisms, special methods must be used to slow down the movement of the organisms. *Methyl cellulose* is a chemical which retards motion. If one drop of this solution and one drop of the water to be observed are put together on a slide, the desired slowing effect will be achieved. If methyl cellulose is not available, threads plucked from cotton and applied to a slide are also effective in trapping some of the larger microorganisms. Have the students experiment to find the amount of cotton required.

Students should recognize that examinations of the water are most easily made when the quantity used is no more than a single drop. Soda straws are excellent sampling devices for this purpose. Students should practice (with tap water) obtaining a *single drop* from a straw sampler. Have them do this by placing the straw partly into the water and then putting one finger over the open end of the straw before lifting the straw from the water. For some students, cutting a straw in half makes it a more manageable device.

In this unit, mention has been made briefly of having the students make drawings and note descriptions of the things they discover in their aquariums. Often, however, these kinds of activities can become the focus of attention rather than aids to investigation. The students should understand that records are kept simply because one can't always recall everything. Records are reminders; they are written evidence of observations and they provide students with source material for visual communication with one another. Therefore, it would be helpful to begin the development of a "gallery" of organisms—pictures of the forms seen by the students. As these are produced, they may be posted on the bulletin board and used as references during class discussion. In the back of the book on page 14, there are sketches of some of the more common organisms which students might find in their samples. You might want to check these for reference.

Maintaining notebooks on a day to day basis will help students keep track of those events occurring in their cultures which can't be *drawn* easily. Color, odor and turbidity (cloudy, clear) are changes in the water which the students should note daily. Eventually, written records should be standardized so that each student will collect the same *kind* of information.

Much of the students' observation may be done without your direct help. The excitement of exploration and discovery should keep the students interested for at least a week. You may expect a great deal of casual sharing of observations and discoveries—most students want others to see what they have found. Encourage them to share their findings with others and you.

Planned Investigation

MATERIALS

rice *brewer's yeast* *cereal*

I. Predictions

After several days or a week of casual observation, some of the students will ask what to do with the pond water. A few might suggest some experiments. Others will want to feed the organisms. When you feel most of the class is ready to become involved in more directed study, it will be time to introduce them to several procedures for investigating the change or succession that takes place in their aquariums.

Experiments can be inconclusive if they are not conducted in a systematic way. On the other hand, experiments suggested and controlled by you may prove to be unexciting to the student whose interests lie elsewhere. Your role, then, will be to exert only that degree of control required to get results—but not too much to interfere with the natural interests of the students.

One way to maintain interest would be to encourage the students to conduct experiments of their own choosing while they are involved in the succession study. In addition, have them discuss their succession data from time to time, noting some of the changes which have occurred. If you maintain your own micro-aquarium you can determine the timing of such discussions. When you observe a rather dramatic event such as an overnight change in numbers or a sudden appearance of many new forms, find out what is happening in the students' cultures. You may also expect the students to raise questions about some changes they have observed. Use these discussion sessions to maintain interest and excitement.

The day before the class begins the more systematic study, have the students feed each culture with several grains of rice, *or* a pinch of brewer's dry yeast, *or* a *few* (3-4) flakes of cereal. (They should use only one type of food per sample.) After this initial feeding do not have the students feed them again. **Ask the students to predict what will happen now that the organisms have been fed.**

In order that the students obtain **meaningful** information about what happens to populations of organisms in their samples of pond water, they will need to sample the populations in a systematic way. The next section, "*Sampling*," outlines some important points you will want to go over with the students as they develop their own sampling procedures.

II. Sampling

The micro-aquariums which the members of the class have set up are small representations of natural habitats. Using the sampling procedures which follow, the students will see that populations—or the numbers of organisms in the aquariums—change over a period of time. These changes are related to many factors, including availability of food, the fact that one organism might eat another, availability of heat, light, moisture, chemicals, and so forth.

As mentioned in the introduction to this unit, succession involves a change in numbers and types of community members. Casual observation can reveal changes in numbers of organisms in the students' samples. The water will turn cloudy when many forms are present and it will clear when they die. General observations, however, are not sufficient for knowing *which form* "bloomed" suddenly or which form died. Also, growth and/or death could occur in one part of an aquarium but not in another. Again, this will not be apparent through casual observation. Therefore, in order to discover more exactly the nature of a change, each aquarium must be sampled carefully and systematically.

If samples are drawn from different parts of the culture (e.g. the top and the bottom of a jar), the samples are apt to yield different types of organisms as well as different numbers of those types. Ideally, to get an overall picture of what's going on throughout the whole aquarium, the most accurate method of sampling would involve actually taking samples from different parts of the culture. But for the students, this could become rather tedious. For purposes of this study, it would be suitable for them to determine the most populous portion of their cultures and then limit their sample-taking to that area only.

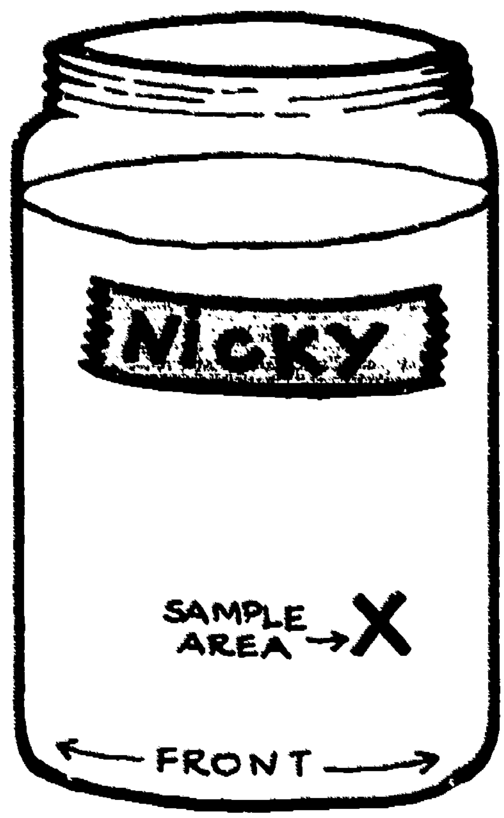
To introduce to the students the importance of standardized sampling, have them recall the predictions they have made about what might happen if the cultures were fed. Ask how they will know if something has happened. Why do they think it might be a good idea to follow the events in the culture for several weeks? How would each student propose to do this? You will want to elicit suggestions for a standard sampling method as part of the student's proposed study. For instance, if they suggest the cultures be examined every day, you could ask how they would examine them. Can they possibly examine the entire contents or, if not, what part could be checked? Have they any ideas about a "best" part of their culture?* Ask if the "best" part would be where many or few organisms are found.

Perhaps "bestness" can now be determined if each student carefully draws samples from relatively distinct areas within his aquarium. These areas might be the top, middle, and bottom portions. Another area might be somewhere in the midst of the debris. Area sampling can be accomplished easily by placing a finger over the top of the straw sampler *before* inserting it in the culture and keeping the finger across the top until the straw reaches the desired spot in the culture. At this point the finger should be removed for a moment and then placed back across the opening. Then the straw should be removed. The straw should now contain a sample of the culture taken from the desired spot in the aquarium.

Once the samples are drawn it will be the responsibility of the students to evaluate them. Ask such questions as "Where are the greatest numbers of organisms found?" or "Which spot seems to contain the greatest variety of organisms?" In order to evaluate their samples, each student will want to make slides from water taken at different points in his aquarium and observe his slides under a microscope. This activity will raise some questions about why the organisms "prefer" one spot to another. Suggest to those interested that they try experimenting with some other water to see if they could discover possible explanations.

For the population estimation procedures which follow, each student, individually, should agree to take all his samples only from that spot in his own aquarium which he considers "best." It is assumed that the spot which each student chooses will contain a diversity of forms occurring in relatively large numbers. A student whose aquarium is a quart jar might decide that his best sample area is that spot just below the water line, in the center of the water surface. Another student might discover that the same depth is right, but that his best spot is near one side of the jar at a point he might mark with a grease pencil or piece of tape. Again, no matter which place the individual student chooses, **all** of his samples in the following activities should come from that same spot.

This method for determining a means of sampling and choice of site is a compromise. Its aim is to have the students recognize the need to standardize the sampling procedure. By taking samples from the same spot in his aquarium over a period of time, each student will have a better chance of detecting changes which occur in the populations of organisms in that sample area. In other words, each student will be able to observe, to some extent, natural selection and succession in a small community. At the end of this investigation, ask the students what they might have found if they had chosen different spots to sample each day.



III. Population Estimation

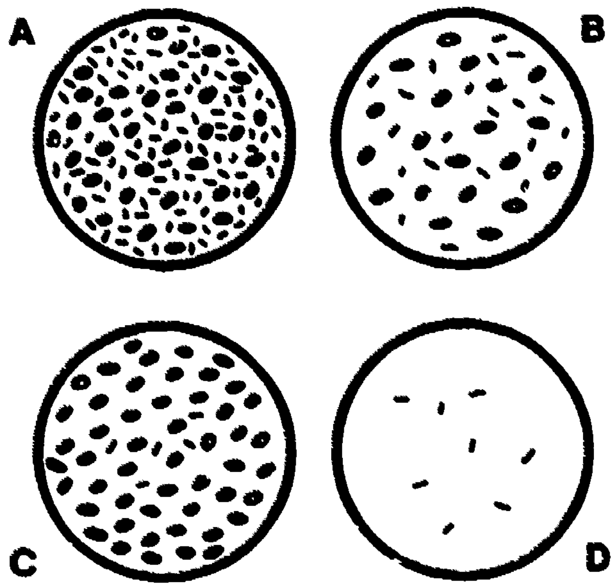
After the class has determined a sampling spot and a procedure, a method must be devised for estimating the numbers of individual organisms in each sample. The purpose of making population estimates is to help each student determine when and if changes are occurring in the numbers of organisms in a particular section of his aquarium. The procedures for estimating need not be too precise, but they should be reliable enough to indicate clearly when a population change occurs.

* "Best" is an arbitrary word. We have used it because students generally think in a qualitative rather than quantitative fashion, although they may be intending a quantitative description. When they determine what "bestness" entails, another descriptive word or phrase should be substituted (e.g., "most dense.")

The following section outlines a method for estimating numbers of organisms by using arbitrary standards. This method would probably be most workable with younger children. Older students should suggest their own methods. Any estimating procedure will be appropriate as long as it is fairly accurate and can reflect *trends in population growth and decline*.

Estimating by using arbitrary standards

Observe the drawings below:



All of these drawings represent different views of slides which might be made from a single pond water aquarium sampled on different days, at the same spot in the aquarium. The slides are not in any particular order. All views are at the same magnification. The views are *not* intended to represent specific kinds of organisms. Rather, they are meant to represent various degrees of density (or total population) that might be noted in different samples.

Sketch similar drawings on the blackboard for the students to observe. You might ask them what they think the drawings represent. Once the general meaning of the sketches is understood, ask the class to put them into some kind of order.

There are several possible ways to order the drawings. One way would involve ordering on the basis of the number of a certain type of organism. Probably the most obvious method would be to order them according to the total number of all forms contained in each field of view. If the four drawings were ordered on this basis of total numbers, ranging from fewest to most, the order would be approximately DBCA.

Now have each student prepare a slide from his sample area. All microscopes should be adjusted to the **same magnification**. Next have the students *estimate* how many forms they can see. (Guesses will vary widely both with samples and with the students' ability to estimate.) The estimates should be recorded. Now have the students *readjust* their microscopes to a **higher magnification**. Again ask the students to estimate how many organisms they see. (Estimates should be lower this time.)

ASK THE STUDENTS:

If you had to make *daily* estimations, which power would you use?

Is the choice of a *specific* power important? (Probably not, except that at higher magnifications fewer organisms are seen, making estimates easier.)

Do you think it's more important to choose a *specific* power each time or to *standardize* the magnification so that the field size is the same each time estimates are made? Why?

Return to the idea of ordering the drawings. Have the students select a magnification which seems to be the best for making estimates. After they are focused on a field, ask them to compare what they see with one of the drawings on the board. They must think in terms of the **density**—or total numbers—of organisms. Do they see very few or many organisms? Ask the students which blackboard drawing they think is the most representative of their field of view. After they have decided, suggest that they check one another's samples. Provide time for checking and comparing. Each student will have looked through his microscope and then selected from the board the view he feels is "most representative" of his own field of view. To what extent do the students seem to agree with each other's choices? Give the students a short time to discuss their choices among themselves. Discussion should further help to acquaint the students with the procedure of choosing the "most representative" view.

The class has now been provided with one means of **estimating total population** of all organisms in a drop of water from a pond water aquarium. In the days ahead, as outlined in the *"Keeping Records"* section which follows, you will want to have each student take a water sample from the sample area of his aquarium, make a slide, and estimate total population. If your students are using the drawings you have put on the board for making their estimates, they should check the population in their sample area every day or two and then compare what they see with the drawings. Each student should determine which drawing most closely resembles the population in the sample area of his aquarium on the various days. By doing this for a number of days, they should each have a record of relative increases or decreases of population in their sample area.

In addition to recording changes in **total** population, you will want the students to make estimates of the numbers of particular types of organisms when compared to all other types in a mixture. Few slides will show only one kind of organism. Instead, several kinds will probably be visible on the slides. The key to estimating relative numbers of particular organisms and comparing these to the total population lies in the student's abilities to distinguish between varieties. Sometimes this is not easy to do, so you won't be able to insist on a great deal of proficiency. Absolute classification is neither necessary nor desired for this investigation. It is important, however, for the students to be familiar enough with the organisms so that they can make a fairly good guess as to which one is the most abundant at a given time. In order to make this process less complicated, the identification of each type of organism can be relative. For example, all "tiny" forms might be counted as one type. All forms having similar characteristics such as legs, "feelers," etc. could together constitute another type.

IV. Keeping Records

Over the next several weeks the students will be taking samples, making slides, and looking at those slides under the microscope to detect changes in numbers and types of organisms. After a period of time, some of the students should be able to notice patterns of succession. Each student should keep records of all his observations. The records should consist of several items: (1) date, (2) types of organisms observed and their relative numbers, (3) description or notes about the total population, and (4) general observations of the water.

The simplest method for keeping the records is to construct a data chart where observations are entered at the appropriate place on the days when observations are made.

The students may decide to take a sample every day, or once every two or three days. Remind each child that on each day he wishes to sample his population, he will have to take a fresh water sample from his aquarium sample area, make a new slide, and then record his findings for that particular day.

In the back of the book, on pages 15 through 20, we have presented drawings of six possible microscope views. The drawings show the kinds of organisms that might be found if you were to take samples from a single aquarium over a period of time. As indicated earlier, there is no way to predict exactly what organisms will be found in a given aquarium. Thus, the six drawings represent only reasonable possibilities. They are included in the unit to illustrate the kinds of drawings students might make as well as the kinds of written data they would record. Seen as a group, the six drawings constitute **one** pattern of events that might take place in a single aquarium over a period of three to four weeks. On page 13 is a blank data sheet which you can use for duplicating copies to give the students for their own studies.

Refer for a moment to the drawing and chart on page 15. Under the heading "Organisms Observed," the children would enter the designations they have chosen for commonly appearing organisms. The students may want to use descriptive words or drawings. If they decide to assign names to the organisms for use during the study, they should agree on names which will be used by all the students in designating each particular type of organism. Under the column headed "Number," any terms descriptive of quantity may be used. Under "Description of Population," the students may either describe changes they note in the total population or they may designate one of the "representative drawings" (see page 9) which most closely resembles the density of their populations on a given day. The final column is included so that some correlations between populations and water conditions can be made at the conclusion of the unit.

Discussion of Results

You will have to use your judgment as to when the investigation should be concluded. Four to five weeks is an average time period for having the students take samples. Check the students' records from time to time to see if changes are taking place. When you feel there are enough changes to illustrate the point that succession occurs, you should begin a discussion of the results. Refer to the initial predictions the students made after the cultures were fed. Did anyone find his prediction to be correct or close?

During the discussion the children will want to report their findings. As they relate what they have found, try to discover whether they noticed any **cycle of events** occurring.

You might bring out this idea of cycles by having each student report his results according to the daily sequence of events. Ask: Beginning a day or two after the cultures were fed, what happened? And after three or four days? etc. As reports are made, check to see how many students found the same or similar events happening at the same time. Record their reports on the board so that the students may see one another's results.

The major point to bring out in class discussion is that **change occurred.** In fact, two types of change may have been observed: (1) changes in *total numbers* of organisms, and (2) changes in *types* of organisms. Ask: Did there seem to be any **pattern** or **sequence** to the changes?

It is difficult to predict what type of pattern may have emerged because the factors which would affect that pattern vary widely from class to class and depend to a great extent upon the contents of the water samples. But some sort of generalized pattern will exist. Many investigators have found the following sequence to be characteristic of the events observed in their studies:

1. *Initial phase before feeding;* a few tiny organisms plus some larger multicellular forms. Water clear.
2. *After feeding;* profusion of the very tiny organisms. Water turns cloudy.
3. *Several days later;* appearance of larger single-celled forms. Water turning clearer.
4. *One week to ten days after feeding;* predominance of large single-celled forms such as the *Paramecium* and related organisms.
5. *Three weeks after feeding;* beginning of mixed form stage. Water clear, fewer Paramecia and increasing numbers of larger multicellular forms such as rotifers, small crustaceans, etc.
6. *Month later;* mixed population, fewer numbers of everything. This stage resembles the initial phase.

The above is a very general description of what might have happened. It is by no means the only sequence of events possible. Some of the phases may not have appeared in your class samples; others may have lasted for a considerably longer or shorter period of time; and, lastly, there may not have been any *obvious* phasing at all.

Once all the data are put in a generalized form and made clear to the class, ask the students what would happen if they fed their cultures again and followed events much as they have in the previous activities.

ASK THE STUDENTS:

If you were to feed the cultures again, do you think you would see similar things happening?

Do you think the pond has changed since we were there?

Should we expect the events in the micro-aquariums to mirror those in the pond?

What are some of the important conditions of life in the pond which are not present in the micro-aquariums? (The students should be aware of the fact that natural conditions of existence cannot be wholly duplicated in the classroom. But they would be correct in suggesting that the kinds of things which happen in the natural setting are similar to those in the classroom aquariums.)

Is change characteristic of ponds alone or is it observable in other parts of the natural world?

What are some other examples of change you have observed?

Perhaps the most common and dramatic changes which the students will think of are seasonal ones. These are good examples of change since they are predictable and recurrent. In this sense, seasonal changes are similar to the cyclic changes which occur among pond organisms.

Through discussion the students should become aware of the concept of change and how it relates to events in the natural community. You could also extend the discussion to include man-made communities. Finally, the class might observe and describe changes in other micro-communities such as rotting logs, forest floor litter, or other decaying vegetable matter.

Additional Investigations

Below are some further investigations some of your students may want to try.

I. Altering the Environmental Conditions

A. Light (keep cultures in the dark)
B. Temperature (maintain some cultures in a refrigerator)
C. Condition of the water (see what effect the addition of a pinch of baking soda has on the successional pattern)
D. Food supply (see if too much food will adversely affect a culture)
E. Air (observe the events in a tightly capped micro-aquarium)

II. Investigating a Single Organism

III. Investigating Other Events in the Aquarium

A. Food chains
B. Growth and reproduction of organisms
C. Role of plant life
D. Behavior of larger forms

Bibliography

The following books contain pictures and descriptions of many micro-organisms; you may find them useful references for both yourself and the class.

Basic Ecology, Buchsbaum, Ralph and Mildred. Pittsburgh: Boxwood Press. 1957.

Taxonomic Keys To Common Animals of the North Central States. Eddy, Samuel and A. C. Hodson. Minneapolis: Burgess Publishing Co. 1967.

A Guide to the Study of Freshwater Biology, Needham, J. G. and P. R. San Francisco: Holden-Day. 1962.

Instructional materials which could also be used in conjunction with this lesson are:

Pond Water. (An Elementary Science Study Unit, Educational Development Center, Newton, Mass.)

Small Things. (Another Elementary Science Study Unit) St. Louis: Webster Division, McGraw-Hill. 1967.

Organisms. (An institutional unit developed by the Science Curriculum Improvement Study, Berkeley) Boston: D.C. Heath and Co. 1968.

The Back of the Book

I. Data Sheets

Water Sample Collection Card

Student Name ______________________________

Date of Collection ______________________________

Collection Site Description ______________________________

____

____

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____

____

Weather ______________________________

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____

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Condition of Water ______________________________

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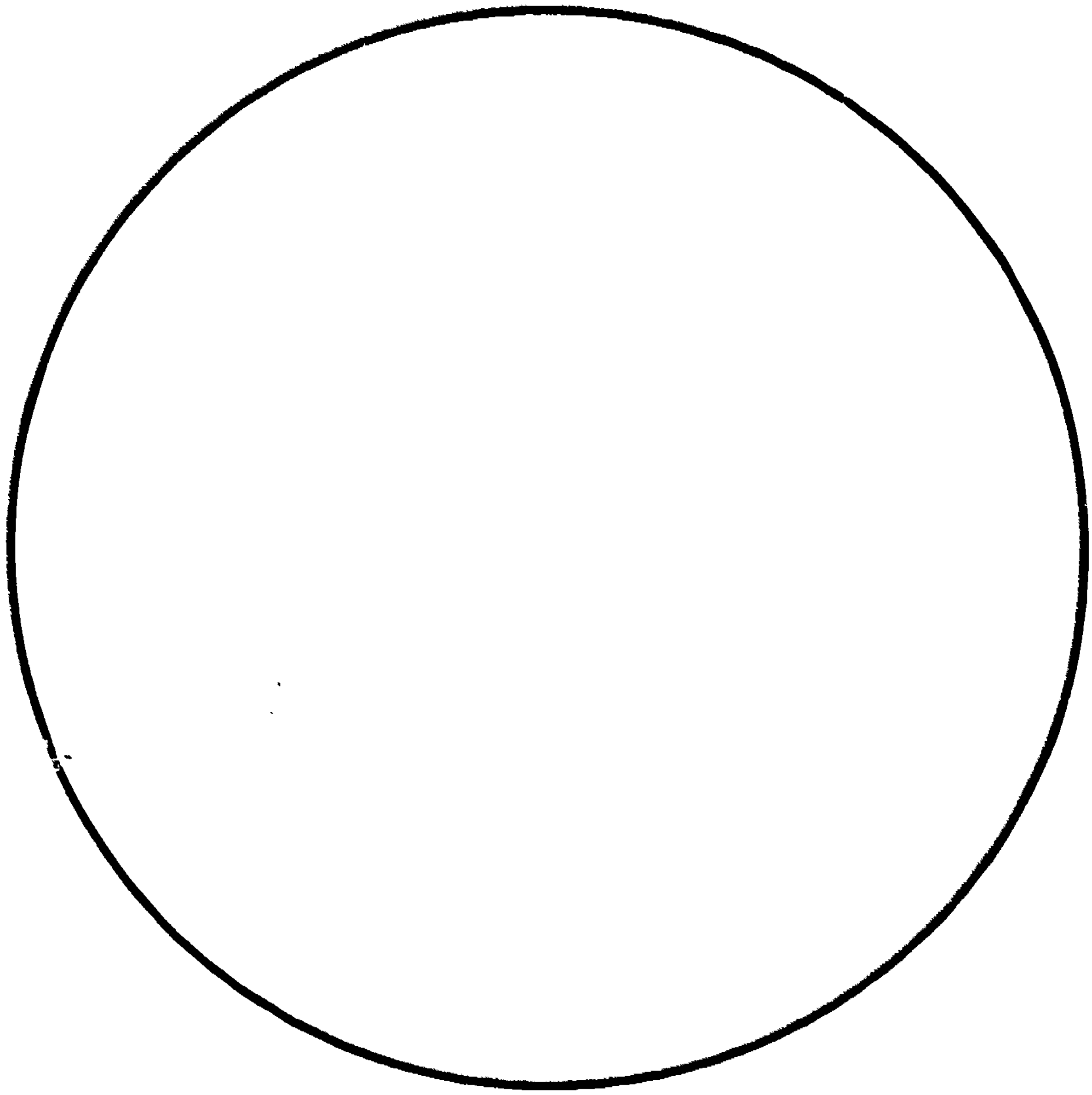
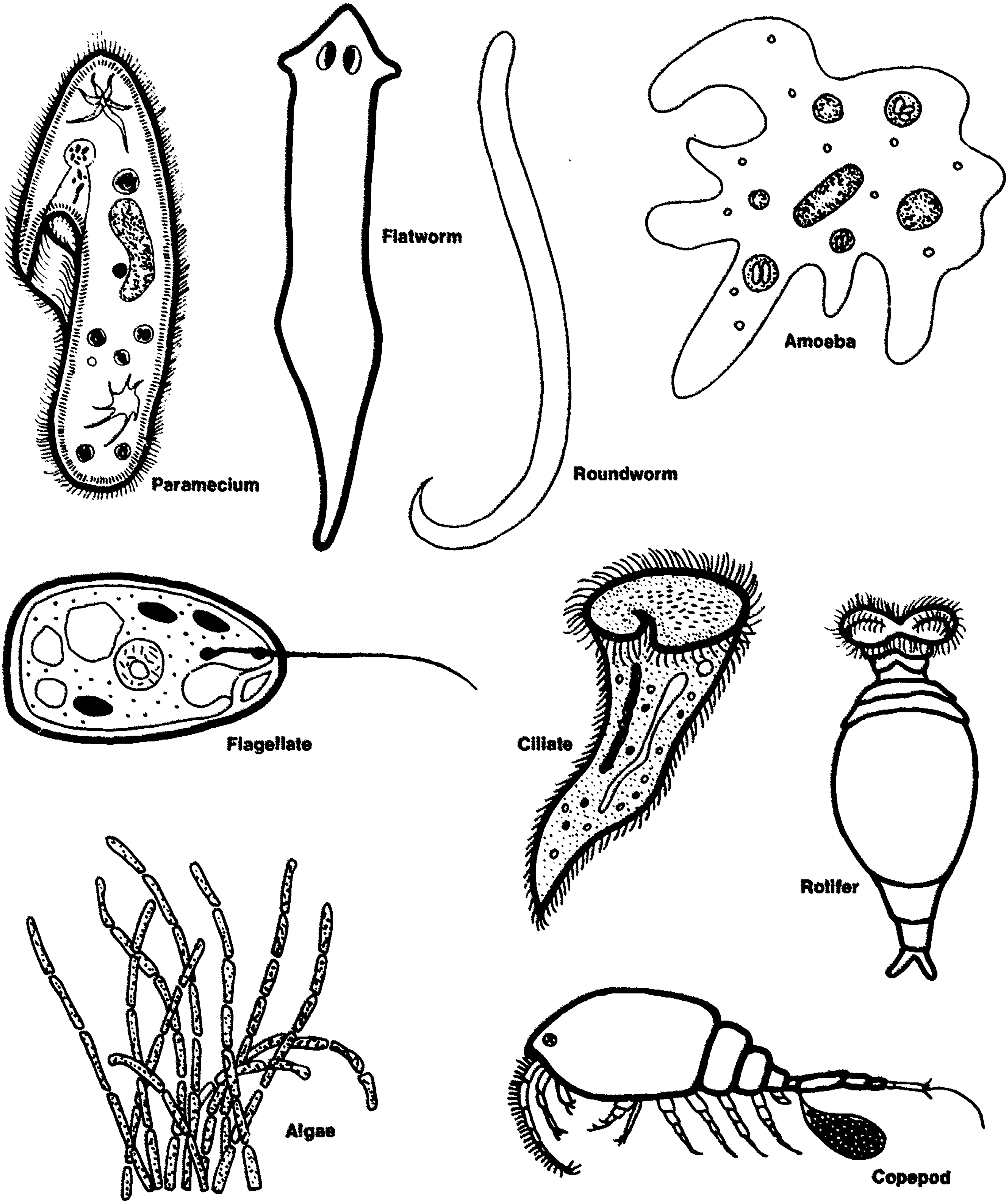
DAY ______

DATA CHART

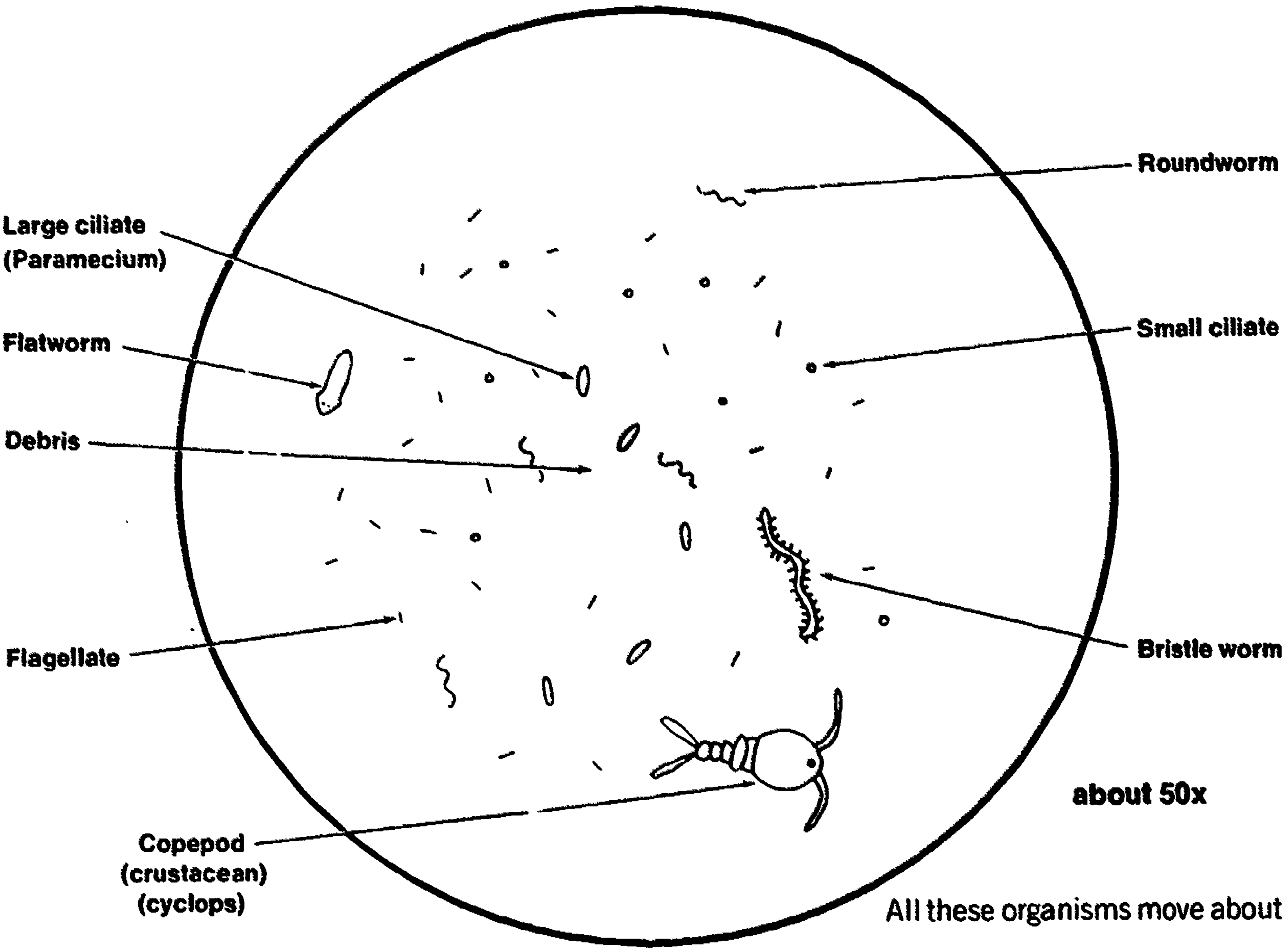


Date	Organisms Observed	Number	Description of Population	Water Conditions

II. Drawings of Common Organisms



DAY 4 (after setting up micro-aquarium)

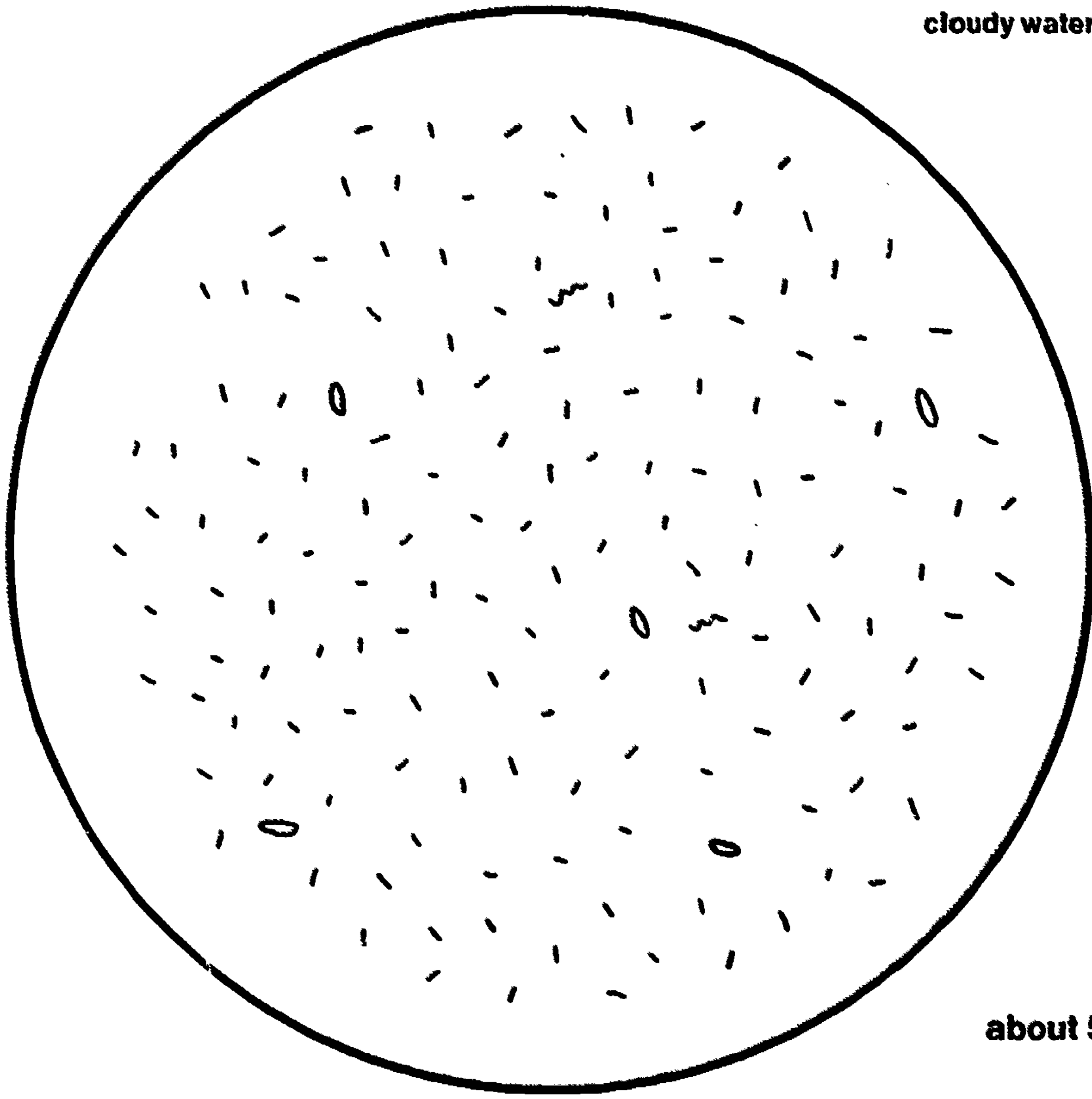


1st		few	mixed population; small dash-like organisms are the most numerous; also several larger forms	clear
		most		
		few	*or*	
		one	most closely resembles View D, except there are also several larger forms and small circular ones.	
		one		
		one		
		few		

FED ON DAY 4-5

DAY 7-8

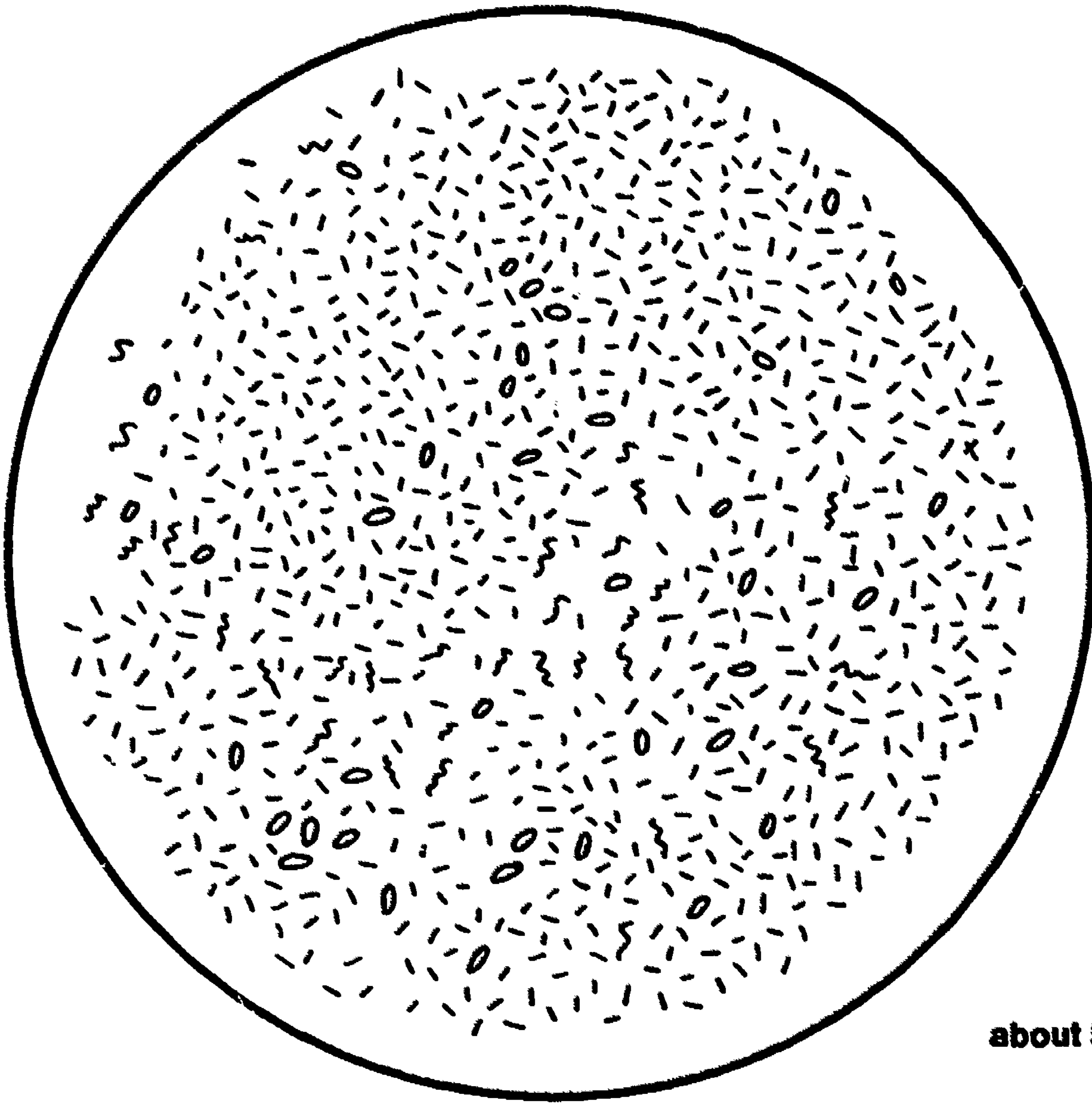
cloudy water from bacteria



about 50x

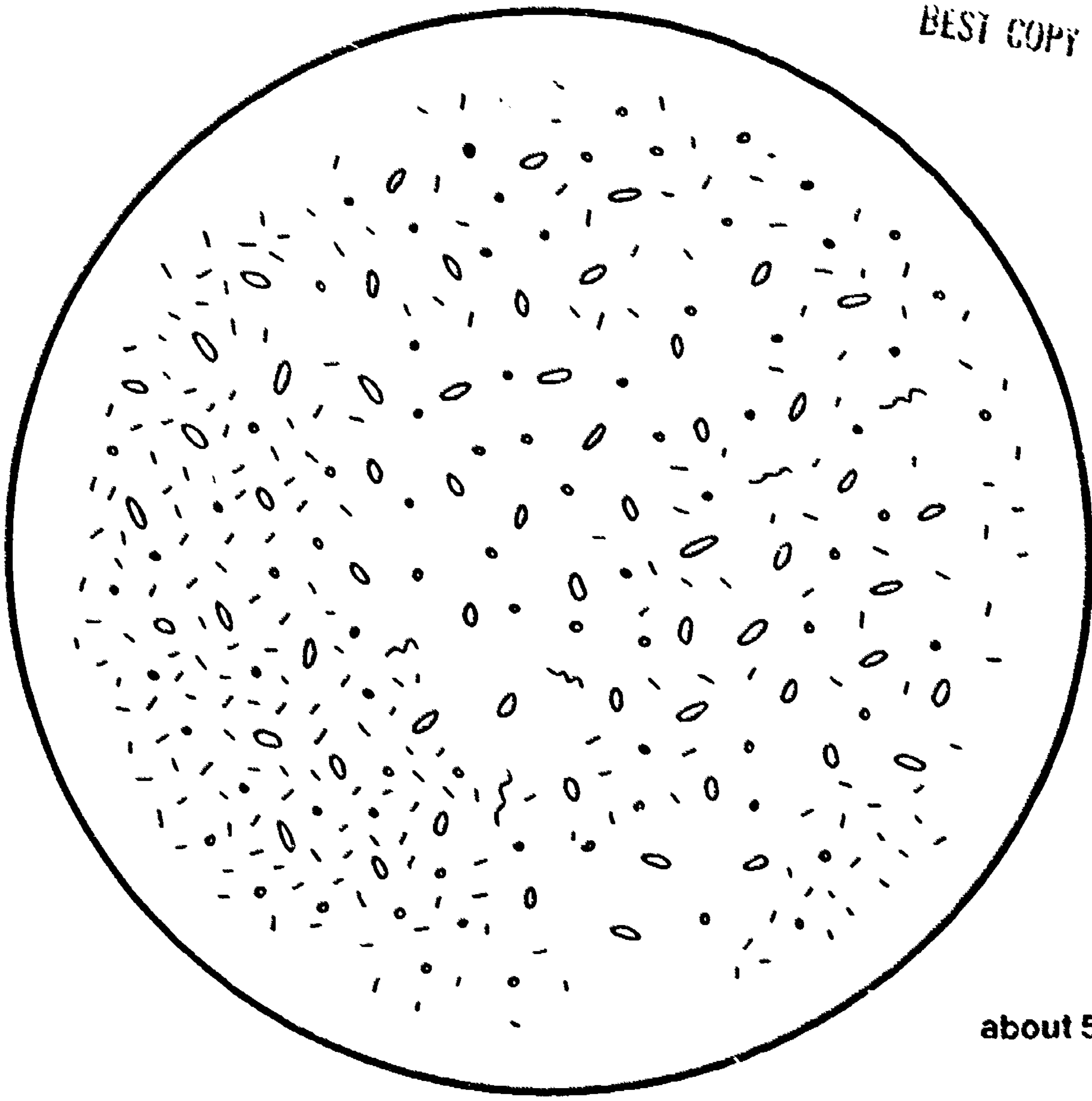
4th	0 〰 –	few two many	mixed population; dash-like organisms still most numerous—many, many more than the previous reading. *or* most nearly resembles View A, except that there are only a few oval forms.	cloudy

DAY 11-12



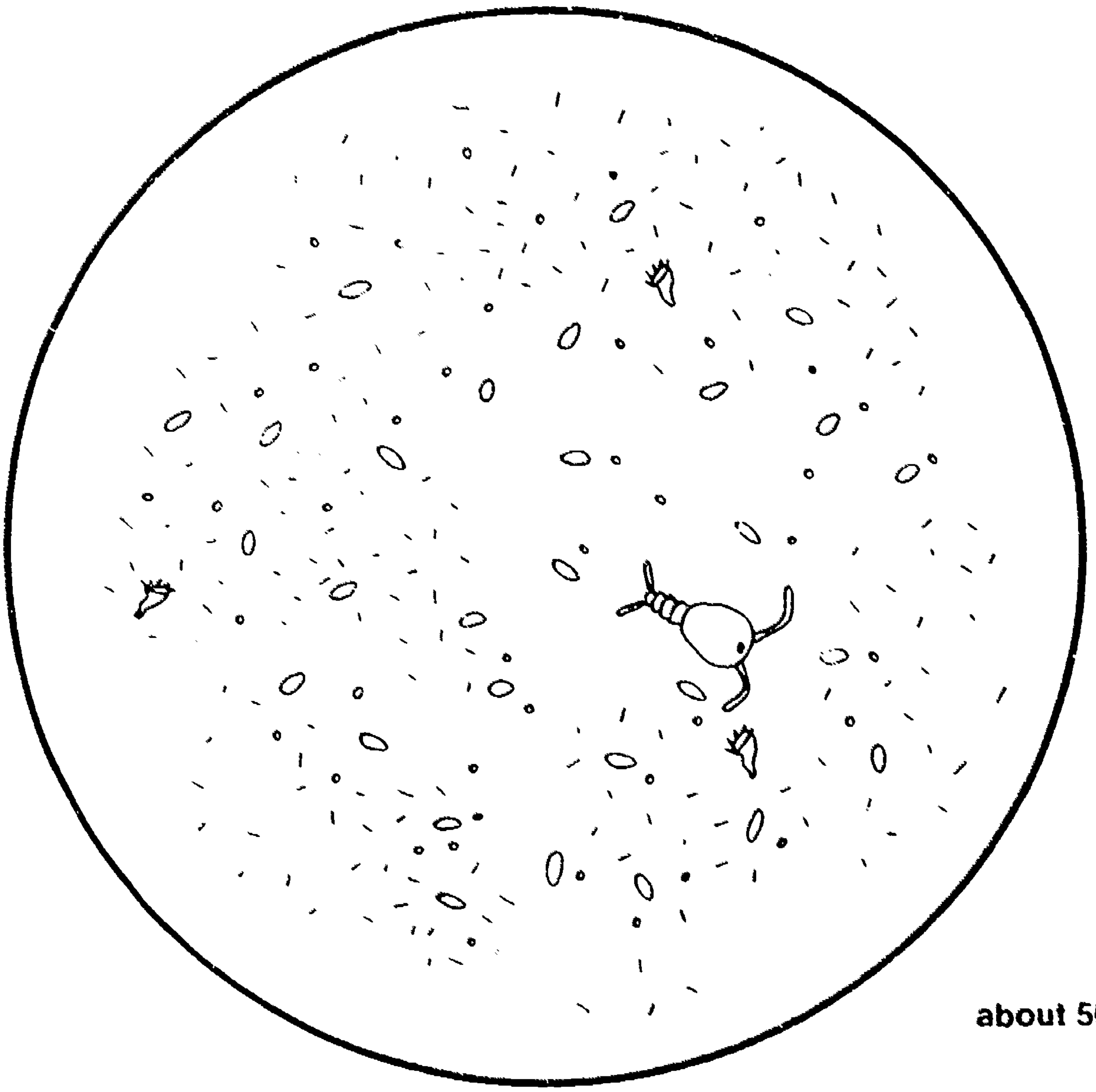
about 50x

8th	⬭ ∿ –	many several lots and lots	mixed population; dash-like organisms still most numerous; oval forms increasing in number. *or* now closely resembles View A.	cloudy

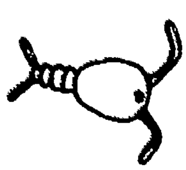


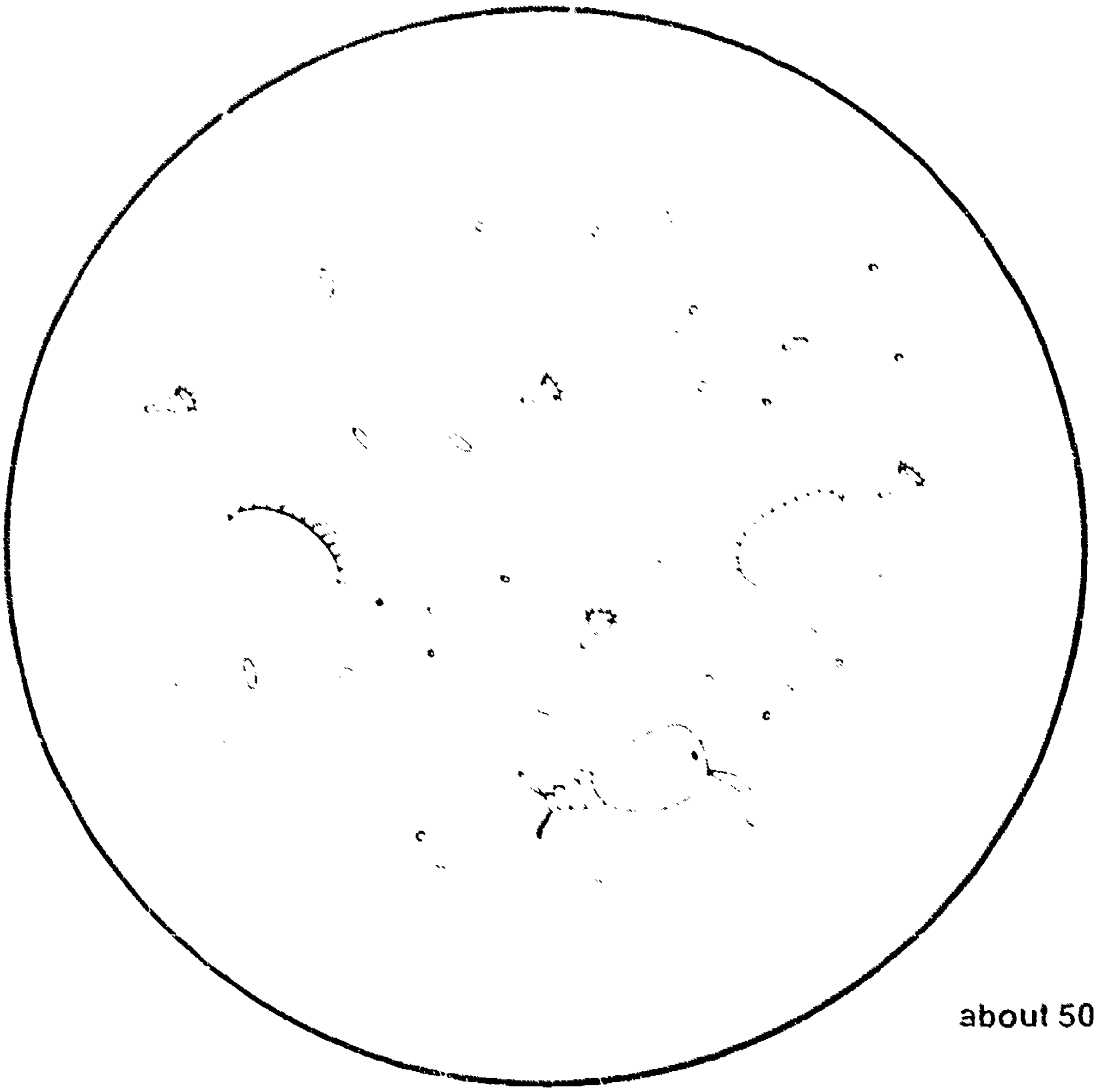
about 50x

Date	Organisms Observed	Number	Description of Population	[illegible]
12th	⬭	many	mixed population; dash-like organisms decreasing in number; many oval forms; increasing number of circular forms. *or* most closely resembles View C, except more dashes than in View C, plus large number of circular forms.	getting clearer
	∿	few		
	•	many		
	—	many		

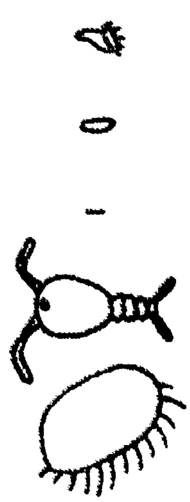


about 50x

Date	Organisms Observed	Number	Description of Population	Water Conditions
16th		few	mixed population; all forms decreasing in number; oval and circular forms most numerous.	clear
		several	*or*	
		several		
		several	most closely resembles View B.	
		one		



about 50x

Date	Organisms Observed	Number	Description of Population	Water Conditions
21st		few few several one two	mixed population; total numbers have decreased; several larger forms have reappeared. *or* most closely resembles View D except that there are several oval forms visible, and some larger forms.	clear; getting green looking if viewed in light

THE ENVIRONMENTAL UNITS

Below is a list of the first titles in the Environmental Discovery Series. The ones with order numbers next to them are available as of August, 1972. The others are in preparation and will be available in the coming weeks. Also, ten additional units will be announced soon.

Next to the titles, we have suggested the grades for which each is most appropriate. We emphasize that these are suggested grade levels. The teacher is encouraged to adapt the activities to a wide range of grade levels, and subject areas depending upon the interests and abilities of the students.

Order No.	Title	Grade Level	Price
79007	Plants in the Classroom	3-6	$1.50
79016	Vacant Lot Studies	5-9	1.50
79025	Differences in Living Things	4-8	1.00
79034	Shadows	1-8	1.00
79043	Wind	3-6	1.50
79052	Snow and Ice	1-6	1.50
79061	Man's Habitat—The City	4-9	1.50
79070	Fish and Water Temperature	4-9	1.50
79089	Oaks, Acorns, Climate and Squirrels	1-6	1.50
79105	Nature Hunt Spec. Ed.	K-1	1.00
79098	Sampling Button Populations	3-9	1.00
79114	The Rise and Fall of a Yeast Community	6-9	1.00

Order No.	Title	Grade Level	Price
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79132	Soil	2-9	1.50
79141	Tile Patterns and Graphs	1-2	1.00
79150	Plant Puzzles	1-6	1.50
79169	Brine Shrimp and Their Habitat	1-5	1.50
79178	Nature's Part in Art	3-6	1.50
79212	Contour Mapping	4-9	1.50
79187	Change in a Small Ecosystem	5-9	1.50
	Transect Studies	3-9	
	Stream Profiles	4-9	
	Color and Change	K-2	
	Outdoor Fun for Students	1-12	

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