Chapter 10

A Laboratory Teaching Model
Which Trains Students to Exercise Discretion

William H. Leonard

College of Education
Clemson University
Clemson, South Carolina 29634

Bill Leonard is a professor of science education and biology at Clemson, where for the past 7 years he has taught science teaching and biology courses at both graduate and undergraduate levels. He has also held similar joint faculty appointments at Louisiana State University and the University of Nebraska. He earned a B.A. in 1964 and an M.A. in 1967 at San Jose State University, and a Ph.D. in 1976 at the University of California at Berkeley. He learned many survival skills while teaching high school biology in San Jose, California. His research interests are developing and testing inquiry learning strategies for biology and the development of biology curricula. He is currently principal investigator of *BioCom*, a large NSF-funded project to develop an environmentally-oriented, active learning curriculum for average-ability high school students.

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Introduction

The Extended Discretion Laboratory Teaching Approach (EDLA) is a version of the inquiry model. It prevents forcing the student to wade through unnecessary cookbook-like recipes in a laboratory investigation. It is theoretically grounded on research which demonstrates that students learn most when actively involved in all phases of the learning process, including identifying the problem, planning procedures, collecting data, and drawing their own conclusions. Rather than give the student specific and prescriptive laboratory procedures, the EDLA biology investigation has the following components:

1. A Task – usually given in one sentence, sometimes as a question.

2. Two to three Steps – one brief sentence each to serve as guidance.

3. A List of Resources Available – which may include definitions, knowledge, special techniques, materials, time parameters, or other information needed to complete the task.

The important distinction between both cookbook and guided inquiry investigations on one hand, and those based on the EDLA, is that EDLA investigations require the student to think through the task and fit the necessary pieces together. This only infrequently means inventing the laboratory procedure from scratch. Usually, the student must *select* which resources to utilize and when to use them. In order to do this, the student must know *why* the resources are used. The point of all this seemingly round-about learning process is that the student is likely to *understand* the respective laboratory concepts far better by having to think through the learning procedure, than by having a procedure already present and then following this recipe in a rote-like manner.

The following references describe results of research studies using the EDLA and how the EDLA can be adapted for use in nearly any biology classroom:

Cavana, G.R., and W. H. Leonard. 1985. Extending discretion in the science classroom. Science Education, 69:593–604.

Leonard, W. H. 1980. An extended discretion approach for high school biology investigations. American Biology Teacher, 43:334–348.

———. 1981. Designing an extended discretion laboratory investigation. American Biology Teacher, 43:254–266.

———. 1989. An experimental test of an extended discretion laboratory approach for university general biology. Journal of Research in Science Teaching, 26:79–91.

Leonard, W. H., G. R. Cavana, and L. F. Lowery. 1981. An experimental test of an extended discretion approach for high school biology laboratory investigations. Journal of Research in Science Teaching, 18:497–505.

Sample Investigation:
Evaluating the Quality of Natural Water Sources

Introduction

One criterion for evaluating the quality of water from natural sources is based upon an examination of the types, variety, and abundance of certain kinds of organisms present. Another is the relative clarity of the sample. Obviously, the abundance of organisms alone can affect the clarity, but significant amounts of impurities of any kind makes a sample unsafe for drinking.

Goal

Evaluate several available water samples in terms of their potential for human consumption.

Steps

1.   Determine the relative turbidity of each sample.

2.   Examine the types, diversity, and relative abundance of organisms in each sample.

3.   Arrange the samples from most to least drinkable and identify those from which you would probably drink.

4.   Prepare a report with your data and responses to #3 above.

Resources

A.   Time: One laboratory period.

B.   Materials: Compound microscope, slides, cover slips, 6–12 water samples from variety of natural habitats, sample from a local swimming pool, Spectronic 20, pasteur pipets.

C.   Information: Three general levels of water quality are:

1.   *Pristine:* This would be equivalent to clear mountain streams free of organic debris. There is typically diverse algal flora relative to total biomass, because of relatively low nutrient levels. (It should be noted that even pristine water can contain undesirable components, such as *Entamoeba histolytica*, whose water products will give a human amoebic dysentery. Such cases are rare, however.)

2.   *Organic enrichment:* This would typically be natural fill-in, sewage input, or fertilizer run-off. Here, species diversity is moderate to low, relative to total biomass.

3.   *Inorganic enrichment:* This would typically be acid mine drainage, sulfur springs, or metallic or industrial pollution. Such water may be highly toxic, resulting in low diversity and low to high biomass depending upon the total nutrient status.

D.   *Diagrams*: Six pages of diagrams of selected algae are found in Appendix D.

E. Techniques:

1. How to determine relative turbidity of a liquid sample: Use the Spectronic 20. Follow the procedure in Appendix A if you are unfamiliar with the use of the Spec 20. Use a tube filled with pure water for your standard. Each natural water sample tested will transmit a percentage of light as compared to pure water.

2. How to use the presence of certain organisms as an indicator of water quality:

    (a) There are four major groups of organisms to consider: *diatoms, green algae, blue-green algae,* and *flagellates.*

    (b) Green algae and diatoms in the absence of blue-green algae and flagellates suggest clean water.

    (c) Blue-green algae and flagellates frequently (with or without diatoms and green algae) indicate higher levels of organic (nutrient) materials.

    (d) As a general rule, when water sources become increasingly enriched organically, they support a greater total biomass.

    (e) Low diversity of organisms in a sample suggests contaminated water and high diversity suggests cleaner water.

3. How to identify diatoms, green algae, blue-green algae, and flagellates:

    (a) *Green algae* are single-celled, multicellular, or occur in strands. They have distinct and identifiable nuclei and chloroplasts and are usually bright green in overall color. Diagrams of some common green algae are found in Figures 10.1 and 10.2 (Appendix D).

    (b) *Diatoms* are single-celled, very symmetrical, and contain a glassy shell. They are not usually motile and are frequently yellow or brown in color. Diagrams of some common diatoms are found in Figures 10.3 and 10.4 (Appendix D).

    (c) *Blue-green algae* are either single-celled or in strands. They have a blue-green color and contain no nucleus or chloroplasts. This gives the inside of the cell a diffuse, granular appearance. Diagrams of some common blue-green algae can be found in Figure 10.5 (Appendix D).

    (d) *Flagellates* are single-celled organisms such as *Euglena* sp. They move about freely by flipping a long, hair-like flagellum. Diagrams of some common flagellates can be found in Figure 10.6 (Appendix D.).

4. Qualitative method to determine relative abundance of organisms (if there is time to be more precise): Actually count the number of individuals of each species (loosely defined as organisms which appear very similar structurally) in three different drops of each sample. Average the three readings. A sampling procedure, such as described in Appendix B, can be used.

APPENDIX A
How To Use The Spectronic 20 Colorimeter

Introduction

One of the most useful tools in the analysis of chemical substances is the spectrophotometer, or colorimeter, an instrument that measures the amount of light a substance absorbs or transmits at a given wavelength. Spectrophotometry is based on the fact that all substances absorb radiation at specific and characteristic wave lengths and that different molecules absorb different amounts of light at different wavelengths.

The spectrophotometer can also be used as a colorimeter to calculate the amount substance present in a solution and its clarity. The amount of light absorbed by a particular substance is proportional to its concentration.

How to Operate a Spectronic 20

1. Obtain a matched set of cuvette tubes. Handle these carefully, as any scratches, marks, or even fingerprints on the tubes will cause absorption and scattering of light and result in inaccurate readings.

2. Turn on the Spectronic 20 and allow it to warm up for at least 10 minutes.

3. Set the wavelength control to the appropriate wavelength setting. For water use 500 nanometers.

4. Without a test tube in the sample holder, adjust the reading on the scale (using the left-hand or "0" control) so that the needle indicates 0% transmittance. The lid on the sample holder should remain closed.

5. Place a test tube containing the *water only* in the sample holder. Close the lid, and with the right-hand control (light control) adjust the position of the needle on the scale so that it indicates 100% transmittance. This tube is the control, or "blank." This step adjusts for the amount of light the solvent itself absorbs, and ensures that readings will be based on the solute absorbance only.

6. Place a test tube containing your test material in the sample holder. *Do not adjust any settings at this point!* Close the lid and read the percent transmittance on the scale.

7. Occasionally insert the blank into the sample holder and check that it is still recording 100% transmittance.

APPENDIX B
Procedure For Sampling The Number Of Microorganisms

Many times, it is impractical to count every occurrence of every organism in an ecosystem. A solution to this problem is to sample the environment and estimate total numbers based on that sample.

When Few Organisms Are Present:

1.   Place a small known volume of solution on your slide. One drop from a typical pipette is approximately 1/20 of a milliliter.

2.   Cover with a coverslip whose surface area has been previously measured.

3.   Count the number of organisms or particles visible under the coverslip.

4.   Estimate the total number of organisms in the environment by the following equation (you can assume that one drop of material placed on the slide has a volume of 0.05 ml): (Number in sample)/(Volume of sample) = (Number in the environment)/(Volume of environment).

$$Total\ number\ of\ organisms\ = \frac{(Number\ in\ sample)\ x\ (Volume\ of\ environment)}{Volume\ of\ sample}$$

When Too Many Organisms to Count Are Present:

1.   Follow steps 1 and 2 above.

2.   Focus at random on an area under the coverslip.

3.   Count the number of organisms visible in the field of view. If there are too many to count in the direct field of view, count the number in 1/4 of your field of view and multiply that count by 4.

4.   Focus again at random on another area of the slide. Count again as in step 3.

5.   Average the numbers obtained.

6.   Use the following formulae to estimate the total number of organisms in the environment:

(a)   Radius = 1/2 diameter

(b)   Area of the field of view = $3.14 \times r^2$ (radius in mm squared)
(c)   Area of coverslip = length × width (in mm)
(d)   Number of organisms under the coverslip

$$\frac{(Average\ number\ in\ field\ of\ view)\ x\ (Area\ of\ coverslip)}{Area\ of\ field\ of\ view}$$

(e)   Number of organisms in the environment =

$$\frac{(Number\ under\ coverslip)\ x\ (Volume\ of\ environment)}{0.05\ ml}$$

APPENDIX C
Student Response Sheet For Evaluating Quality Of Water Sources

Name: Date: Section:

Table 10.1. Data on water quality (from steps 1 and 2).

Sample number	Turbidity rating	Organism types	Organism diversity	Organism abundance

Discussion:

APPENDIX D
Diagrams Of Selected Algae, Diatoms, And Flagellates

1. Chlamydomonas   Unicellular Forms   2. Euglena

3. Scenedesmus   4. Pandorina   5. Volvox

Colonial Forms

6. Spirogyra   7. Ulothrix   8. Chaetophora

Filamentous Forms

9. Enteromorpha   10. Ulva lactuca
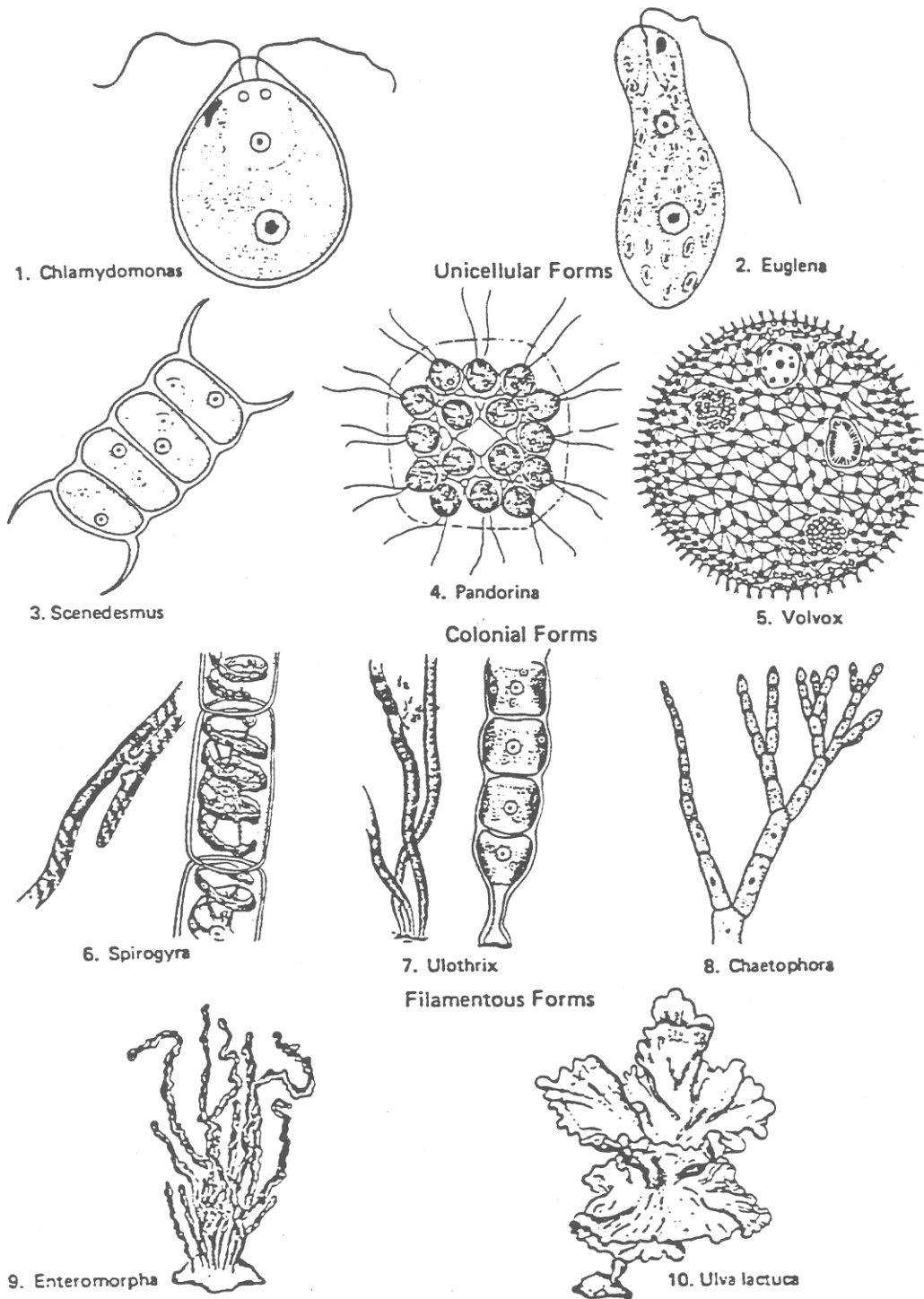
Figure 10.1. Types of green algae.

Figure A. Scenedesmus (varied) X1500

Figure B. Pediastrum (varied) X400

Side view →

Figure C. Gonium X800

Figure D. Pandorina X1800

Figure E. Eudorina X800

Figure F. Pleodorina X445

Sexual reproduction   Figure G. Volvox, Aureus   Asexual reproduction
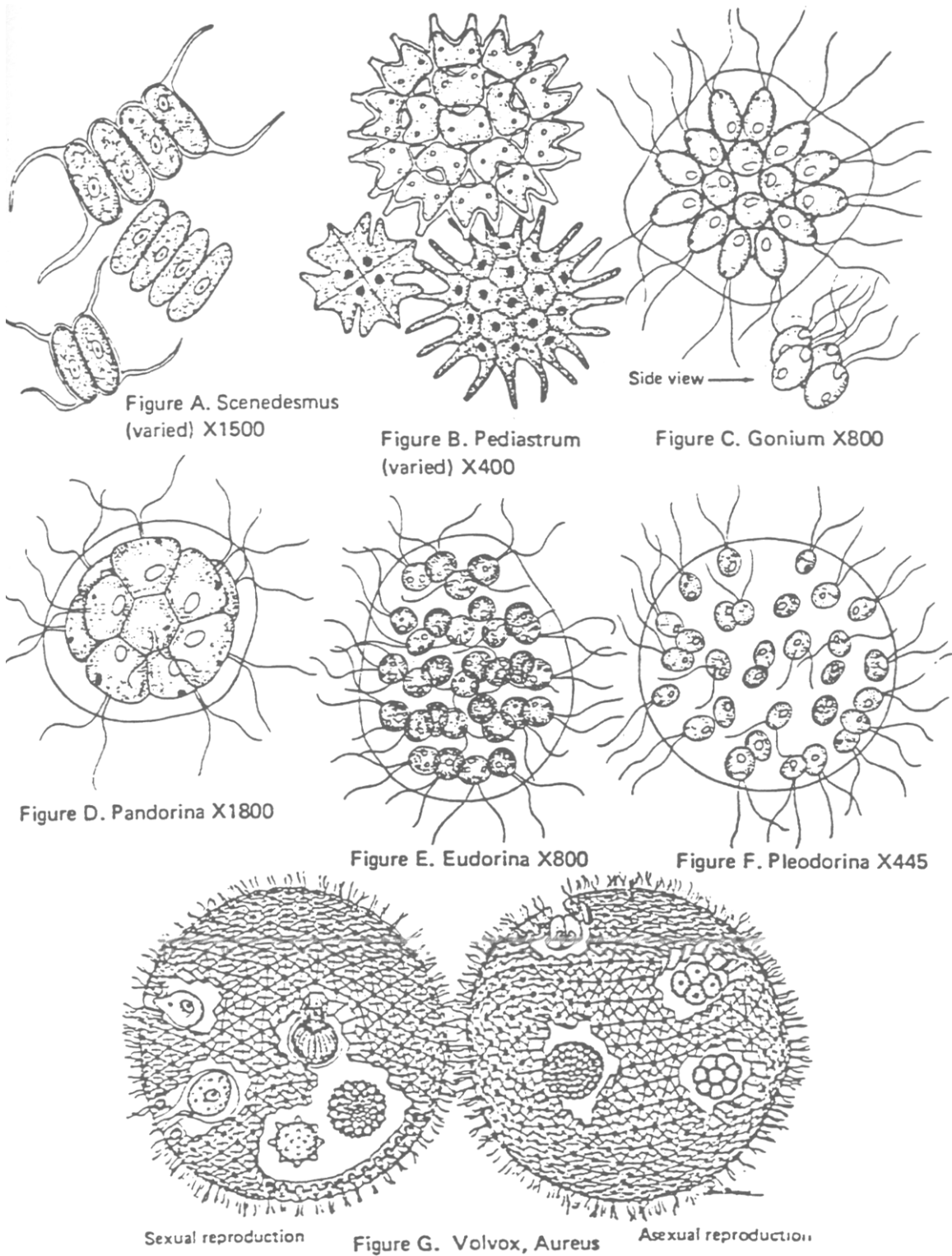
Figure 10.2. Types of colonial green algae.

Navicula

Gomphonema

Surirella

Pinnularia

Pleurosigma

Amphipleura
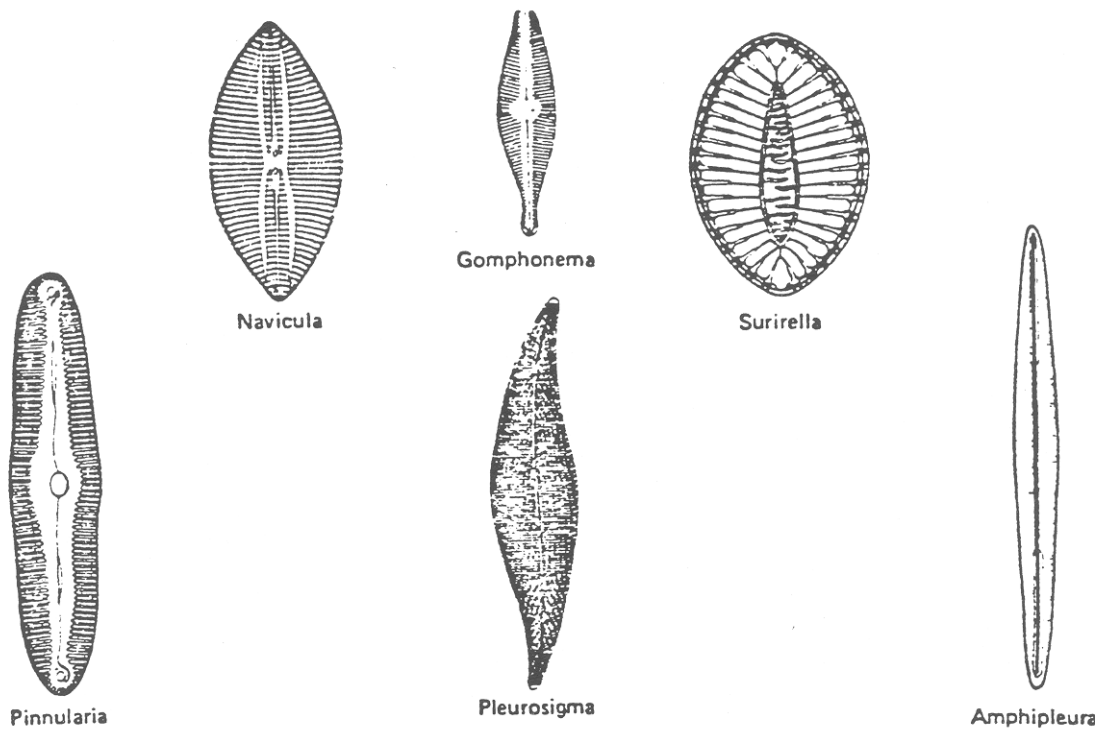
Figure A. Pennate Diatoms

Coscinodiscus

Isthmia

Stictodiscus

Arachnoidiscus

Triceratium

Aulacodiscus
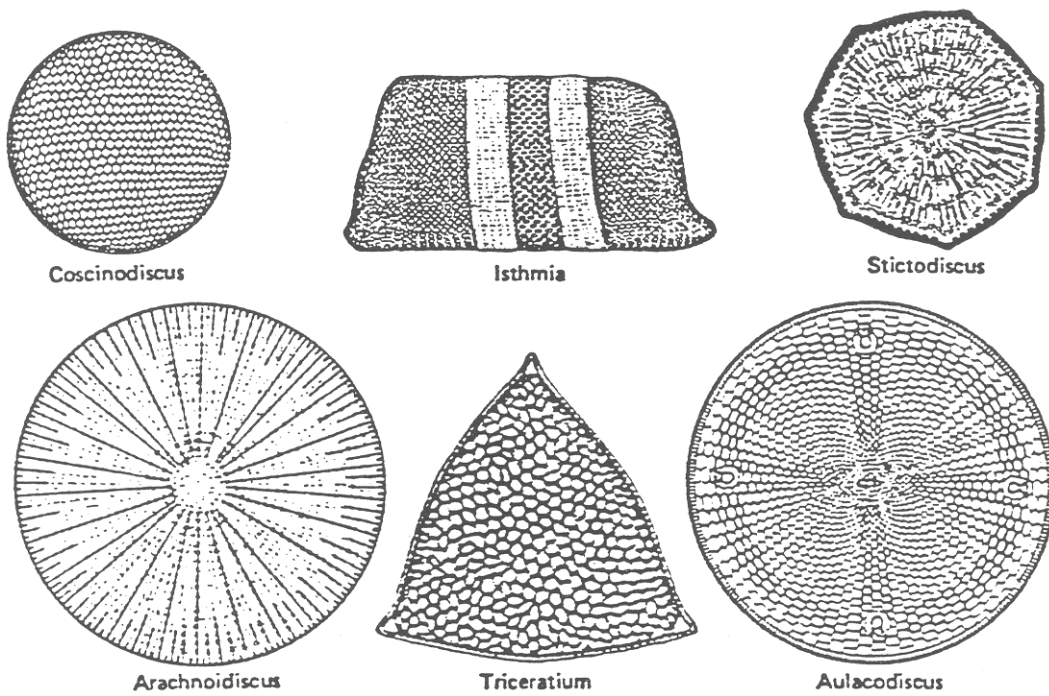
Figure B. Centric Diatoms

Figure 10.3. Types of solitary diatoms.
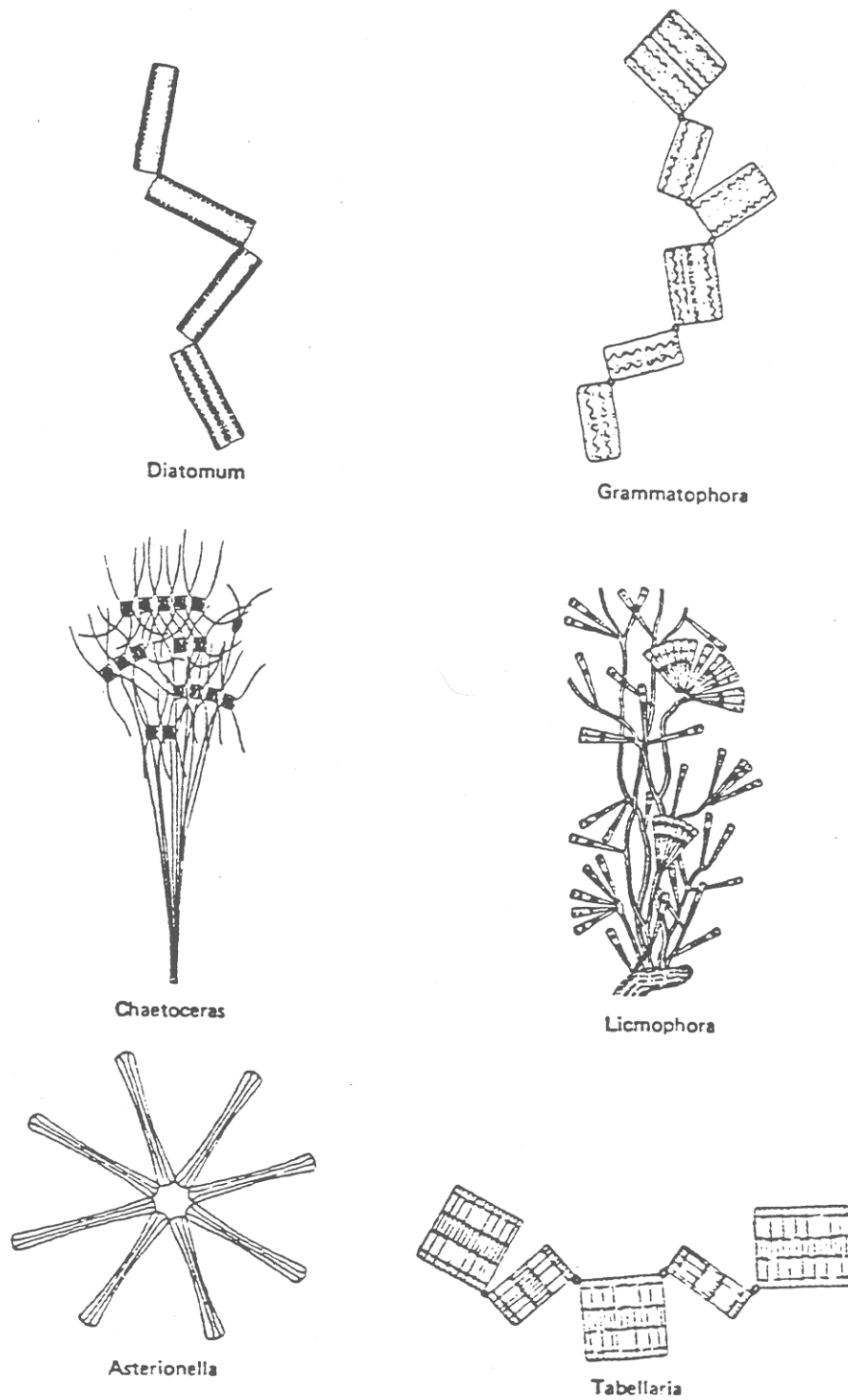
Figure 10.4. Types of colonial diatoms.
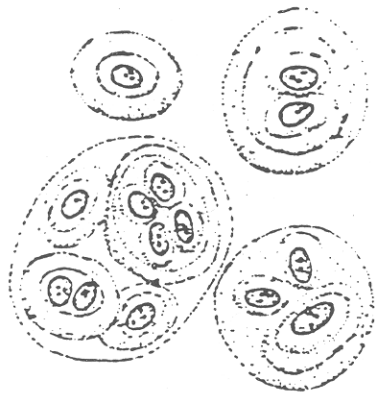
Figure A. Gloeocapsa
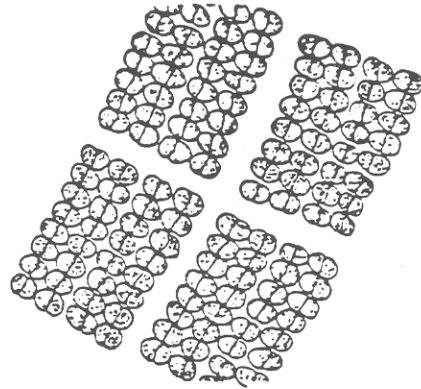
Figure B. Merismopedia
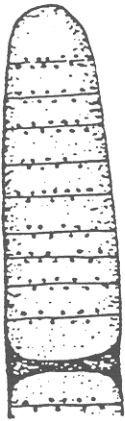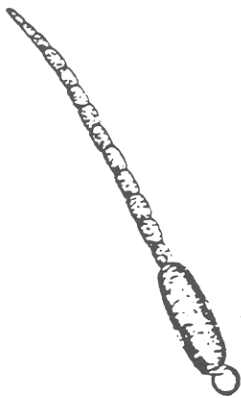
Figure C. Oscillatoria
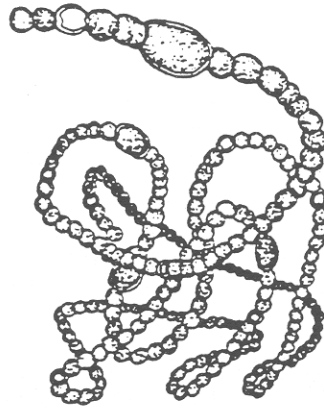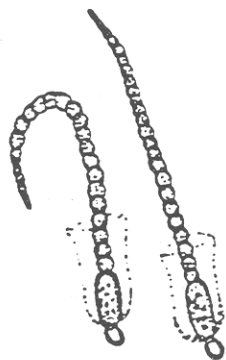
Figure D. Anabaena
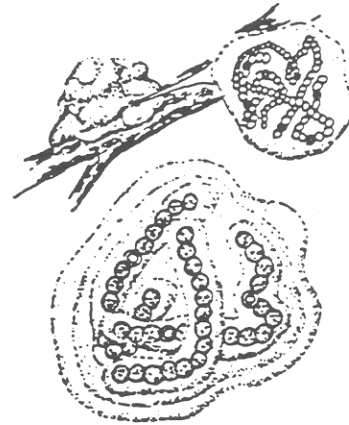
Figure E. Nostoc

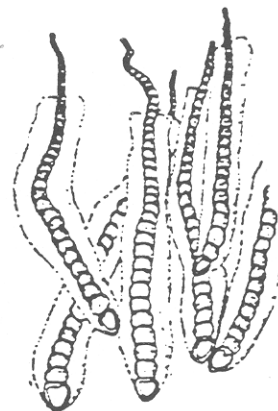Figure F. Cylindrospermum

Figure G. Gloeotrichia

Figure H. Rivularia

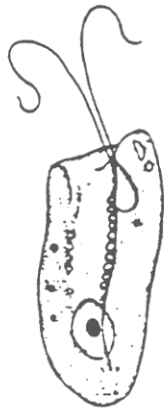**Figure 10.5.** Types of blue-green algae.

Figure A. Chilomonas

Figure B. Peranema
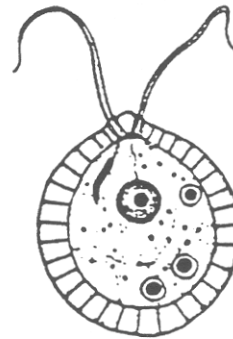

Figure C. Euglena

Figure D. Hematococcus

Figure E. Phacus

(Not drawn to scale)

Figure 10.6. Examples of common flagellates (Protozoa).