An Introduction to Using Periphyton in Bioassessment

Gary Lester

EcoAnalysts, Inc.

Woodland, CA

Moscow, ID

Bozeman, MT

Portland, OR

Overview

In the next 15 minutes I hope to:

- Provide introduction to the world of periphyton
- Discuss how periphyton may be a useful tool for water quality managers
- Discuss sampling methods and costs
- Provide you with a few web resources to help you get started
- Have some fun with algae!

Getting Started With Periphyton:

Barbour, M.T., J. Gerritsen, B.D. Snyder, J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish. 2nd Edition. EPA 841-99-002

Chapter 6: Periphyton Protocols

http://www.epa.gov/owow/monitoring/rbp/wp61pdf/ch_06.pdf

(see handout)

Introduction

- The science of ***bioassessment*** (that is, using biological communities as indicators of waterbody condition) has developed rapidly over the last 20 years.
- Bioassessment is the best way to directly measure the ***biological integrity*** of our surface waters: chemistry and physical habitat are important measures of waterbody condition, but they do not directly document biological integrity

Introduction

- EPA is “encouraging” ☺ the use of multiple community assemblages in water quality assessments.
- The three primary biological communities we currently use in bioassessment are fish, macroinvertebrates and periphyton.
- ***Fish*** are the most visible, publicly-endeared, and economically important assemblage. However, they are not present in all waters that need to be assessed. In addition, sampling permit issues and labor requirements make acquiring data a challenge.
- ***Macroinvertebrates*** are presently the most commonly used assemblage in bioassessment for a variety of reasons.
- ***Periphyton*** are emerging as a strong supporting measure of biological integrity, especially when used in conjunction with macroinvertebrates and physical habitat measures, as these three measures are closely linked in the stream ecosystem.

What is Periphyton?

- Attached benthic algae (as opposed to planktonic algae).
- A natural component of streams.
- Cosmopolitan (worldwide) distribution of many species.
- Primary producers, converting sunlight and nutrients into biomass - usable form of energy in the food chain.
- Represents a variety of algae types including single-celled, filamentous, colonial, red, yellow, blue-green, etc.
- Respond predictably to nutrient, chemical and physical alterations in the environment. Same pattern of responses in Europe as in North America.
- Can reach damaging nuisance levels under certain conditions.

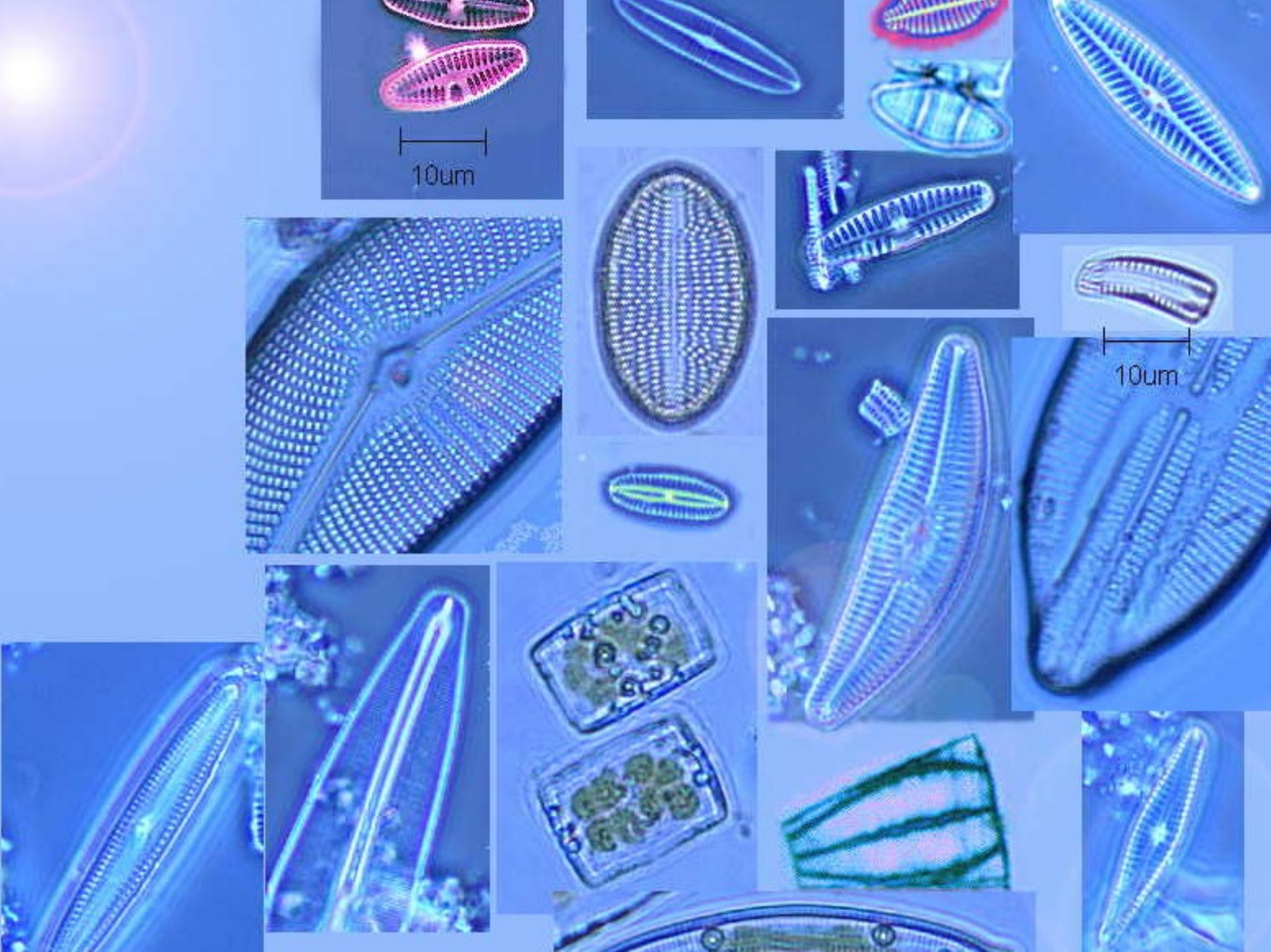
FIGURE 12.2 Filamentous green algae. (Photo by C. E. Cushing.)

FIGURE 10.3 Photograph of *Cladophora* mats in Sycamore Creek. (Photo by S. G. Fisher

FIGURE 3.2 Filamentous green algae, San Juan River, New Mexico. (Photo by C. E. Cus

Diatoms

- Single-celled algae
- Produce a silica shell composed of 2 valves that fit together like a Petri dish and cover
- Valves cover a wide range of size and shapes
- Taxonomic ID based on valve architecture
- 2000+ species in North America
- 35-70+ species may occur in high quality streams
- Some are sessile, others are mobile!
- A nutritious food source for invertebrates and algae-eating fishes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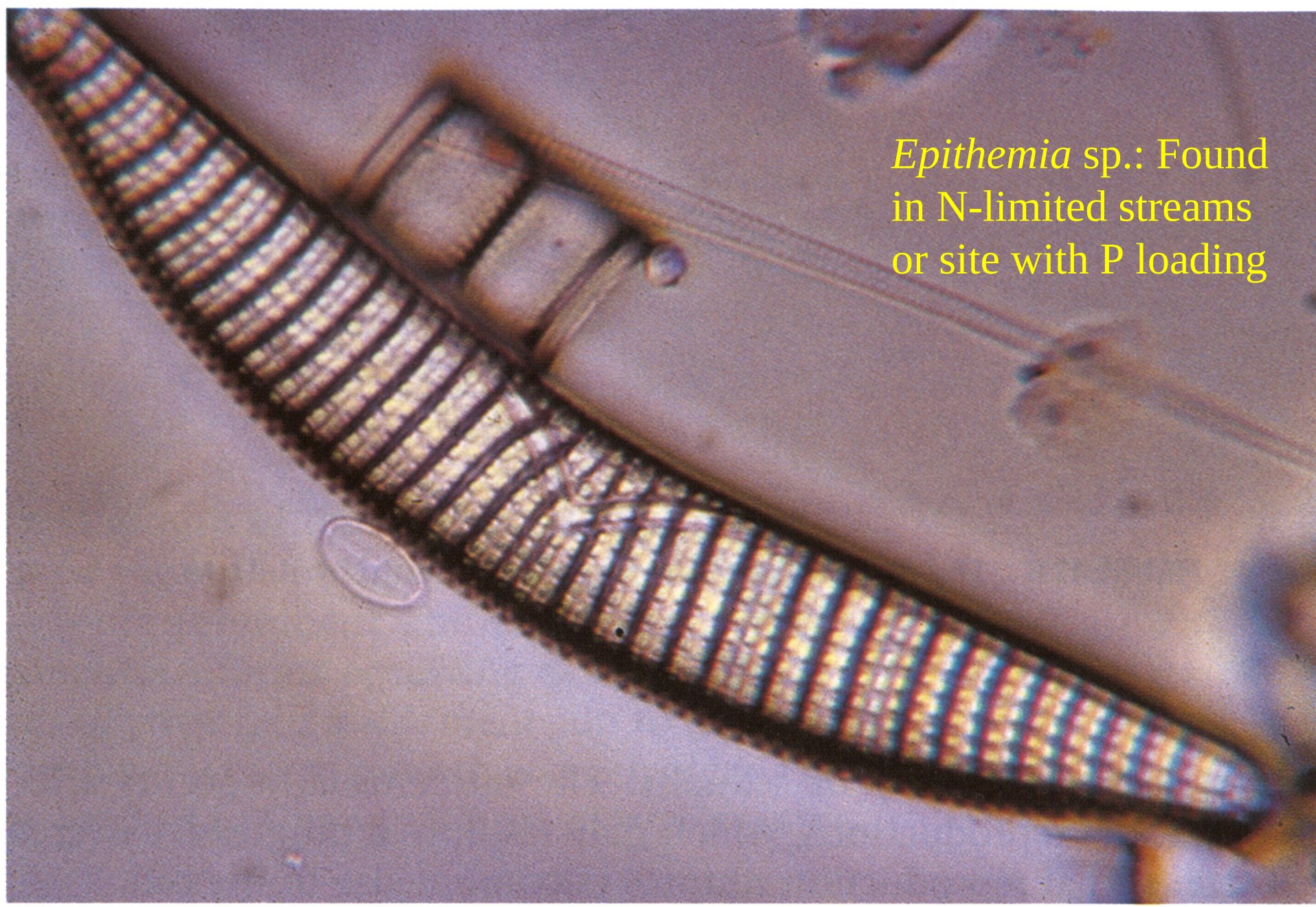


FIGURE 12.4 The diatom *Epithemia* sp. (Photo by R. Lowe.)

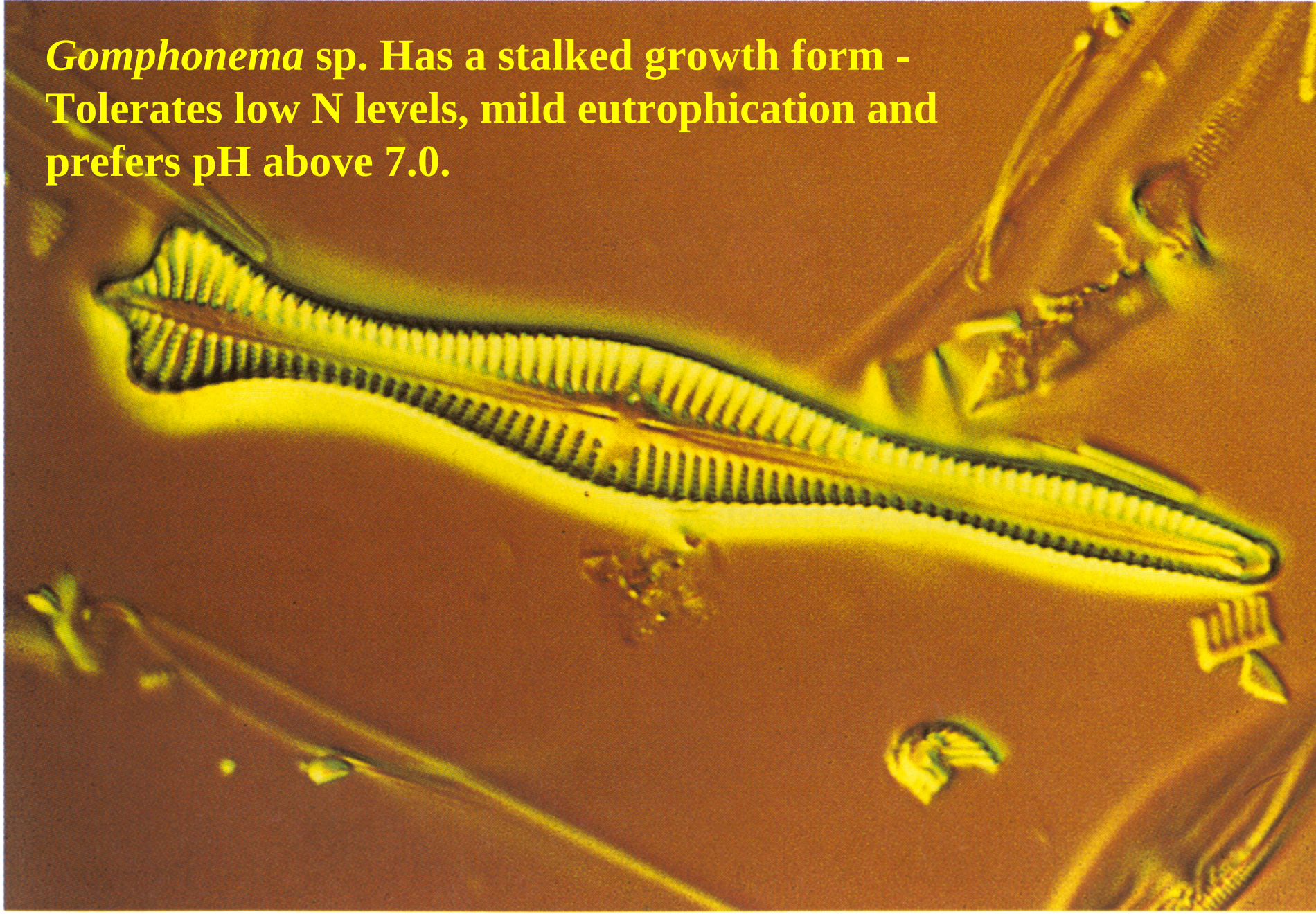
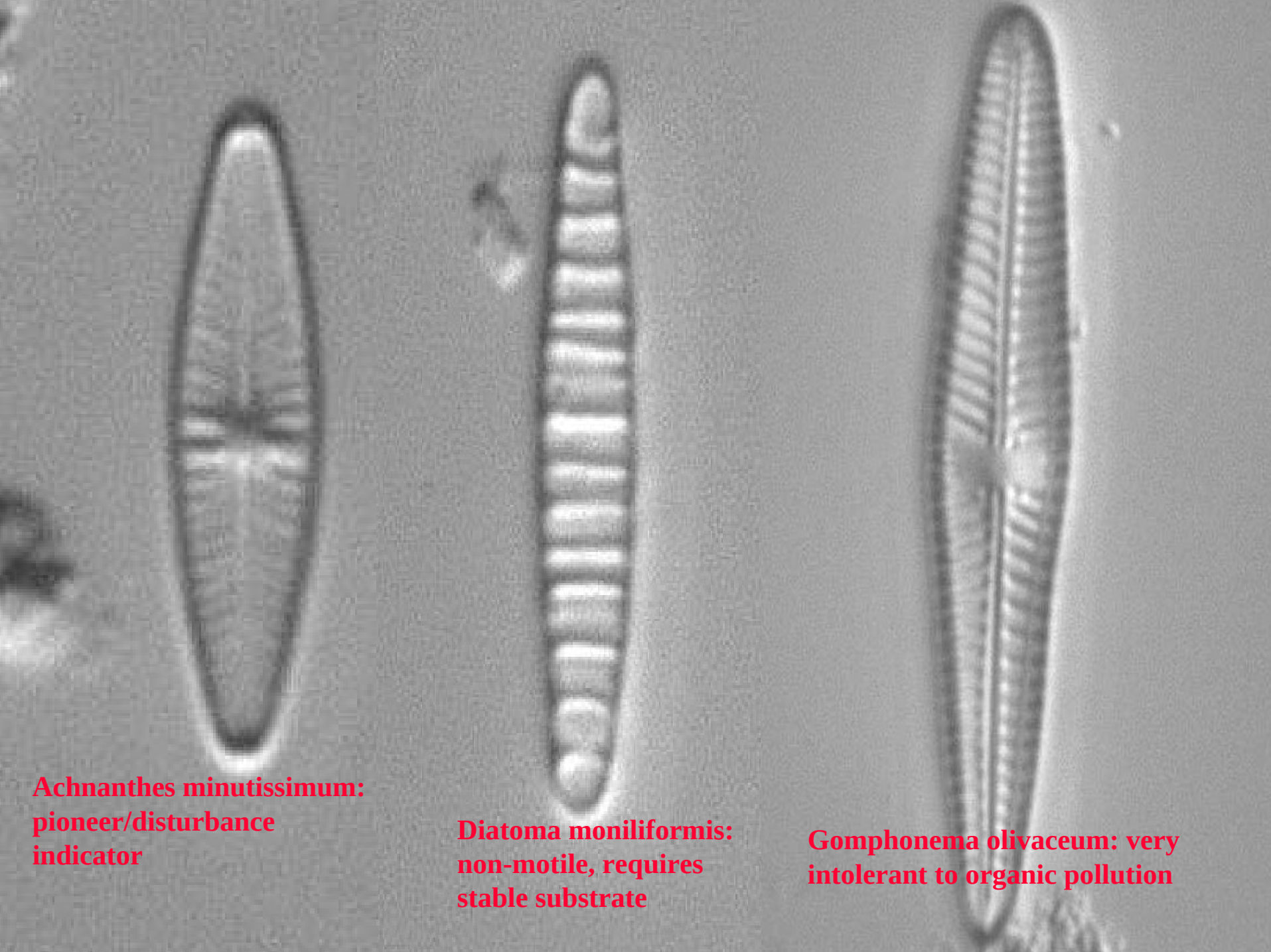


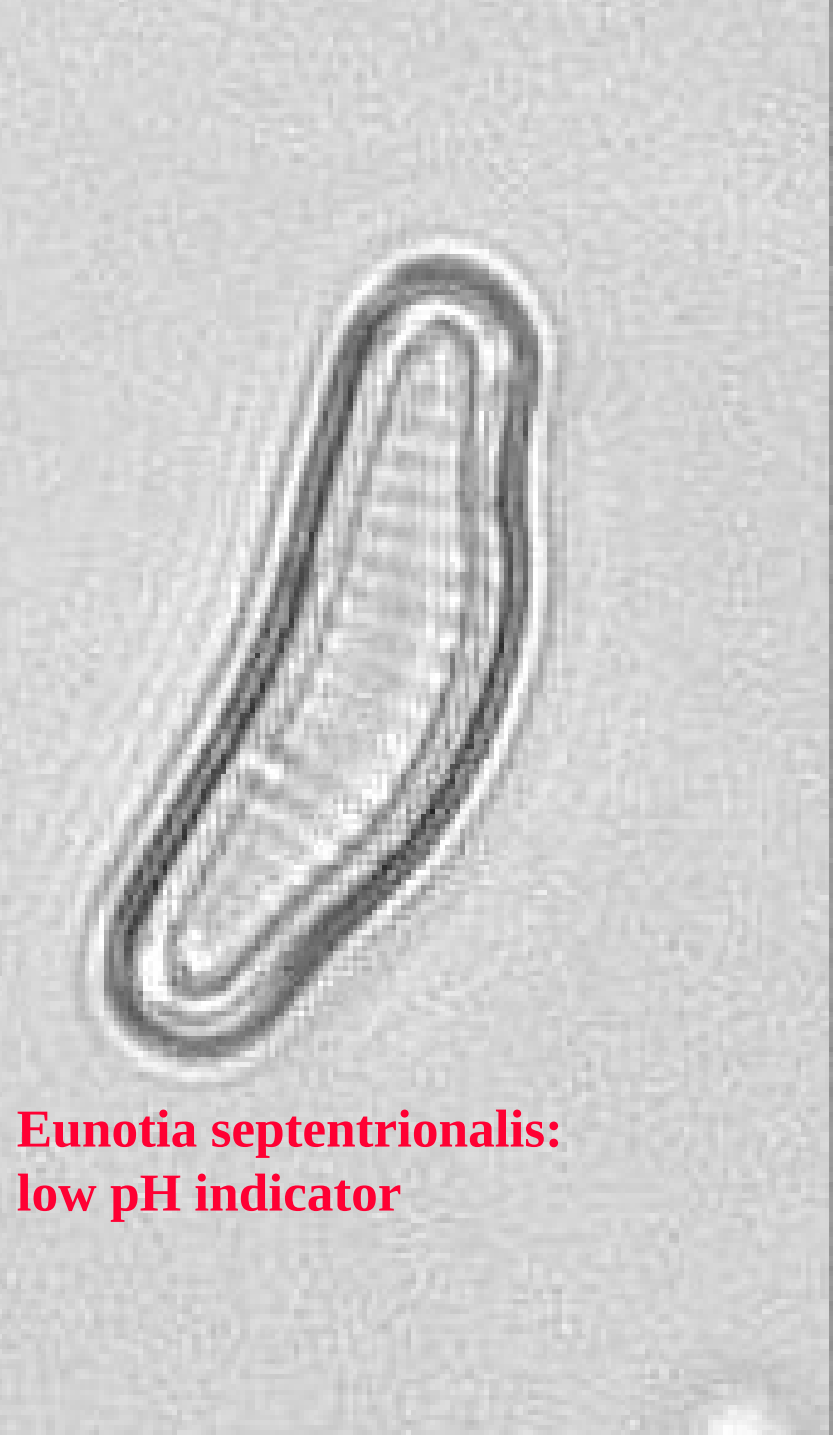
FIGURE 12.5 The diatom *Gomphonema acuminatum*. (Photo by R. Lowe.)



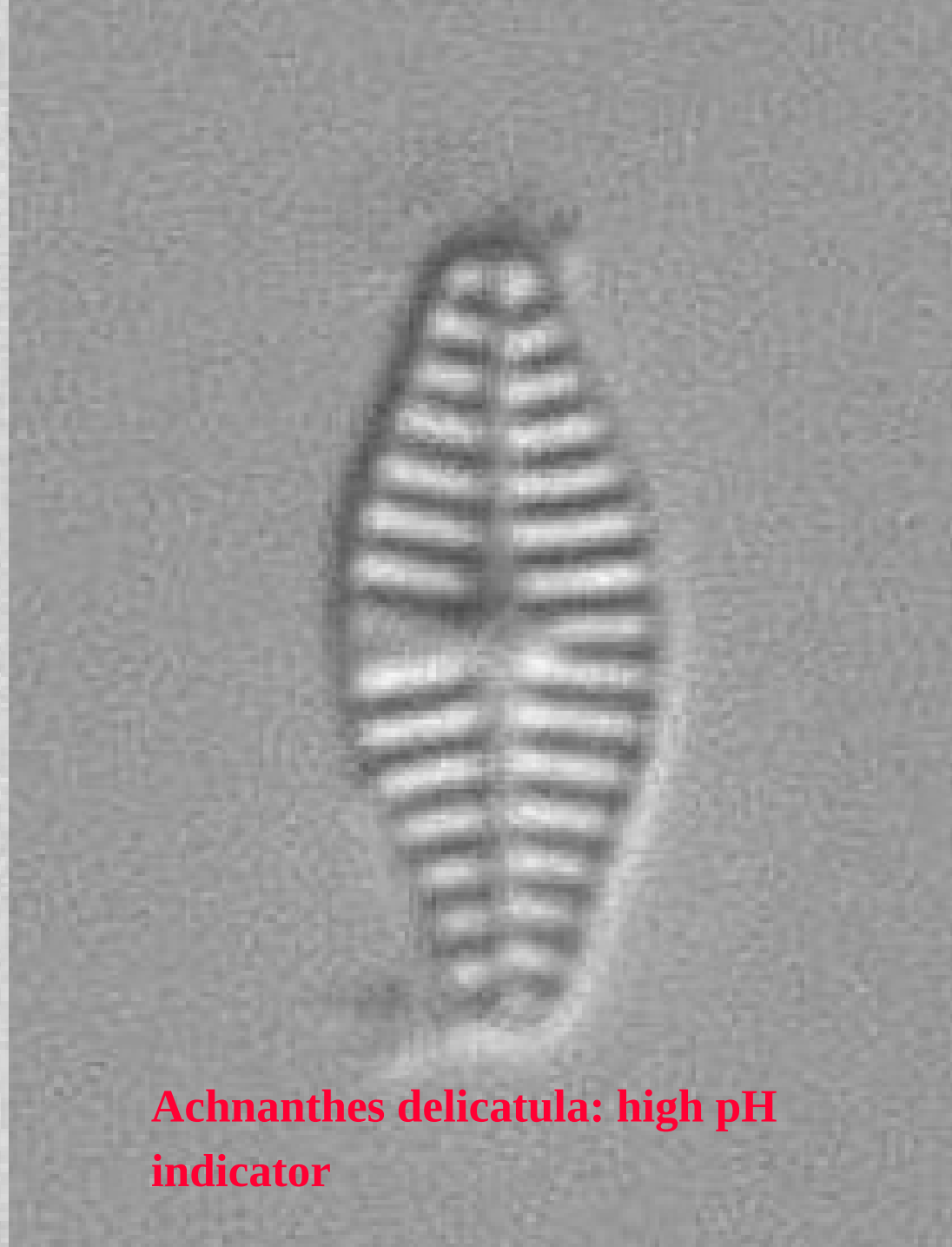
Achnanthes minutissimum: pioneer/disturbance indicator

Diatoma moniliformis: non-motile, requires stable substrate

Gomphonema olivaceum: very intolerant to organic pollution

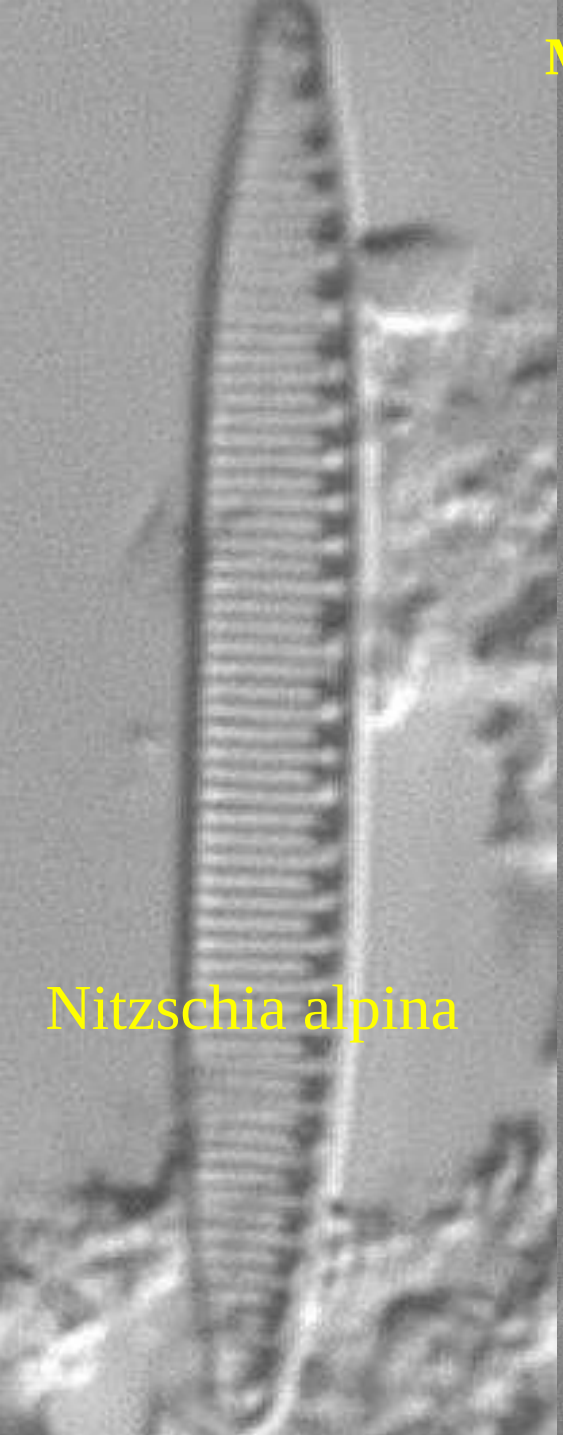


Eunotia septentrionalis: low pH indicator

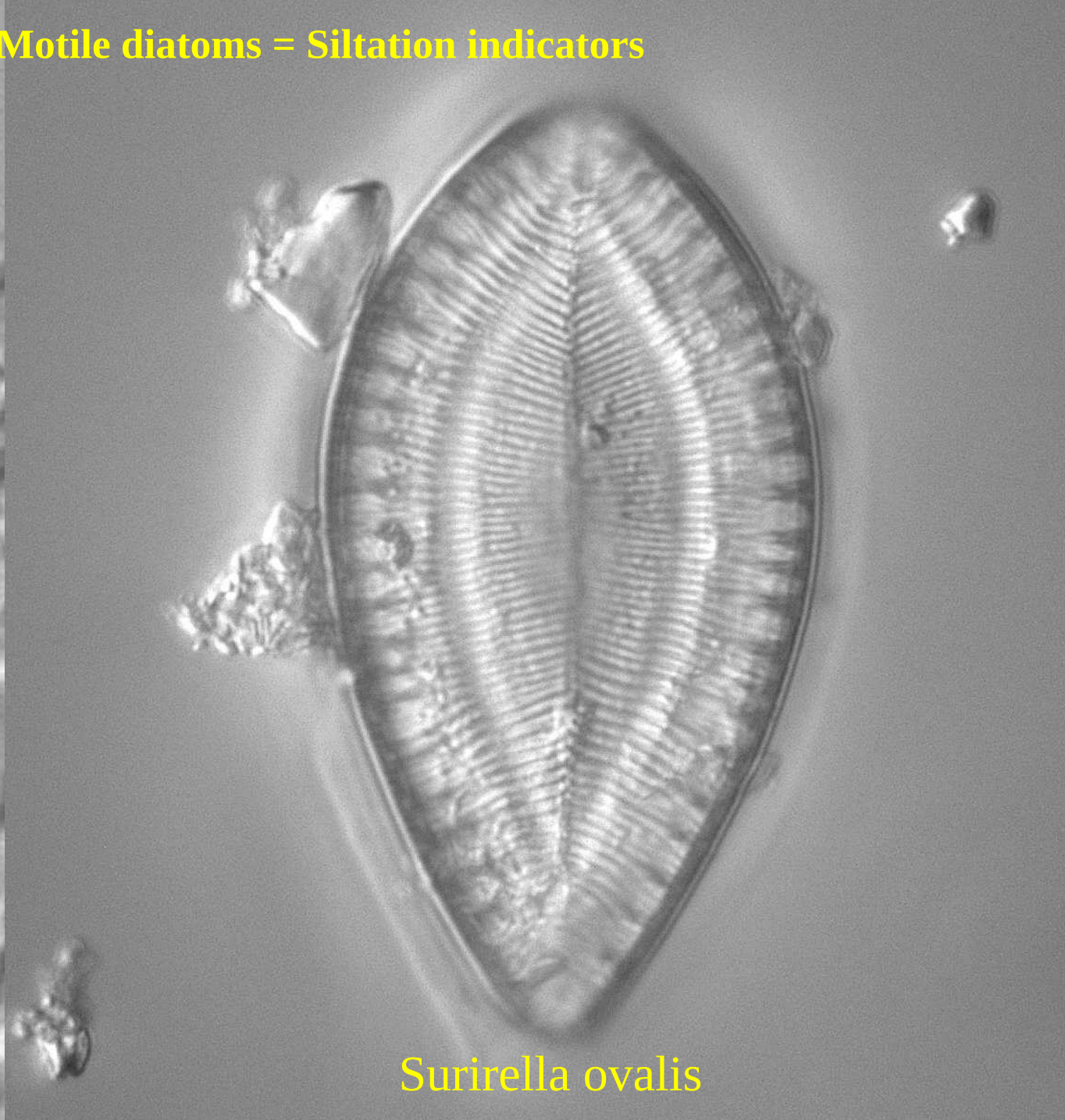


Achnanthes delicatula: high pH indicator

Motile diatoms = Siltation indicators



Nitzschia alpina



Surirella ovalis

FIGURE 12.1 Periphyton coating on rock. (Photo by R. Lowe.)

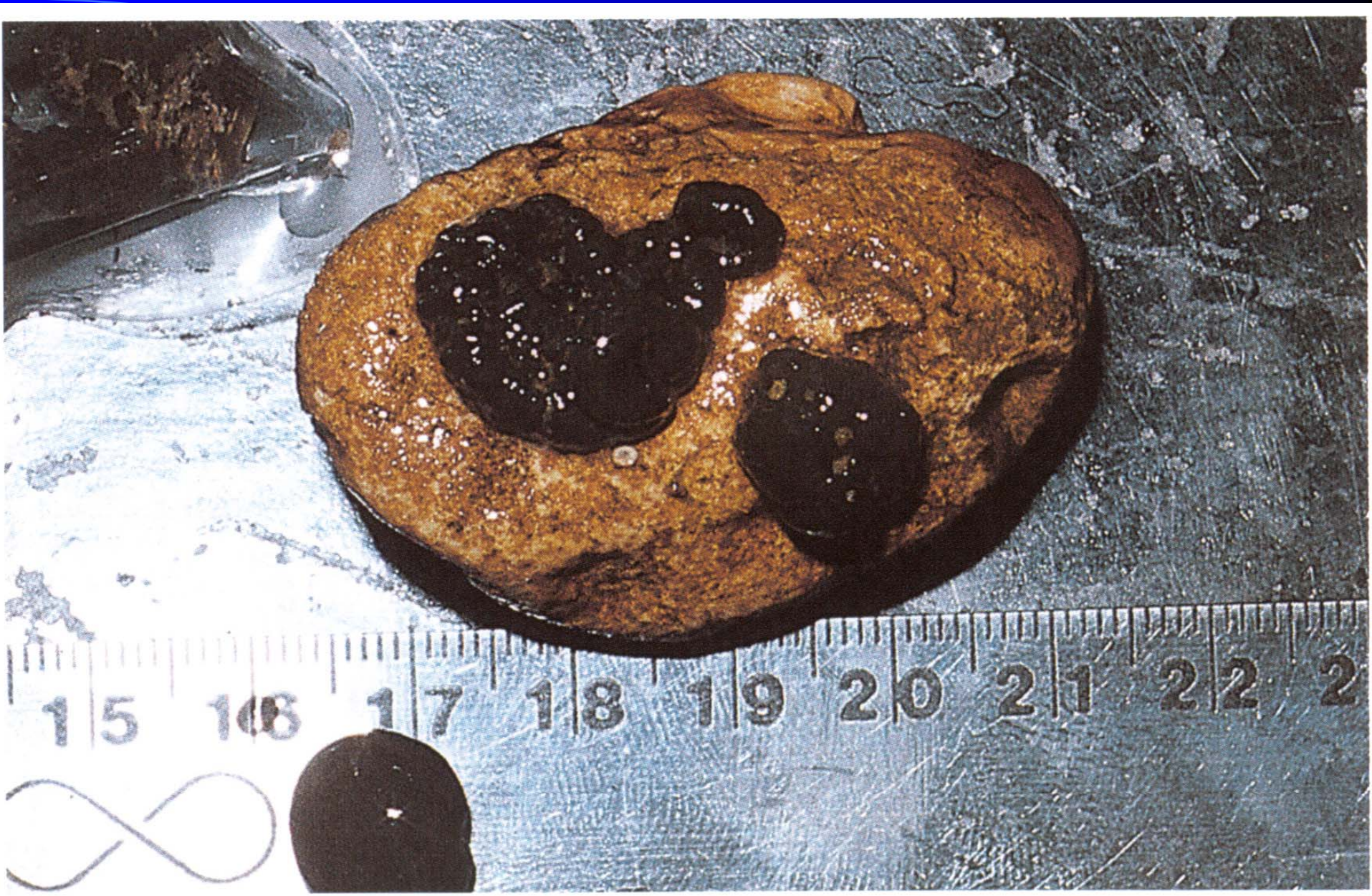


FIGURE 12.7 The cyanobacterium *Nostoc*; this is an example of the thallus growth form. (Photo by W. Dodds.)

Where Can Periphyton Bioassessments be Applied?

Many regulatory applications including:

- 305(b) water quality assessments
- 319 nonpoint source assessments
- 303(d) TMDL
- 402 NPDES permits
- Ecological risk assessments
- ALSO: nuisance algae blooms in reservoirs and lakes can be a significant ecological/economic problem

Periphyton as a Measure of Biotic Integrity

- Periphyton community indices have been developed for several regions of the US (Montana, Kentucky, Oklahoma, etc.) and Europe
- These are useful for detecting and diagnosing impairments in many situations.

Periphyton Metrics

Species Richness: decreases with increasing pollution, except where streams are naturally nutrient poor.

Total Number of Genera: similar response, but might be a more robust measure of change in diversity.

Shannon Diversity: change in diversity is a good indicator of impact.

Periphyton Metrics

Pollution Tolerance Index for Diatoms: Diatom species are rated on a scale of 1-3, with 1 being most tolerant to pollution. A decrease in score means increased pollution.

Percent Similarity: Measures how similar communities from 2 samples are. Very good when using paired sites.

% Achnanthes minutissima: This cosmopolitan diatom can thrive anywhere, including streams impacted by acid mine drainage, other chemical impacts, recent scouring, etc.

Periphyton Metrics

% Aberrant Diatoms: Positively correlated to heavy metal contamination.

% Motile Diatoms: Reflects the amount and frequency of siltation events. Expressed as the relative abundance of *Navicula sp.*, *Nitzschia sp.*, and *Surirella sp.*

Simple Autecological Indices: Using the published ecological preferences for diatoms, the community can be characterized according to various stressor gradients (ph, nutrient, organic, conductivity, habitat).

Periphyton Biomass

- Measures of periphyton biomass can be important in studies that address nutrient enrichment or toxicity.
- Several methods can be used, including Chlorophyll *a*, ash free dry mass, or biovolume.
- Greater than 10 micrograms/cm of Chlorophyll *a* *may* indicate enrichment problems (Biggs 1996).

Field Sampling Approaches

- ***Sampling approach should follow clearly defined study objectives!***
- These objectives will determine whether you sample:
  - Natural or artificial substrates
  - Single or multiple habitats
  - Qualitative or quantitative samples
  - Replicated or single samples

Field Sampling Approaches

- Generally, periphyton is easy to sample.
- Quantitative samples are collected by scraping a known area of substrate into a container and preserving (Lugol's, M3, 4% formalin, 2% gluteraldehyde)
- Qualitative samples are collected by scraping all available substrate types in proportion to their relative abundance at the site. A single composite sample is created and preserved.

Artificial Substrates

- Artificial substrates are useful in non-wadeable rivers, wetlands, littoral zones of lakes.
- Microscope slides, clay tiles, glass rods, or plexiglass plates can all be used.
- Allow at least 3 weeks for periphyton colonization before removal.
- Replicates can be placed at the site to allow for spatial variability and ***statistical power analysis***.

From Field to Lab

- After field collection and preservation, periphyton samples must be sent to a laboratory for processing.
- In the lab, diatom samples are cleaned using nitric/sulfuric acid or concentrated hydrogen peroxide.
- Permanent slides are made in a mounting medium with high refractive index (Naphrax).
- Diatoms are identified under a high power (1000x) microscope.
- A minimum of 600 valve counts (300 diatoms) per sample are counted and identified.
- Soft-bodied algae are counted before the sample is bleached and a minimum of 300 biological units (some are colonial) are identified.

Laboratory Costs

Costs will vary depending upon the services requested from the lab.

- Species level diatom ID: $200 - $400+ per sample.
- Soft bodied algae and diatoms to genus: $135+ per sample.
- Chlorophyll *a*: $25-$65 per sample depending on method used.

Commercial Labs
(see handout)

- Dr. Loren Bahls, Helena, MT
  lbahls@selway.umt.edu 406-443-2196
- EcoAnalysts, Inc. Portland, OR
  www.ecoanalysts.com 503-330-0879
- Phycotech, Inc. Ann Arbor, MI
  www.phycotech.com 269-983-3654

University Labs
(see handout)

- Portland State University: Dr. Yangdong Pan 503-725-4981
- Michigan State University: Dr. Jan Stevenson 517-432-8083
- Bowling Green State Univ: Dr. Rex Lowe 419-352-3053

Fun with Algae! ☺

Google search: “algae jokes”

Found a webpage of the “Top 10 Worst Algae Jokes Ever”

(?!?!?!?)

Fun with Algae! ☺

What do algae mothers hope for?

Fun with Algae! ☺

That their daughter cells will grow up and marry pond scum!

Fun with Algae! ☺

Why did the alga fail math class?

Fun with Algae! ☺

Because he divided when multiplying!

😐 😐

Fun with Algae! ☺

What is the most common form of algae transportation?

Fun with Algae! ☺

The nitrogen cycle!

Fun with Algae! ☺

And finally….

Why do many algae couples drift apart?

Fun with Algae! ☺

Because they prefer planktonic relationships!
☹

Fun with Algae! ☺

PETA

People for Ethical Treatment of Algae

- People for the Ethical Treatment of Algae (PETA), with more than one hundred and fifty members, is the largest algae rights organization in the world. Founded in 1987, PETA is dedicated to establishing and protecting the rights of all algae. PETA operates under the simple principle that algae is not ours to eat, wear, experiment on, or use for masturbatory purposes. PETA focuses its attention on the four areas in which the largest numbers of these beautiful, unicellular creatures suffer: on factory farms, in laboratories, in the manufacture of health-food, and in the entertainment industry. We also work on a variety of other issues, including cruel poisoning by manufacturing plants and the curse of algae-eating fish.
- PETA works through public education, cruelty investigations, research, algae rescue, legislation, special events, celebrity involvement, and direct action.

http://len.schmid.com/peta/peta.htm

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