Course Change Request

New Course Proposal

Date Submitted: 04/24/23 5:48 pm

Viewing: EVPP 441 : Protist Diversity and Ecology

Last edit: 04/25/23 9:23 am

Changes proposed by: ykih

Are you completing this form on someone else's behalf?

Yes

Requestor:

Name	Extension	Email
Younsung	Kim	ykih@gmu.edu

Effective Term: Spring 2024

Subject Code: EVPP - Environmental Science & Policy **Course Number:** 441

Bundled Courses:

Is this course replacing another course? No

Equivalent Courses:

Catalog Title: Protist Diversity and Ecology

Banner Title: Protist Diversity and Ecology

Will section titles vary by semester? No

Credits: 4

In Workflow

1. **ESP UG Committee**
2. **ESP Chair**
3. **SC Curriculum Committee**
4. SC Associate Dean
5. Assoc Provost-Undergraduate
6. Registrar-Courses
7. Banner

Approval Path

1. 04/24/23 5:49 pm Younsung Kim (ykih): Approved for ESP UG Committee
2. 04/24/23 6:59 pm Larry Rockwood (lrockwoo): Approved for ESP Chair

Schedule Type: Lecture w/Lab

Hours of Lecture or Seminar per week: 3

Hours of Lab or Studio per week: 3

Repeatable: May be only taken once for credit, limited to 3 attempts (N3)

Max Allowable Credits: 12

Default Grade Mode: Undergraduate Regular

Recommended Prerequisite(s):

Recommended Corequisite(s):

Required Prerequisite(s) / Corequisite(s) (Updates only): EVPP 210 or BIOL 213; EVPP 301 or BIOL 300

Registrar's Office Use Only - Required Prerequisite(s)/Corequisite(s):

And/Or	(	Course/Test Code	Min Grade/Score	Academic Level	)	Concurrency?

Registration Restrictions (Updates only):

Registrar's Office Use Only - Registration Restrictions:

Field(s) of Study:

Class(es):

Level(s):

Degree(s):

School(s):

Catalog Description:

This course is designed to examine the diversity and ecology of photosynthetic and non-photosynthetic protists (one of the five Kingdoms of organisms) and cyanobacteria (precursors to protists) primarily distributed in freshwater and marine habitats. The evolution and phylogeny of these related, but relatively distinct organismal groups are highlighted. An ecological perspective is used to explore the diversity and ecological significance of algae which are the main primary producers in aquatic ecosystems and heterotrophic protozoa which play an important role as consumers in microbial food webs. Biotechnological applications of protists such as their potential as energy sources and as building materials is explored as well economic and health concerns caused by harmful and nuisance algal blooms and protozoan parasites are discussed. The laboratory provides students with hands on exercises to sample, view and identify protists as well as experience in laboratory and field methods used.

Justification:

What: Creating a new course

Why: This course reflects growing scholarship and will be the only course on campus that covers the Kingdom Protista in detail. Mason offers multiple courses on the other Kingdoms (Plants, Animals, Fungi, and Bacteria) but no Protista course is offered in Mason despite its subject importance. The course will provide more needed applications regarding algae bloom and its related environmental issues control.

Does this course cover material which crosses into another department?

No

Learning Outcomes:

- Knowledge of algal and protozoan diversity and ecology
- Understanding of how the major groupings of protists are differentiated and the major evolutionary steps that led to such a diversity
- Current concepts in protist systematics, ecological adaptations and reproductive strategies
- Ability to discuss the basic characteristics of photosynthetic cells and the role of single and multiple endo-symbioses in major algal lines
- In-depth appreciation of ecological roles of protists in aquatic ecosystems. Consideration of importance and functional role of autotrophic algae and heterotrophic protozoa in aquatic ecosystems and food webs
- Examine and be able to recognize representative common members of each major group of algae and protozoa, including cyanobacteria, both freshwater and marine
- Learn current field and laboratory methods for collecting and identifying benthic and planktonic algae and protozoa
- Learn how to measure some aspects of protist activity and growth in the lab and in the field.

Attach Syllabus ProtistDiversityAndEcology.pdf

Additional Attachments

Staffing: Dr. R Christian Jones &
Dr. Rosalina Stancheva

Relationship to Existing Programs: Adding the subject of Protist to BS in Environmental Science and Policy

Relationship to Existing Courses: Deepening student learnings from EVPP 210 and EVPP 301

Additional Comments:

Reviewer Comments

Key: 18221

EVPP 441 PROTIST DIVERSITY AND ECOLOGY

(4 credits)

Spring 2024 Syllabus

Course Description:
This course is designed to examine the diversity and ecology of photosynthetic and non-photosynthetic protists (one of the five Kingdoms of organisms) and cyanobacteria (precursors to protists) primarily distributed in freshwater and marine habitats. The evolution and phylogeny of these related, but relatively distinct organismal groups are highlighted. An ecological perspective is used to explore the diversity and ecological significance of algae which are the main primary producers in aquatic ecosystems and heterotrophic protozoa which play an important role as consumers in microbial food webs. Biotechnological applications of protists such as their potential as energy sources and as building materials is explored as well economic and health concerns caused by harmful and nuisance algal blooms and protozoan parasites are discussed. The laboratory provides students with hands on exercises to sample, view and identify protists as well as experience in laboratory and field methods used by aquatic ecologists to sample and study protists.

Prerequisites: EVPP 210 or BIOL 213; EVPP 301 or BIOL 300

Course Learning Outcomes:

- Knowledge of algal and protozoan diversity and ecology
- Understanding of how the major groupings of protists are differentiated and the major evolutionary steps that led to such a diversity
- Current concepts in protist systematics, ecological adaptations and reproductive strategies
- Ability to discuss the basic characteristics of photosynthetic cells and the role of single and multiple endo-symbioses in major algal lines
- In-depth appreciation of ecological roles of protists in aquatic ecosystems. Consideration of importance and functional role of autotrophic algae and heterotrophic protozoa in aquatic ecosystems and food webs
- Examine and be able to recognize representative common members of each major group of algae and protozoa, including cyanobacteria, both freshwater and marine
- Learn current field and laboratory methods for collecting and identifying benthic and planktonic algae and protozoa
- Learn how to measure some aspects of protist activity and growth in the lab and in the field.

Course Content and Instructional Methods: Our examination of this material will include lectures, selected readings, and laboratory exercises. The laboratory is a required component of this class.

Any student missing a graded assignment (including tests) for health reasons or other extenuating circumstances may be required to submit at doctor's statement or other appropriate documentation to avoid a zero for that assignment.

Disability Statement: If you are a student with a disability and you need academic accommodations, please see the instructor and contact the Office of Disability Resources at 703-993-2474. All academic accommodations must be arranged through that office.

Honor Code Statement: George Mason University has an Honor Code, which requires all members of this community to maintain the highest standards of academic honesty and integrity. Cheating, plagiarism, lying, and stealing are prohibited by the code. The instructor will make it clear when working together in lab is acceptable and when independent work is required. If you are uncertain, ask the instructor. It is the responsibility of all members of the community, both students and teachers, to report violations of the code.

Enrollment Statement: Students are responsible for verifying their enrollment in this class. Schedule adjustments must be made by the deadlines posted in the Schedule of Classes.

Course Topics and Schedule: Lecture

WEEK 1a
Why we study protists? Defining Protists. Protist habitats and ecology. Their ecological importance. Their role in altering the composition of the atmosphere and lithosphere. Their use in products such as concrete, drugs, vaccines, lubricants, fertilizer, cosmetics, dentistry, soil treatments, and foods. Harmful algal blooms. Their presence in symbiotic relationships: corals, liches, etc.
• *Reading: Graham et al. 2015, Chapter 1, 2, 3, 4*

WEEK 1b
Protist phylogeny and relationships. Biological classification and species concepts. Vertical vs. horizontal gene transfer. Molecular phylogenetic approaches and applications. Endosymbiosis and the diversification of eukaryotic algae. Origins of algal plastids.
• *Reading: Graham et al. 2015, Chapter 5, 7; Archibald et al. 2020, Chapter "Protist Diversity and Eukaryote Phylogeny"*

WEEK 2a
Overview of major protist groups. Their morphology, reproductive approaches and life cycles, pigmentation, photosynthesis, nutrition in non-photosynthetic protists, and life cycles. Mixotrophy. Protists and biochemistry.
• *Reading: Graham et al. 2015, Chapters 1, 2*

WEEK 2b
Cyanobacteria I – "The toxic harmful blooms producers"
Prokaryotic cell structure. Cyanobacteria as precursors of protists. Morphology, diversity, reproduction, distribution and ecology. Extreme habitats. Nitrogen fixation, toxin and odor production. Cyanobacterial symbioses. Fossil record.
• *Reading: Graham et al. 2015, Chapter 6*

WEEK 3a

Cyanobacteria II

Cyanobacterial toxic harmful blooms (planktonic and benthic: overview, distribution, importance, monitoring and management.)

• *Reading: ITRC 2020 (https://hcb-1.itrcweb.org/), ITRC 2022 (https://hcb-1.itrcweb.org/)*

WEEK 3b

Euglenoids – "The swimmers in polluted ponds"

Morphology, life history, diversity, distribution and ecology.

Applications: nuisance and toxic blooms.

• *Reading: Graham et al. 2015, Chapter 8*

WEEK 4a

Cryptomonads – "The swimmers in lakes"

Relationships and life histories. Morphology, diversity, distribution and ecology.

Applications: Mixotrophy, kleptoplastidy, ejectosomes.

• *Reading: Graham et al. 2015, Chapter 9*

WEEK 4b

Haptophytes – "The calcifying plated unicells and their toxic freshwater relatives"

Relationships and life histories. Morphology, diversity, distribution and ecology.

Applications: carbon sequestration. Toxin producers (*Prymnesium*). Cryptic species. Fossil record.

• *Reading: Graham et al. 2015, Chapter 10*

WEEK 5a EXAM 1

WEEK 5b

Dinoflagellates – "The toxic red tides producers"

Photosynthetic Alveolates: relationships and life histories. Dinoflagellates: morphology, diversity, distribution and ecology.

Applications: toxic marine red tides blooms, freshwater nuisance blooms.

• *Reading: Graham et al. 2015, Chapter 11*

WEEK 6a

Diatoms (Bacillariophyta) – "The golden unicells enclosed within a silica box"

Relationships and life histories. Morphology, diversity, distribution and ecology.

Applications: importance in food webs, toxic marine blooms (*Pseudo-nitzschia*). Fossil record.

• *Reading: Graham et al. 2015, Chapter 12*

WEEK 6b

Chrysophyceans, Synurophyceans, Eustigmatophyceans, Dictyochophyceans

Xanthophyceans – "The golden microalgae with one hairy flagellum"

Relationships and life histories. Morphology, diversity, distribution and ecology.

Applications: Mixotrophy. Nuisance blooms. Fossil record.
• *Reading: Graham et al. 2015, Chapters 13 & 14*

WEEK 7a
Brown Algae (Phaeophyta) – "The marine brown giants"
Photosynthetic Stramenopiles III: cellular and flagellar features.
Morphology, diversity, distribution and ecology. Life cycles. Ecological importance in benthic marine communities.
Applications: biotechnology, food industry, mariculture.
• *Reading: Graham et al. 2015, Chapter 14*

WEEK 7b
Red Algae (Rhodophyta) – "The marine red carpet"
Morphology, diversity, distribution and ecology. Life cycles. Ecological importance in benthic marine communities.
Applications: biotechnology, food industry, mariculture. Fossil record.
• *Reading: Graham et al. 2015, Chapter 15*

WEEK 8a
Green Algae I: "The Precursors to Plants"
Ulvophyceae, Treboxiophyceae, Chlorophyceans (including Volvocales, Oedogoniales, Chaetophorales)
Morphology, diversity, distribution, reproduction and ecology. Importance in aquatic ecosystems.
Applications: biotechnology, food industry, aquaculture.
• *Reading: Graham et al. 2015, Chapters 16, 17, 18, 19.*

WEEK 8b
Green Algae II: Streptophytes: Zygnematophyceae, Coleochaetophyceae, Charaphyceae)
Morphology, diversity, distribution, reproduction and ecology. Importance in aquatic ecosystems.
Applications:
• *Reading: Graham et al. 2015, Chapter 20*

WEEK 9a EXAM 2

WEEK 9b
The Protozoa - "The heterotrophic Protists"
Ciliates (Ciliophora) – "The hairy protozoa"
Morphology, diversity, distribution, reproduction and ecology. Importance in aquatic ecosystems.
• *Reading: Lynn 2007*

WEEK 10a

Amoebozoans: "The Blobby Protists"
Lobose amoebae (naked and testate), Rhizarians, Radiolarians, Foraminiferans,Plasmodial slime molds, Cellular slime molds - morphology, life cycle, ecology and habitats.
• *Reading: Archibald et al. 2020, Chapters: "Amoebozoan Lobose Amoebae, Myxomycetes Dictyostelia"*

WEEK 10b
Heterotrophic Flagellates
Non-photosynthetic Excavates: *Trypanosoma*, *Naegleria, Giardia*: parasites on humans.
Non-photosynthetic Alveolates: Apicoplexans: parasites on humans and animals (e.g. *Plasmodium, Toxoplasma, Cryptosporidium*).
Non-photosynthetic fungus-like Stramenopiles: structure, diversity, distribution and ecology Applications: parasites on plants and aquatic organisms.
• *Reading: Archibald et al. 2020, Chapter: "Apicoplexa", "Kinetoplastea", "Polycystinea", "Stycholonche", "Hyphochytriomycota and Oomycota,", "Labyrinthulomycota"*

WEEK 11a/b
Phytoplankton Ecology
Response to physical and chemical environment. Productivity and food chain contributions. Growth and loss processes. Competition. Grazing.
• *Reading: Graham et al. 2015, Chapter 21; Reynolds 2006*

WEEK 12a
Periphyton Ecology
Response to physical and chemical factors. Productivity and food chain contributions. Growth and grazing. Lakes vs. streams.
• *Reading: Graham et al. Chapter 23*

WEEK 12b
Non-photosynthetic protists in aquatic food webs: microbial loop. Mixotrophy.
• *Reading: Esteban and Fenchel 2020, Chapters 4, 7-10*

WEEK 13a
Protists in symbioses: lichens, corals, zooxanthellae, zoochlorellae, nitrogen-fixing cyanobacterial endosymbionts in diatoms. Importance of symbioses in terrestrial, freshwater and marine ecosystems.
**Reading: Graham et al. 2015, Chapter 3*

WEEKS 13b,14a
Harmful, nuisance and invasive algae. Distribution, ecological and economic importance. Impact of climate change on harmful algae. Example: "Rock Snot" diatom *Didymosphenia*
https://dwr.virginia.gov/fishing/didymo/
• *Reading: Watson et al. (2015)*

WEEK 14b

Role of algae and cyanobacteria in sedimentary rock formation (stromatolites, diatomite, chalk from coccolithophores, coralline rock, lime secreting algae). Production of fossil fuels, and global Carbon cycling. Protists in building materials (algae as substitute for concrete). Use of algae in biotechnology, food and pharmaceutical industries, aquaculture.
(https://time.com/6192603/algae-plant-buildings-carbon/)
Graham et al. 2015, Chapter 4

FINAL EXAM (Finals Week)

Grading Criteria

There will be two mid-term exams (50 points each) and a final exam that will have two parts: 50 pts for material since the 2nd midterm and 50 pts on the whole lecture content (100 points total).

Graded Items	Points
1. Mid-term exams 1 and 2 (2 x 50 points each)	100
2. Final exam	100
3. Lead journal article discussion	50
4. Class activity (bonus points)	30
5. Laboratory	100
Total Points	**350 (380-30)**

A = 90-100%, B = 80-89%, C = 70-79%, D = 60-69%

- **Mid-Term and Final exams**

All exams are closed book and subject to the Honor Code (see above). The exams will need to be completed in the available time. We will devote a whole class period to the Mid-term exams and the normal 2+ hour period to the Final.

- **Lead journal article discussion**

For undergraduate student: A brief paper (50 points) is required consisting of a total of approximately 2500 words (4 pg single spaced) on any topic of your choosing related to one of more of the lectures. The paper will pull together information from online sources on an environmental issue involving protists (algae or protozoa) or cyanobacteria and published online. Example publications are provided below:
"Didymo (Invasive Freshwater Algae) in Virginia" (https://dwr.virginia.gov/fishing/didymo/) or "2021 Cyanobacteria Bloom and Recreational Advisory for the North Fork Shenandoah River, Virginia, USA" (https://www.youtube.com/watch?v=5N-YZon1a_k); PEREC Gunston Cove Ecosystem Study https://perec.science.gmu.edu/our-research/gunston-cove-study/

Guidelines will be forthcoming as a separate document.

● **Class activity**

Each lecture finishes with review questions. Students will receive 5 points per correct answer during the class discussion or answers could be sent via email to instructor. The maximum bonus points per student are 30.

Reference Texts:

Archibald, J. M., Simpson, A.G.B., Slamovits, C.H., Margulis, L., Melkonian, M., Chapman, D. J., Corliss, J. O. (2020) Handbook of the Protists. Springer. https://link.springer.com/referencework/10.1007/978-3-319-32669-6 (free download*)

Esteban, G.F. and T.M. Fenchel (2020) The Ecology of Free-living Protozoa. 2nd Ed. Springer. file:///C:/Users/rcjones/Downloads/978-3-030-59979-9.pdf (free download of entire book*).

Graham, L.E., Graham, J.M., and L.W. Wilcox (2015) Algae. 3rd ed. https://www.ljlmpress.com/algae.html

ITRC (Interstate Technology & Regulatory Council). 2020. Strategies for Preventing and Managing Harmful Cyanobacterial Blooms (HCB-1). Washington, D.C.: Interstate Technology & Regulatory Council, HCB Team. www.itrcweb.org., https://hcb-1.itrcweb.org/

ITRC (Interstate Technology & Regulatory Council). 2022. Strategies for Preventing and Managing Harmful Benthic Cyanobacterial Blooms (HCB-2). Washington, D.C.: Interstate Technology & Regulatory Council, HCB Team. www.itrcweb.org., https://hcb-2.itrcweb.org/

Lynn, D.H. (2007) The Ciliated Protozoa. Characterization, Classification and Guide to the Literature. 3rd Ed. Springer. file:///C:/Users/rcjones/Downloads/978-1-4020-8239-9.pdf (free download of entire book*)

Reynolds, C.S. 2006. The Ecology of Phytoplankton. Cambridge University Press. https://doi.org/10.1017/CBO9780511542145

Watson, S.B., Whitton, B.A., Higgins, S.N., Pearl, H.W., Brooks, B.W., Wehr, J. (2015) Harmful Algal Blooms. In: Wehr, J.D., Sheath, R.G. & Kociolek, J.P. (eds.) Freshwater algae of North America. Ecology and classification. Elsevier Academic Press, Amsterdam. 873–905 pp.

Yeager, R.G. (1996) Protozoa: Structure, Classification, Growth, and Development. Chapter 77 in: Medical Microbiology. 4th Ed. https://www.ncbi.nlm.nih.gov/books/NBK8325/ (Chapters 78-85 contain more detailed descriptions of specific disease-causing protists.) (free download*)

PROTISTOLOGY LAB

Welcome to Protist Lab! This is a required part of the Protist course. In this portion of the course you will be an aquatic scientist who explores the freshwater environment and protist diversity based on your own field and laboratory data. I have no doubt that you will do great things with the aquatic ecology you learn in this lab because of who you are as a person and the values you bring with you from your experiences.

Throughout the course we will explore the diversity and ecology of most common freshwater and marine protists (eukaryotic algae and protozoa) and cyanobacteria by investigating living specimens with microscopes and watching video material when needed. The intent of learning the aquatic biological diversity is to prepare you for your own identifications and quantifications of aquatic organisms collected by you from local freshwater habitats. In addition to the laboratories, there are two required field trips where hands-on experience will be gained, while sampling planktonic and benthic protists from a local pond and deploying mesocosm to allow growth of protozoa. We also will learn how algae are used as indicators of ecological conditions in freshwater ecosystems. The course concludes with group presentations of your aquatic environmental studies. This lab is based on a collaborative approach to learning: you will work in groups of 3-4 to explore and develop understanding of course concepts and support each other's learning. You will actively engage one another to increase your comprehension. Consequently, participation in small group and class discussions is critically important, and the grading reflects this: class participation is 25% percent of your grade (25 points). Small group members will also review each other's work (peer review), to offer feedback and help improve it. We can learn a lot by helping each other to succeed.

Course Topics and Schedule: Lecture

WEEK 1
Laboratory methods for identification and quantification of aquatic protists. How to use microscopes. Discuss projects. Observe and identify Cyanobacteria from cultures**.**

WEEK 2
Observe and identify Euglenoids, Cryptomonads, Haptophytes (Coccolithophorids), Dinoflagellates from cultures, preserved specimens and prepared slides
Start **Microcosm Experiment**: Collect water and sediment from PEREC pond and river for laboratory microcosm observations. Start **Artificial Substrate Experiment**: Place various substrates in PEREC pond and streams for colonization studies.

WEEK 3

Diatoms from cultures, preserved specimens and possibly nature. Learn how to prepare permanent diatom slides.
Assignment#1: Apply diatoms in stream bioassessment using computer simulation software package SimRiver.

WEEK 4
Chrysophyceans, Synurophyceans, Eustigmatophyceans, Xanthophyceans, and Phaeophyceans (brown algae): Structure and Diversity. From cultures, preserved specimens and prepared slides.

WEEK 5
Red Algae: Structure and Diversity. From cultures, preserved specimens and prepared slides.
Microscope Observations: examine organisms from **Artificial Substrate Experiments** put out in Week 2 and from laboratory **Microcosm Experiments**.

WEEK 6
Green Algae: Structure and Diversity. Ulvophyceae, Treboxiophyceae: Chlorophyceans (including Volvocales, Oedogoniales, Chaetophorales) Structure and Diversity. from cultures, preserved specimens and prepared slides

WEEK 7
Green Algae: Streptophytes: Zygnematophyceae, Coleochaetophyceae, Charaphyceae: Structure and Diversity. from cultures, preserved specimens and prepared slides.

WEEK 8
Non-photosynthetic Protists including Ciliophora (ciliates) Rhizarians, Radiolarians and Foraminiferas: Lobose amoebae (naked and testate), Plasmodial slime molds, Cellular slime molds: Structure and Diversity. from cultures, preserved specimens and prepared slides.

WEEK 9
Microscope Observations: examine organisms from **Artificial Substrate Experiments** put out in Week 2 and from laboratory **Microcosm Experiments**.

WEEK 10
PRACTICAL EXAM

WEEK 11
Field methods for collecting freshwater planktonic and benthic protists. Qualitative vs. quantitative sampling. Sample preservation. Isolation. Culturing conditions. Aquatic habitats for protozoa.
Collect quantitative samples for chlorophyll a analysis from the water column and the surface of deployed **artificial substrates**. Measure water temperature, pH, conductivity and turbidity in both field locations. Laboratory identifications of planktonic and benthic algae and protozoa. Preserve samples for microscopic quantification.

WEEK 12

Complete laboratory analyses and data workup
WEEK 13
No new lab or field work. Work on Final Presentations.

WEEK 14
FINAL PRESENTATIONS

Course Assessment

• **Class participation (required). (25 pts.)** The communication and collaboration are important in research teams. You will have many opportunities to be an active member of our aquatic ecology team, and to contribute in cooperative learning and connect with colleagues and a researcher visiting our lab.

Self-Assessment Exams are part of the class participation. I designed them to prepare you for the practical exam**.** These exams will test your understanding of concepts and will be cumulative to ensure you leave the course with a solid understanding of organismal biology and ecology. They will consist of images of organisms and questions which require short answers provided by you, so you could practice the new terminology and knowledge obtained. We will discuss your answers during the following class meeting.

• **Practical Exam (required).** (25 pts) You will be given 25 aquatic organisms (microscopic or macroscopic). For each organism you will be expected to provide its higher taxonomic position (phylum to order), for instance cyanobacteria, diatom, green algae, ciliate, so on. If you know the genus name you will gain extra points, but it is not required. In addition, you will answer two questions for each specimen, concerning its morphology, ecological preferences, distribution, specific habitat, food web position, feeding type, etc. The exam will be timed.

• **Final Presentation (required). (25 pts)** You will work in groups of 3-4 as a real scientific team to prepare a PowerPoint presentation about your investigations of aquatic protists collected from a local stream and pond. The presentation should be organized in 4 sections: introduction, material and methods, results, and discussion. Results should include all field observations and measurements, e.g., physical habitat and organisms recorded in each habitat (e.g., pond plankton, stream benthos: epiphyton, epilithon, epipelon, etc.). Discussion should be focused on identification and relative quantification of aquatic protists and potentially observed interactions. The group presentation should be maximum of 15 minutes, and each section must be presented by a different student.

• **Assignment #1 (25pts).** This assignment is using the computer simulation software package SimRiver (www.u-gakugei.ac.jp/~diatom/en/index.html), which will show you what diatom taxonomists do. This is a free international education project developed to help understanding of relationships between human activity, river environments and diatoms. First, you will watch

videos on diatom morphology and field and lab methods for diatom analysis, and answer some questions. Then you will use the simulation software to identify and quantify a diatom population from a selected stream sample, and evaluate the water quality based on a Diatom Saprobic Index.

Identification books for the lab

Wehr, J. D., Sheath, R. G. & Kociolek, P. 2015. Freshwater Algae of North America: Ecology and Classification. Academic Press, San Diego, 2nd Edition.

Patterson, D. J. & Hedley, S. (1996) Free-living Freshwater Protozoa. A Colour Guide. Manson Publishing.(free download of entire book*)

On-line identification resources for the lab

Diatoms: https://diatoms.org/

Soft-bodied algae: https://data.sccwrp.org/sbsac/index.php (user/password will be provided upon request)

AlgaeBase: https://www.algaebase.org/

Sources of Protists and Cyanobacteria

ATCC (American Type Culture Collection). https://www.atcc.org/microbe-products/protistology#t=productTab&numberOfResults=24

Carolina Biological Supply

UTEX culture collection of algae: https://utex.org/collections/living-algal-strains

Algal Resources Collection, UNC-Wilmington: https://www.algalresourcescollection.com/strains

Center for Applied Aquatic Ecology, NC State. https://caae.cals.ncsu.edu/research/research-labs/algal-culture-and-microbiology-laboratory/