

Rediscovering *Chlamydomonas*

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Abstract: We have found *Chlamydomonas* sp. to be excellent model systems for undergraduate research and teaching labs. Integrating this alga into teaching labs throughout a curriculum is not difficult. It is cost-effective, easy to grow, and requires little space. Moreover, students can learn proper aseptic technique, culture methods, and microscopy techniques quickly. These aspects are important in situations where the students need to carry out a research project in only one semester. Readily available references provide protocols for class labs; one described here demonstrates the effect of light on taxis. Some of the many useful websites for instructors are listed.

Key Words: *Chlamydomonas*, phototaxis, curriculum, Internet.

Finding a relatively inexpensive model system for student research that has appeal for both the instructor/mentor and the students is a challenge. Part of the curriculum Avila College requires that students complete a research project by the time they finish their senior year. The other author (D.L.R.) was seeking a research model system for students who expressed an interest in pursuing biology research for a single semester. A colleague suggested that the ubiquitous alga, *Chlamydomonas reinhardtii* might be the solution to our problem. What began as a whim has blossomed into a successful pedagogical story for both of us.

Chlamydomonas reinhardtii is a unicellular, eukaryotic, green alga. The genus *Chlamydomonas* is a large one in the Chlorophyte division of algae. Over 600 species have been identified. *Chlamydomonas* (Chlamies, as they are known to those who work with them) has a worldwide distribution and species have been isolated from fresh water and soils, as well as marine environments and even snow.

In favorable environments, *Chlamydomonas* reproduces asexually by dividing mitotically into two cells within a 24-hour period. The zoospores that result resemble parent cells. However, under periods of stress, such as an environment lacking an essential nutrient, *Chlamydomonas* cells function as isogametes. Two distinct mating types, designated mt⁺ and mt⁻, exist. These fuse sexually, thereby generating a thick walled zygote. The diploid zygotic nucleus undergoes a reduction division (meiosis) with respect to chromosome number. The “daughter” nuclei are surrounded by a membrane-encased cytoplasm. The membranes continue to develop, further isolating the

nuclei. These cells undergo mitotic divisions until the zygote ruptures releasing zoospores.

Because Chlamies divide rapidly, have a rapid sexual turn around time (10-14 days), and are easy to maintain in a lab, they have been important experimental models in genetics, cell and molecular biology, and plant physiology. However, they have not been used widely in undergraduate biology education. Bacteria, *Drosophila*, and yeasts have enjoyed wider popularity in genetics and introductory biology courses.

We began to use *Chlamydomonas reinhardtii* as a model system for our undergraduate senior research students. The students defined research projects based on their interest but Chlamies were required as the experimental organism. At first, students were lukewarm to the idea. It didn't strike them as being as exciting as working with humans or mice. They had never heard of Chlamies before, except perhaps briefly in a plant biology class. However, as they became more comfortable with culturing and microscopic observation, these attitudes changed. Students would ask more questions; manage their culture collections; and actually express enjoyment at what could be accomplished with this organism.

A good starting point for anyone interested in *Chlamydomonas* is *The Chlamydomonas Sourcebook* by Elizabeth Harris (1989). This book gives a detailed view of *Chlamydomonas* biology including cell structure and function, population biology, and genetics. Isolation, culture, and experimental protocols are also available. Most of the protocols are inexpensive cultures and can be confined to a relatively

small space within a teaching laboratory. The highlight of the sourcebook for educators is a series of protocols that can be integrated into courses that involve laboratory exercises. For example, a simple exercise described below can be enjoyed by both science and non-science majors involves phototactic responses to light.

The procedure (Harris, 1989) begins with a population of cells cultured in liquid medium. A confluent sample of cells is placed in a 35-mm petri dish. A portion of the lid of the dish is covered with dark paper so that the cells are not exposed to light. A series of assays are performed in which the cover is shifted at 45-degree angles, varying the culture's exposure to the light. Upon exposure, cells can be observed migrating toward the light *en masse*. Students may then develop hypotheses about factors that influence this phenomenon. The protocol recommends additional experimentation with compounds such as cycloheximide, antimycin A, and colcemid. We've varied these exercises in several classes and found that students enjoy them. They especially enjoy the "green blob" migrating through the water toward the light. We've allowed them to consider and test different factors, including a variety of chemicals, that might influence this phenomenon. We've found that by introducing Chlamies early in one or more classes, students are provided with sufficient background that they can begin to think about advanced research projects.

Three sites on the Internet update the material found in *The Chlamydomonas Sourcebook*. The first is the *Chlamydomonas* Genetics Center site (<http://www.botany.duke.edu/chlamy/ChlamyGen/maps.html>). The site is maintained by Elizabeth Harris, who directs the stock center at Duke University. Published abstracts, culture sources, laboratory website links, and teaching materials are available here. This site is hyperlinked to a second valuable site AGIS *Chlamydomonas* Database (<http://probe.nal.usda.gov:8300/cgi-bin/browse/chlamydb>). Current literature on just about every conceivable topic relating to *Chlamydomonas* is available at this site.

Perhaps the most valuable internet source for biology educators is the *Chlamydomonas* Teaching Center (<http://biology.ecsu.ctstateu.edu/ChlamyTeach/chlamymain.htm>) developed by Mike Adams at Eastern Connecticut State University. Adams has been a recognized expert in *Chlamydomonas* biology for many years (Adams, 1975; Adams *et al.*, 1981). His site provides up-to-date information and protocols in an easy to understand format. There are links to other instructors who have used *Chlamydomonas* sp. for teaching purposes, as well.

We have been pleased by the enthusiasm that undergraduates at each stage of the curriculum have developed toward Chlamies. We hope to develop additional labs in the future, including both inquiry-based and cookbook protocols. We believe these remarkable organisms are excellent learning tools that both majors and non-majors can enjoy.

References

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