Where Shall I Go? What Shall I Do? Using Chlamydomonas For Signal Transduction Experiments

A. Daniel Johnson

Dept. Biology, Wake Forest University
Rm. 226 Winston Hall
Winston–Salem, NC 27019
johnsoad@wfu.edu

Chlamydomonas reinhardtii is a biflagellate alga found in fresh water and damp soil worldwide. This organism, which has been described as the "photosynthetic alga," is an exceptional model for demonstrating many principles of cell biology. Additionally, students can use them to conduct a range of experiments they have designed. In this mini–symposium I summarized how we use this model for a two–week, inquiry–based lab that focuses on principles of signal transduction.

Chlamydomonas has several behaviors that students can measure easily in a teaching lab setting. One such behavior is binary phototaxis; at low illumination cells are positively phototactic, but above a certain light intensity they abruptly switch swimming direction and become negatively phototactic. This behavior is initiated by a photopigment–containing eyespot that controls the flagella through at least two separate pathways (Nagel, 2003). Other easily observed behaviors (transition from immotile palmelloid cells to free–swimming cells, flagellar growth and repair, and mating of compatible strains) are also controlled partly by calcium–dependent and G–protein coupled signaling pathways (Quarmby and Hartzell, 1994; Quarmby, 1994). However, many steps in the signaling pathways that control these behaviors have not yet been mapped out, providing students with an opportunity to design and conduct experiments that can contribute new knowledge to an area of active research.

In our sophomore–level lab course, students spend the first week learning to quantify phototactic responses, and measure flagellar formation and regeneration. With some minor modifications, this portion of the lab can also be used as a one–week standalone exercise. In the second week, students conduct an experiment they have designed to test some aspect of signal transduction. Students manipulate several steps in the known signaling paths experimentally simply by adding chemical agonists or blockers to the algal culture medium.

Participants in this workshop received an information packet (available from the author) containing our exercises and guidelines for possible student experiments. The packet also included supplemental instructional and preparatory notes describing how we grow bulk cultures of vegetative cells and mating–competent gametes, and a list of signaling activators and blockers that we provide students.

Literature Cited

Nagel, G., Szellas, T., Huhn, W., Kateriya, S., Adeishvili, N., Berthold, P., Ollig, D., Hegemann, P., and Bamberg, E. 2003. Channelrhodopsin-2, a directly light-gated cation-selective membrane channel. Proceedings of the National Academy of Sciences, USA, 100:13940–13945

Quarmby, L.M., and Hartzell, H.C. 1994. Dissection of eukaryotic transmembrane signaling using Chlamydomonas. Trends Pharmacological Science, 15:343–349.

Quarmby, L.M. 1994. Signal transduction in the sexual life cycle of Chlamydomonas. Plant Molecular Biology, 26:1271–1287.