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Tips & Tools

Using Student-Produced Time-Lapse Plant Movies to Communicate Concepts in Plant Biology †

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INTRODUCTION

Why do students think plants are "boring"? One factor may be that they do not see plant movement in real (i.e., their) time. This attitude may negatively impact their understanding of plant biology. Time-lapse movies of plants allow students to see the sophistication of movements involved in both organ development and orientation.

The objective of this project was to develop simple methods to capture image sequences for lab analysis and for converting to movies. The technology for making time-lapse movies is now easily attainable and fairly inexpensive, allowing its use for skill levels from grade school through college undergraduates. In addition, this type of exercise can be expanded for inquiry-based or service-learning projects. Time-lapse movie exercises have been integrated into an undergraduate plant physiology course and also used in outreach activities.

PROCEDURE

Camera set-up and image capture

The camera should be set up in a relatively undisturbed area so that the plant can be imaged over a period of time (all day, overnight, or longer). A ring-stand is helpful for positioning the camera. A light source should be placed to minimize reflections and provide even illumination on the subject. If the set-up is near a window, sunlight may alter the illumination during the image capture session, so blinds may be needed to block sunlight. Also, the area behind the plant should be plain, to provide sufficient contrast to the subject and avoid introducing unwanted images. A white or colored tri-fold poster board is an easy solution (Fig. 1).

A webcam which comes with photo capture capability (such as Microsoft LifeCam or Logitech QuickCam) is an inexpensive option for plant video projects. A digital camera that interfaces with a computer can also be used. Camera features such as face recognition and autofocus are useful for subjects that change position as they grow (e.g., a flower opening). However, if there are several items in the image (e.g., many leaves on a plant), such camera features may focus on the wrong object.

FIGURE 1. A simple webcam set-up using a white tri-fold poster board. In this set-up, a Logitech QuickCam is mounted on a ring attached to a ring stand.

The collection of images at specific intervals can be performed manually as a "fun" class exercise. Alternatively, Nimisis Webcam Flix is an inexpensive ($10), user-friendly shareware product which automatically connects to most digital cameras and webcams. Other similar, more-expensive types of software, such as Willing Webcam Lite (Willing Software) and Active WebCam (PY Software) include timed image-capture options.

Movie-making and image-processing

There are several options for making a time-lapse movie, depending on the goals of the exercise. Flix software can generate a video immediately after collecting the images. This feature is convenient for previewing but has some drawbacks: it does not allow editing, cannot produce videos slower than 10 frames per second, and is disabled once you close the program. Windows Movie Maker is fairly user-friendly and offers a wide variety of editing features for adjusting frame timing, inserting text frames, and adding visual and

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audio effects. ImageJ (http://rsbweb.nih.gov/ij/), an open-source image processing and analysis program, runs on any computer system and accepts most image file formats. The program allows you to import a sequence of images that can be processed as a batch. You can crop, adjust brightness, and simultaneously change the contrast of all images prior to saving them as a video file or as individual frames. Because ImageJ was developed for scientific image analysis, it can be used for taking measurements from images, providing a valuable tool for undergraduate or high school laboratory exercises.

Curriculum considerations

An exercise for the quantitative measurement of root growth in radish seedlings, with an option to study downward curvature after reorientation (gravitropism), is presented in Appendix 1. Students begin with a basic introduction to root growth and gravitropism through assigned readings and laboratory discussion. In the first session, students observe plant materials (or images) at various stages of growth, outline the parameters needed for collecting time-lapse images, and schedule a time for camera use. Subsequent image analysis can take place in a computer lab or on a student's computer. For this, students use ImageJ to take measurements, analyze data, and use the collected images to produce a video.

Time-lapse plant exercises are adaptable to numerous topics that incorporate core science concepts, competencies, and disciplinary practices (1, 2) as well as to the integration of higher-order thinking skills (3). In plant physiology, time-lapse movie design encourages students to apply conceptual knowledge of plant growth principles to experimental design and data analysis. The exercises can be expanded to teach students how to use the preliminary data to generate hypotheses to test the nature of the response. The collected images provide a mechanism for students to translate their results through a video that can be posted to YouTube or simply passed around to their friends, thus contributing to another competency-disseminating science to society. Another unique aspect of these videos is that the students feel that they have produced something in biology, rather than simply consuming knowledge. This fulfills part of the "cognitive process dimension," outlined in Bloom's Taxonomy of Educational Objectives (3). Comments generated from one YouTube video developed from student-produced time-lapse movies included the following: "Your video has been a huge help to me" and "I am gonna pass on this video to his [my son's] classroom!!"

The development of videos provides a platform for communicating concepts in plant biology, as well as a fun and interactive way to engage students in the learning process. Movies generated from the plant physiology projects were featured at a science night at a local elementary school. Students attending the science night were initially not interested in plants but became interested once they saw the plants move. Some students stayed to make their own stop-action movie, which is a simple way to teach the time-lapse technique and an indication that this type of teaching method could foster enthusiasm for scientific exploration. Examples of grade school projects (Appendix 2) include root growth and root hair formation, flower opening, and leaf movements.

CONCLUSION

The use of time-lapse movies of plant growth and other plant movement can help stimulate interest in plants and can be adapted for specific learning outcomes with varying levels of quantitative analysis, hypothesis development, and communication of results. Even if you prefer not to make your own plant movies, using them to enhance your curriculum by illustrating core concepts, or in case studies, will make plants more exciting and interesting to students. Online resources for plant videos include Plants in Motion (http://plantsinmotion.bio.indiana.edu/plantmotion/starthere.html, time-lapse movies with clearly written explanations), and Chlorofilms (http://www.chlorofilms.org/, a competition to produce plant biology videos).

SUPPLEMENTAL MATERIALS

Appendix 1: Root growth and gravitropism – undergraduate laboratory exercise
Appendix 2: Plant movie projects and making plant movies

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