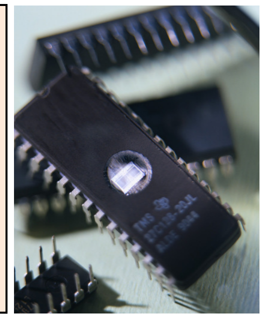
USING IMAGING TECHNOLOGY



It is easy to know what to write in your lab notebook when making quantitative measurements. For instance, you simply record the reading from a balance when measuring plant mass. Still, science also involves collecting qualitative data. What is the best way to describe data that is harder to put into numbers, such as leaf shape or flower color? Many plant scientists have learned to precisely sketch the parts of a plant, but not everyone feels comfortable making conclusions based on their own limited artistic skills. Other people may have color blindness and must depend on their teammates to accurately judge colors. In cases like these, imaging technology can be helpful in collecting objective data.

Digital Cameras

Because of the cost of developing film, the falling prices of computer chips, and the ability to store lots of data for free in the "cloud," digital photography is now more popular than film photography for beginners and experts alike. Most science labs have a digital camera to take photos of plants, molecular biology gels, and even microscopic samples! Even if your teacher does not have a digital camera for the classroom, most cell phones can now take basic pictures. These are not as detailed as photos from a digital camera, but such images can still help you make judgments about plant health, leaf shape, or flower development between experimental treatments.

If you plan to take digital photos to record data, keep in mind the following tips:

- Include a white or black background or test card in all photos to help you control for changes in lighting. Otherwise, it is easy to misjudge colors between different photos.
- Placing a ruler or familiar object, such as a quarter, next to small samples will help you get an idea of their overall scale.
- For field work, taking photos of your field site each day you visit can quickly record the weather, overall conditions, and habitats.
- Different settings are usually available to take photos of landscapes, whole plants, or close-ups ("macros").
- You can often take digital photos directly through the eyepiece of a microscope by using the camera's macro setting.

> ***Thought Exercise:*** *How can digital photos help you communicate with your scientist mentor?*

Remember to treat the camera with care, especially if the entire class shares the same one!

- Special lens cloths can remove dust and fingerprints from the camera lens. Use a dust-free cloth or Kimwipe to clean the view screen.
- Some cameras focus automatically, while others can give extremely sharp photos if you focus by hand. Ask your teacher or read the manual to figure out how to do this.
- Switch the camera off to save battery power if you need to carry out any experimental procedures or plant care between photos.
- If you are the last to use the camera, check to see whether the battery is low. Ask your teacher how to recharge the battery if needed.

The photo files will be your record of the photographic data you have collected, so you should keep them carefully organized.

- Record in your lab notebook how to tell which photo matches with each sample. At first, you only need to record the order in which they were taken (e.g., #1, #2, #3), but you should add the file names to your notebook after uploading the photos.
- Move all of your photos onto a computer or class website in the "cloud" each day after you are done.
- Make a file folder for all of your team's photos to avoid mixing them up with those belonging to any other team or class.
- Delete your photos from the camera *only* after you have moved all files to the computer and the file names to your lab notebook. Be sure that no other photos are on the camera before doing this – don't delete anyone else's files!
- You may want to print a small copy of each photo to tape into your lab notebook, just to be extra safe.

Time-Lapse Photography

While some experiments need only one or two photos for each treatment, others need changes recorded regularly over time. Since most plants grow and move very slowly, time-lapse photography can be useful for collecting a series of data. Repeated photos are taken from the same position, observing the same plant(s) over time, then placed back to back in a slideshow or short movie. This lets you speed up your visual observation of the plant's biological processes. You can show others the "big picture" of plant growth, development, and movements in less than a minute.

The most important factor in good time-lapse photography is determining **how often** to take each photo. As you take more photos, you will need more computer storage and more time to make the final slideshow or movie. This favors taking photos that are spaced far apart, such as once or twice each day. On the other hand, you can see smaller changes in the plant if you take photos once or twice each hour.

Images: Steve Rosset (golden 009, Flickr)

When you set up your experiment and camera for time-lapse photography, you will need to think about their location. You don't want to place the plants or the camera where someone might accidentally bump into them or need to move them. Putting the camera on a **tripod** will keep the camera position and photographs stable throughout the data collection period. If you are taking more than one photo each day, you will also want to set up a **timer** to automatically take a photo at each time point.

Any events that might show up on the camera can be jotted in your lab notebook. For example, the leaves of many plants may begin to droop over time without water, and then "perk up" again a few minutes or hours after watering. If you note the date and time of watering, as well as the date and time of the first photo, you can count out which photos were taken just before and just after you watered the plants. This will let you look more carefully for changes in the condition of the plant.

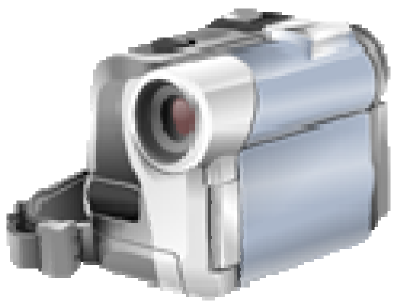
After you have collected all the photographic data, you will need to transfer the photos from the camera to your electronic storage space – a computer or a website in the "cloud" where you can access the photos. If any photos did not turn out well, you may want to discard them before making the slideshow or movie.

If you want to make a movie, you can make the photos into a digital video using software such as Windows Live Movie Maker or Roxio VideoWave. Be sure to put the photos together in the same order that you took them. Each photo should be shown on screen for one second at most. The more photos you have, the shorter each one can be shown, and the more "movie-like" the time-lapse will look when you are finished. Early silent films used at least 14 images each second to let viewers to see movement, while Hollywood movies are now filmed at 24 or 25 images per second! Your time-lapse video doesn't need to be Hollywood quality, but if you plan to take 15 or more photos for each second of footage you want to make, you can put together a true movie.

If you have too few photos to make a movie, you can make a photo slideshow or an animated GIF. Presentation software, such as

Microsoft PowerPoint, is relatively easy to use for making slideshows. Simply insert one photo per slide or panel in the order the photos were taken. You can also add text, arrows, or circles to presentations to point out important observations. If you want to animate the presentation, several free websites can create animated GIF files. You will need to add any text or visual aids to your photos before uploading the images to the site, and you may need to make each image smaller. After uploading the images, the website will put them into a short, repeating sequence that plays automatically.

Digital Video



Time-lapse photography will give you good qualitative data for most plant behaviors. To collect data on faster processes, though, you might want to record a digital video. Unlike time-lapse photography, you can also record sound. With a video, you can record your teammates as one carries out a special procedure and another narrates what is happening. The video can become part of your final presentation, or your teacher might share it with teams carrying out similar experiments in the future.

> ***Thought Exercise:*** *Which plant species move quickly enough that you need video to record it? Are there other biological processes involving plants that you could record on video?*

Digital camcorders can record high-quality video of your experiment, and some high-definition models cost about as much as a digital camera. Still, you may want to check any digital cameras you already have before buying a camcorder – many can record basic video footage, including sound.

As always, write in your lab notebook the date and time you recorded the video, which team member recorded the video, what was recorded, and the name of the file(s). Make sure you have what you need afterwards:

- Upload your files to a computer as soon as possible after you record them.
- Test them in a video player to make sure you have the footage you want.
- Delete the camcorder file only *after* you know the uploaded file works.
- Keep the original file and any edited copies on the computer in the same folder.

Digital video can be edited with a little bit of practice and play using special software. Editing can be much shorter for recorded video than for time-lapse photography. Instead of putting dozens of photos in order and adjusting how long each is shown, you may need to:

- Edit out extra footage to make the movie shorter,
- Add transitions between different segments,
- Reduce the effects of bumping or shaking the camera,
- Change the sound volume, or
- Add a title screen at the beginning and credits at the end.

Online Resources & References

Video & Visual Resources:

Laboratory Photography series, by ASMSedu. This video series can give you a basic introduction to lab photography and using digital photo software. These videos use a digital webcam, but the ideas also apply to handheld digital cameras and camcorders.
http://www.youtube.com/watch?v=7SWJctfvQbo
http://www.youtube.com/watch?v=Hnat9KbsfjQ
http://www.youtube.com/watch?v=_smnGTznkxw

Make a Gif, by Sparked Ventures, LLC. Upload a series of images to create an animated GIF file for short time-lapse sequences. You may need to make your images or files smaller first.
http://makeagif.com/

Plants-In-Motion, by Robert Hartanger. This website has over forty time-lapse videos of plants growing, flowering, and responding to their environments. Tips on time-lapse photography and possible lab exercises are also included.
http://plantsinmotion.bio.indiana.edu/plantmotion/starthere.html

Web Pages:

Computers, by Biocyclopedia. This page describes the many types of software that can be useful in biological research.
http://www.biocyclopedia.com/index/biotechnology_methods/tools_and_techniques_in_biological_studies/computers.php

Digital Photography-Based Biology Projects, 2002-2003, by Dave Stone. A teacher at the University of Illinois Laboratory High School shows two biology projects his students carried out.
http://www.uni.illinois.edu/~dstone/digital_biology_projects.html

Macro – Digital Handbook of Biological Imaging, by Dave McShaffrey. This large website helps readers use digital photography and photo software for biology research.
http://www.marietta.edu/~mcshaffd/macro/index.html

Learn Time Lapse Photography, by Ryan Chylinski. This beginners' guide to time-lapse photography focuses on artistic photography, but the information can also be used for research.
http://www.learntimelapse.com/time-lapse-photography-how-to-guide/

<u>Books and Articles:</u>

Matsumoto, B. 2010. *Practical Digital Photomicrography: Photography Through the Microscope for the Life Sciences*. Santa Barbara, California: Rocky Nook, Inc. 184 pp.

O'Neal, M.E., Landis, D.A., and R. Isaacs. 2002. An inexpensive, accurate method for measuring leaf area and defoliation through digital image analysis. *Journal of Economic Entomology* 95(6): 1190-1194.