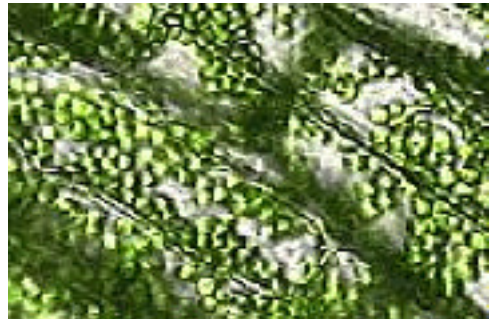


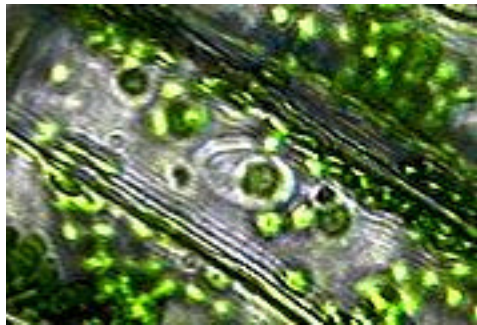
## Elodea

A very common laboratory exercise in biology involves an examination of the fresh water plant elodea. In Science Standards/NSTA it is stated that “Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world”. As part of this exercise the rigid cell wall of plants will be contrasted with the flexible semi permeable membranes of plant and animal cells. Elodea, or Anacharis as it is called in most pet stores, is a particularly good example of a plant cell. It has the cell walls, vacuoles and chloroplasts that students look for in

comparing plant cells with animal cells. When the leaf is wet mounted on a slide and examined under low power the view is quite similar to that shown in Figure 1 (~100X). This view, in addition to showing cell walls, chloroplasts and spaces occupied by the cell vacuole also gives the students a three-dimensional



view of these rectangular cells. It is apparent under this magnification when using the microscope fine adjustment that the leaf has several cell layers. Under a higher magnification Figure 2 (~400X) the chloroplasts exhibit a regular cyclotic movement around the cell. An obvious question at this point is why the chloroplasts move in a certain pattern throughout the cell. Is this due to the presence of the vacuole? Also, the



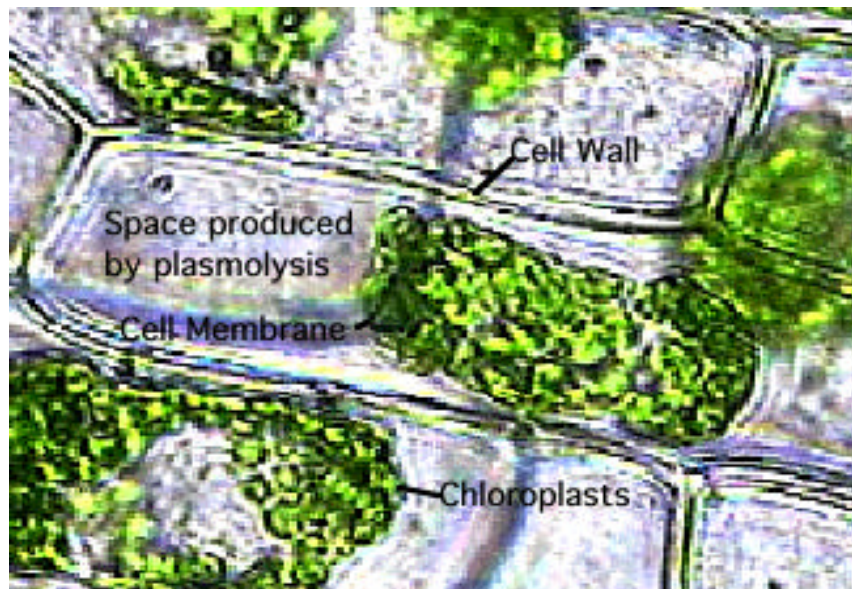
three-dimensional structure of the leaf can be further reinforced by drawing the students' attention to the apparent movement of chloroplasts from one cell to another through the cell wall. This occurs only because the movement is actually taking place on a cell layer above or below the layer the student is focused on. Many plant cells take on a tapered rectangular shape where their width is very similar to their depth. Using their fine adjustment students might reach a similar conclusion that the width of these

cells is a reasonable approximation of their depth.

The elodea plant can also be used to demonstrate plasmolysis. Quite often this investigation of the Elodea takes place two or more weeks after the original examination and is coupled with a discussion of osmosis and various class demonstrations of this process. I have modified this traditional exercise into a class investigation that leads to an examination of the process of plasmolysis<sup>1</sup>. We start off with a wet mounted Elodea plant showing the **Figure2**(~400X) view.

The investigation begins by posing the question; if this is a plant cell then where is the cell membrane? (Pressed up against the cell wall?) Where is the vacuole? (Where the chloroplasts are not moving?) What is the principal constituent of the vacuole? (Water?) Is there some way we can demonstrate that the principal component in the vacuole is water? This leads us to

examine what will happen to the cell if we try to draw the water out using a form of osmosis called plasmolysis. To produce this effect a highly concentrated drop of salt water is placed outside the cover slip to draw water from the leaf cells. **Figure3**



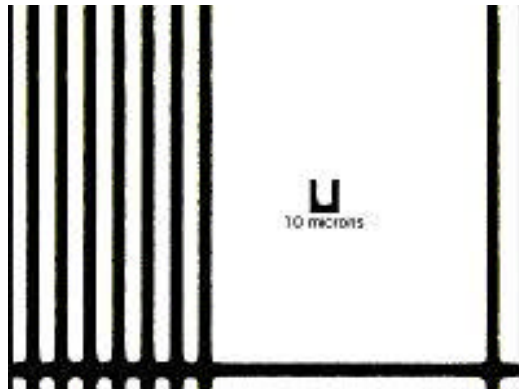
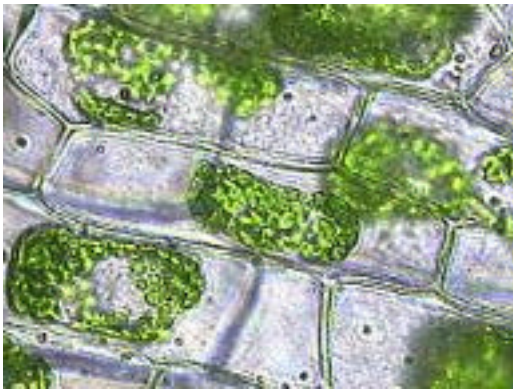
(~400X) is a typical view of several plasmolyzed elodea cells.

In the plasmolyzed cell the cell contents have shrunk into the center of the cell as the cell has lost water to the outside. Is it now possible to see the cell membrane. Once the students understand why this osmotic movement has taken place I then pose the question; is it possible that the "space" between the cell wall and the cell membrane now represents the "space" that was previously occupied by the vacuole? (Some of the outgoing water comes from the cytoplasm, but the greatest amount is coming from the vacuole which is largely composed of water.)

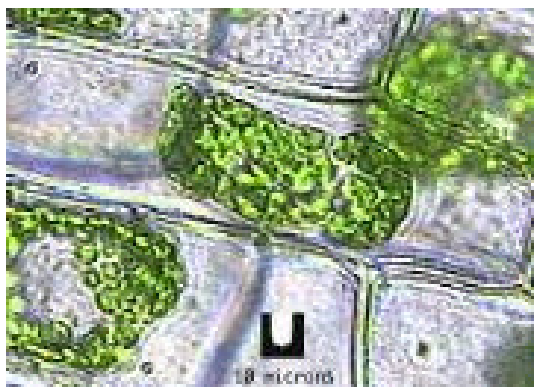
the vacuole which is largely composed of water.)

To accurately measure a number of cellular parameters we take some digital photographs through the microscope<sup>2</sup>. Several student slides of the plasmolyzed elodea cell are photographed as well as a photograph under the same magnification of a micrometer slide<sup>3</sup>. One of the photographs of a plasmolyzed cell is printed out on an overhead and is used in a subsequent class discussion.

Following this discussion we meet as a class in a computer laboratory area. A copy of the plasmolyzed cell image **Figure4**(~400X) and the micrometer image **Figure5**(~400X) have been



put on the school File Server. Both images are brought up under the freeware applications NIH Image (Macintosh), Scion Image (PC) or ImageJ (Internet)<sup>4</sup>. These are computer applications that the



students have used before in measuring/comparing cheek and onion cells. Part of the scale is copied and pasted on the image of the plasmolyzed elodea and the scale is labeled. **Figure6**(~400X) The image is then calibrated so that the results will appear as length in micrometers and area in square micrometers.<sup>5</sup>

The students then consider how they would calculate the area of the central cell in the image. (Using the straight line tool in the application the students determine length and width and from that calculate the area. The area can also be calculated by taking the freehand tool and tracing around the cell wall.) These two methods can be compared. Is there a way to calculate the

two methods can be compared. Is there a way to calculate the volume? (No, but it can be estimated based on the assumption that the depth of the cell is roughly the same as the width as students have previously observed.)

Because of plasmolysis most of the water has left the cell, particularly the vacuole. The area of the vacuole might be represented by the clear area between the cell wall and the cell membrane. By tracing around the inner wall and then the cell membrane of a single plasmolyzed cell, the area of the two structures can be obtained. Subtracting the cell membrane area from the cell wall area will give the area of the hypothesized vacuole. The percent of the cell occupied by the vacuole can then be determined.

Students are asked to take a look at other cells in the image and to comment on the accuracy of the various procedures and assumptions we have made in this exercise. It will be obvious that different cells have lost different amounts of water and that all the cells are not in focus at a particular time for purposes of accurate measurement.

I find this extension of the traditional elodea exercise to be particularly good in provoking student discussion. It helps students develop an improved comprehension of plant cell structure, and a quantitative understanding of cell structure and what happens in plasmolysis. Data from the elodea experiment can be compared with the data of previous laboratory exercises like the cheek and onion cell.

### Summary:

#### Science Objectives:

- Identify typical plant structures
- Compare the elodea plant cell before and after the process of plasmolysis
- Identify plant cellular structures both before and after plasmolysis
- Calculate the size of the plant's vacuole based on this experiment

## Image Processing Skills:

- Copy and paste between images
- Set image scales
- Measure length, width and area and calculate volume

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Questions about this exercise can be directed to:

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<http://science.exeter.edu/jekstrom/default.html>

### **Footnotes:**

- <sup>1</sup> Plasmolysis is a particular form of osmosis where there is a loss of water from a plant. Specifically, the water moves from where it is more concentrated through the cell membrane to the outside where there is a lower concentration of water. The lower water concentration is typically produced by having a strong salt or sugar solution placed on the outside.
- <sup>2</sup> There are a number of various ways to digitize images through a microscope. The least expensive method was described by the author in an Idea Bank article that appeared in the January, 1999 issue of the Science Teacher.
- <sup>3</sup> Microscope slides with a micrometer scale on them can be purchased from a number of biological supply vendors. They typically sell for around \$12.00. It is only necessary to have one of these these slides. The slide can be photographed under the different magnifications of a typical student microscope. These digital images can then be retained as a reference for a number of microscopic exercises.
- <sup>4</sup> Downloads of these applications can be obtained from the WEB site for the Center for Image Processing for Educators (CIPE). <http://www.cipe.com> If you go to the software site from their Home Menu Index you will find download areas for NIH Image (Macintosh) and ImagePC for Windows. There is also a download site for ImageJ. ImageJ is an internet based application that is available for both Mac and PC platforms. It is constantly being updated and is able to open the JPEG compressed images. This very common compression format will allow you to put several JPEG images of the exercise on a floppy disk. This obviates the need for a file server. You need only have ImageJ on the computer and open up your images that are on the floppy.

5 Depending on student ability and computer resources there is another way to do this exercise. A print-out can be made of **Figure 6** (The plasmolyzed image with the calibration scale) and duplicates of this image can be given to groups of two or three students. Each group also receives thread and a metric ruler. They are then asked to find any or all of the measurements asked for in the computerized exercise. (Cell width, length, area and volume, plus the area, volume and percentage of the vacuole.)

You can then demonstrate computerized measurement with a single classroom computer and TV monitor. Results can be compared between the two different methods of measurement. This is a particularly good approach to take if you have limited computer resources.

