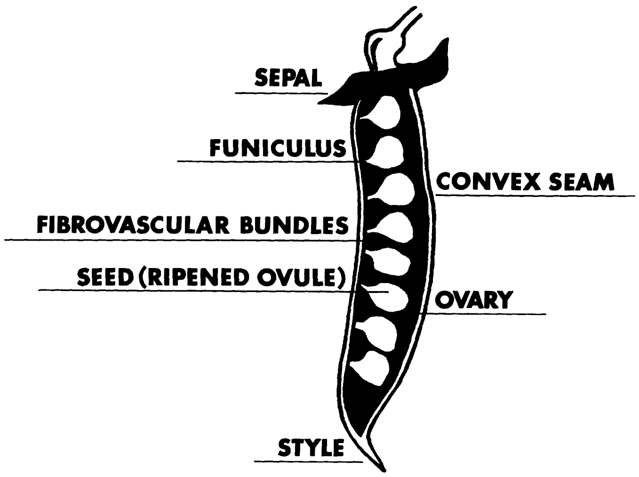

Fig. 2. Internal view of the pea pod.

with the razor blade or scalpel. Remember that this is the *raised* seam, also called the artificial groove. If the concave side is cut in error, the seeds will be disturbed from their natural position.

5. Note the cavity in which each seed lies. The inner ovary wall (as well as the outer ovary wall) is leathery and therefore inedible. The ovary wall in the string-bean, however, is edible. Note the position of the peas (ripened ovules). Observe the alternating pattern in the opened pod. This is an example of the survival mechanism. Since the peas are attached to two *fibrovascular bundles*, if one of the bundles is destroyed and unable to bring nourishment to the seeds, the other bundle would be able to keep the remaining seeds alive. Note any undeveloped peas in the pod. There are two reasons for this condition. Either one of the fibrovascular bundles was destroyed, or the ovule was not fertilized and therefore could not develop into a mature seed.

6. Count the number of peas in the pod. Are any two of them alike? The old adage "as alike as two peas in a pod" is a stretch of biological truth. Since peas are produced as a result of sexual reproduction, we can always expect to find variation.

7. Note the structures to which the seeds are attached. These are the *fibrovascular bundles*, tubes which bring nutritive materials to the peas as they are developing. The stalk connecting the seeds to these bundles is the *funiculus*. The indentation on the seed where the funiculus is attached is the *hilum*.

8. Remove a well-formed pea from the pod. Cut off the seed coat and lay open the two parts of the seed. Note the two flat-faced halves. These are the *cotyledons*. Since there are two, the botanist has classified the pea as a dicotyledon. Two cotyledons and five floral parts, as noted earlier, confirm the fact that the pea is a dicotyledon.

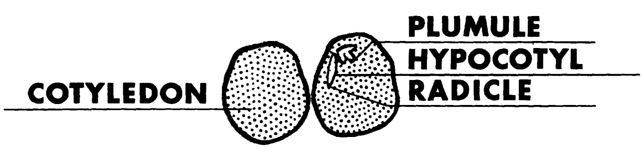

Fig. 3. Split pea, containing the embryo.

9. Note the small nib between the cotyledons. This is the embryo plant (fig.3). It is the product of sexual reproduction. The food stored in the cotyledon would have been enzymatically converted to usable nutrients to nourish the embryo until it was capable of making its own food.

10. Make a complete sketch of all the structures you have observed externally and internally. To review your understanding, give the function of each structure named in your diagrams.

Ralph Postiglione
South Senior High School
Great Neck, N.Y. 11020

INEXPENSIVE OCULAR MICROMETERS

High school biology teachers frequently want their students to accurately measure the size of a particular microscopic specimen. Because of the high cost of ocular micrometers and stage micrometers, many teachers resort to having their students estimate the number of times a specimen could be placed end to end across the diameter of the field of view and then divide that diameter by the estimated number of specimens for an approximation of specimen size.

A. Amaro (1965) presented a technique for producing relatively inexpensive ocular micrometers, but his article did not provide the necessary data to duplicate the method of production. The article motivated me to experiment with a technique for making fairly good quality ocular micrometers at a cost of about ten cents each. The equipment and materials are as follows:

Single lens reflex camera (35-mm with 50-mm lens)
Reflected light-light meter
Copy stand with pair of flood lamps (3200 °K)
HC 135-36 High Contrast Copy film ASA 64
Black matte finish construction paper (14 by 16 inch)
White self-adhesive label cut into 11 strips (1/16 inch by 1 inch)
Microscope slide
Canada Balsam
Transparent metric ruler cut into 1-cm increments

The white strips are placed parallel to each other in approximately the center of the black construction paper. The camera, on the copy stand, is focused on the white lines so that the lines pattern covers a very small area on the viewer. Many viewers have a small focusing circle which is about the correct length for the white lines to cover. Each flood lamp is positioned so that the illumination is even. (To determine if illumination is even, hold a pencil so that one end of the pencil is touching a piece of paper. Then, adjust the flood lamps until the shadows cast on both sides of the paper are equal in darkness.) Determine the correct

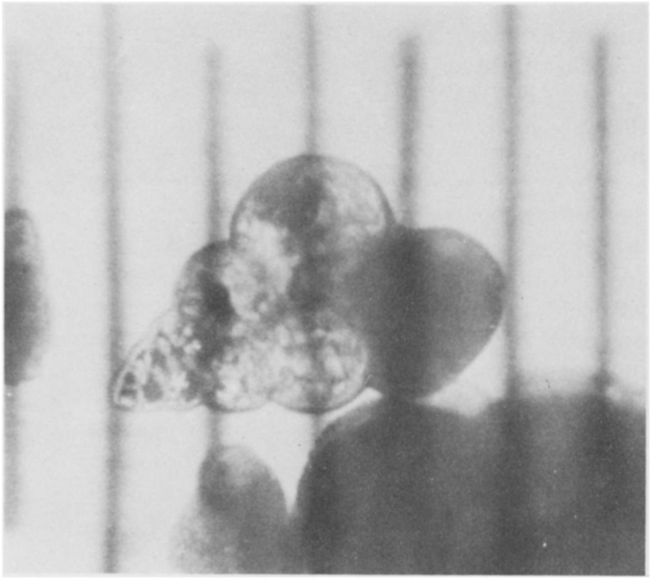

Fig. 1. The foraminiferan *Testularia* sp. is four subdivisions long. Each subdivision measures approximately 77 microns, thus the specimen is approximately 308 microns long. (Photo by author.)

camera setting for shutter speed and aperture with the light meter, and then overexpose the film one full f/stop. This will insure that the small white lines will be as black as possible and that the black background will be as clear as possible on the resulting negative. Develop the film normally. After the negatives are processed, cut the film into small square ocular micrometers. The ocular micrometers are now ready for calibration.

An ocular micrometer is placed on the small shelf of the microscope's ocular lens. Calibration follows the procedure set forth by Peleczar and Chan (1972): An inexpensive stage micrometer can be constructed by cutting a transparent metric rule into one-cm sections with millimeter divisions. These sections are mounted with Canada balsam onto standard student-grade microscope slides. The distance between the leading edge of one millimeter marker and the leading edge of an adjacent millimeter marker is 1,000 microns. Therefore, by counting the number of ocular micrometer subdivisions at low power (100X) between these two positions, one can easily calibrate the length of each subdivision. The method of calibrating at higher magnifications is to measure the width of one of the millimeter lines at low power and then count the number of ocular micrometer subdivisions across this same line at high power and divide.

Fig. 1 shows that the foraminiferan *Testularia* sp. is four ocular micrometer subdivisions long. Each subdivision of the ocular micrometer used measures approximately 77 microns; therefore, the specimen is approximately 308 microns long. Obviously, the measurements achieved by these inexpensive micrometers are not as accurate as the more expensive commercial kind, but they do allow the high school student to become familiar with the technique of calibration and measurements through the microscope with ocular and stage micrometers.

REFERENCES

AMARO, A. 1965. An inexpensive substitute for special eyepieces and measuring accessories. *American Biology Teacher* 27(9):688.

PELECZAR, M. J., Jr., and E. C. S. CHAN. 1972. *Laboratory exercises in microbiology*, 3rd ed. McGraw-Hill Book Co., New York.

Stanley D. Whelchel
Central High School
Waterloo, Iowa 50701

Aquaculture . . .

from p. 78

If the mariculture of fish, shellfish, and plants is successful, what does this mean to the world of the future? Statesmen of note have pronounced that, between the farming of seafood and more efficient harvesting of what is found in the wild, the oceans are the answer to the population explosion. That is a shortsighted and most dangerous illusion. Wild harvests now seem to be close to their maximum sustained yield. Mariculture, in its infancy, is quite costly. It provides food for the gourmets, but not for the masses.

So, at present, mariculture provides a welcome addition to the diets of those who enjoy and appreciate seafood. As techniques and efficiency improve, it may provide lower-cost protein which may give us a little more time to learn to stabilize our world population. But to accept mariculture as a panacea to population expansion is simply to pass this most crucial of problems on to our children. Such procrastination is simply to encourage still more people to a day when there is no new ocean to exploit.

Education

Education is the instruction of the intellect in the laws of Nature, under which name I include not merely things and their forces, but men and their ways; and the fashioning of the affections and of the will into an earnest and loving desire to move in harmony with these laws.—*Thomas Henry Huxley*