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The Oyster

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ABSTRACT

This unit discusses an invertebrate, the oyster. The physiology of the oyster and the environment in which it lives will be outlined. Since oysters are cultivated in New Haven this topic offers different science and math opportunities or local interest.

INTRODUCTION

This unit on the oyster is intended for use with seventh and eighth grade students. However, the material may be appropriate for elementary and high school. It is the instructor who can best judge its usability.

The first and perhaps most elementary objective or this unit is to introduce the student to the oyster by telling them what an oyster is, its development and its feeding.

Sea animals touches the lives of everyone in our society, either directly through family experiences or indirectly through friends and the discipline of math and science. All tables and diagrams are after Galstoff. All diagrams are at the end or the paper.

What is an Oyster?

An oyster is a soft-bodied invertebrate that is found in the shallow waters of the sea. It has a rough irregularly shaped, double-hinged shell. There are two kinds or oysters, the crassostrea and the ostrea. Many kinds of oysters are used for food. With few exceptions, oysters thrive in shallow water and their distribution extending from a level approximately halfway between high and low level tides to a depth of about one hundred feet. Commercially exploited oyster beds are rarely found below a depth of forty feet.

The body of the oyster is covered with two calcareous valves joined together by a resilient ligament along a narrow hinge. These two valves make this animal a bivalve. The shape or a bivalve shell is expressed as a ratio between its height and length or by some other numerical index. (see figure 1)

Composition of *crassostrea virginica* shell from Galvestron Bay (presented as oxides)

calcium—53.6
carbon—42.5
sodium—0.33
magnesium—0.32
silicon—0.17
moisture—0.59
sulfur—0.18
strontium—0.11

The oyster creates its own environment by secreting a shell composed or ninety-five percent (95%) of calcium carbonate. The remainder of the shell is made up of organic material and trace amounts of manganese, iron, aluminum, sulfate and magnesium.

The Shell

The structure or the shell consists or four distinct layers: (1) periostracum, a tissue of organic material called conchiolin, secreted by the cells located near the edge of the mantle. The periostracum is poorly developed in *crassostrea virginica* and it is not round in old shells, (2) prismatic layer, which is made up of bricklike prism units. Each prism consists or calcite crystals laid in a matrix of conchiolin. The conchiolin can be destroyed by boiling in potassium hydroxide and the prisms are separated, (3) calcite-ostracum is a subnacreous layer consisting or foliated sheets or calcite laid between thin membranes of conchiolin. This layer is interrupted by soft chalky deposits which consist of amorphous material. This layer makes up the major part of the shell, (4) hypostracum layer is made or shell material under the abductor muscle. In the *crassostrea virginica* the layer is pigmented and consists of aragonite. As the oyster grows the adductor muscle increases in size and the new areas or attachment become covered with aragonite. (see figure 2)

Shells grow by the accretion of material secreted at their edges. The rings on the outer surfaces or a bivalve shell represent the contours of the shell at different ages. Rings are common to all bivalves shells. Depending on the shape of the shell, the rings are either circular or oval with a common point or origin at the extreme dorsal side near the umbo. The rate of growth along the edge of the shell is not uniform (see figure 1) and may actually change direction in response to environmental factors (see figure 2).

The Mantle

The animal inside the shell is covered by a mantle. The principal function of the mantle is the formation or the shell and its calcification. It is made up of soft and freshly tissue. The structure of the mantle consists of a sheet of connective tissue containing muscles, blood vessels, nerves and it is covered on both sides by epithelium. The mantle receives sensory stimuli, and conveys them to the nervous system and aid in the

shedding and dispersal of eggs. It also participates in respiration, stores reserve materials, secretes large quantities of mucous and aids in excretion.

The most obvious components of the mantle are the radial muscles, blood vessels and nerves. The radial muscles are large bands of fibers which extend almost the entire width of the mantle. The radial muscle contracts and pulls the entire mantle inside and throws its surface into ridges. The mantle's blood vessel are the circumpallial artery which sends out many branches; the common pallial artery, and a large pulsating vessel in the anteriorventral part of the mantle called the accessory heart. The nerve provides communication. Close nerve contact is maintained between the muscles and the organs of the mantle through a fine nerve network.

The Environment

The environment may interfere with the welfare of the oyster. Negative factors decrease or inhibit reproductive capabilities. They destroy the population by causing external adverse conditions that increase the incidence of disease, inhibit the growth of the oyster or interfere with the formation or the shell, thus depriving the oyster of its principal means of protection against adverse situations and attacks of enemies.

Oysters grow on a hard, rocky bottom or on semihard mud firm enough to support their weight. Oysters can and do adapt themselves to a great variety of bottoms. They thrive best on shore rocks and underwater structures which are left exposed at low tide. The controlling factor is the climate since no oyster can survive for an extended growing period where the temperature is below freezing.

Salinity, turbidity and depth or water play an important role in the growth of the oyster. Oysters are able to live in sea water of a very wide range of salinity. The oyster is unusually tolerant to brackish water. Some survive better in a more saline environment.

Oysters replanted from a low salinity area to a high salinity area will perish within two or three weeks after planting. Sudden change in the salinity can be the cause of mortality.

Rapid settling of suspended material may be highly destructive to an oyster community. Coastal waters contain a certain amount or solids in suspension or either organic or inorganic material.

The Digestive System

The organs that are associated with food intake, digestion and elimination are: the mouth, esophagus, stomach, crystalline style sac, digestive diverticula, midgut, and rectum. (see figure 3)

The Mouth

The Oyster is a filter feeder. Its mouth is a u-shaped slit between two lips lined with columnar ciliated epithelium cells. The epithelium cells or the mouth contain a few mucous glands and they are taller than those of the labial palps. (see figure 4) There are two pairs of palps, one on each side and they form a single unit which serves primarily for final sorting of rood particles and for the delivery of food to the mouth. Each pair consists of one external and one internal palp. The two external palps from the upper lip and the two internal palps from the lower lip.

In the central area of the two internal palps is a median gutter which leads to the center of the lower lip. Both lips are arched and the lower lip is shorter and thicker than the upper one. Two lateral gutters form on each

side where the external palp meets its opposing internal member are the principal paths by which food is conveyed to the mouth.

The labial palp consists of a layer of connective tissue covered by columnar ciliated epithelium which set on a membrane. There are large vesicular cells, muscle fibers and blood spaces which are occasionally filled with leucocytes. Leucocytes are round in the tissue cells and on the surface of the mouth. Leucocytes are tiny white cells or the blood that destroy disease germs.

The Esophagus

The esophagus is a funnel-shaped dorso-ventrally compressed tube lined with epithelium similar to that or the mouth. The esophagus acts as a passageway for rood.

The Stomach

The stomach is a large irregularly shaped sac with several outgrowths. From the entrance of the esophagus, the stomach forms an anterior chamber which leads into larger posterior chamber (see figure 3) and outgrowth called the caecum. The anterior and posterior ends of the caecum carries and forms the anterior and posterior appendices. The appendices vary in size and a groove along the wall of the caecum leads to the opening or the midgut and serves for sorting of food. Below the left side of the caecum, the stomach wall bulges out to form a pylaric caecum which leads to a long outgrowth alongside the midgut and this is called the crystalline sac.

Three groups of ducts emerging from the stomach lead to the digestive diverticula. Two of these ducts originate at the anterior chamber and the third duct from the posterior chamber.

The Crystalline Style Sac

The crystalline style is not a permanent structure. It is a sac which extends along the neutral arms of the visceral mass and an important part of the digestive system. The sac is slightly twisted around the midgut and occupies a dorsal position. The style sac is lined with cylindrical cells that have a large oval nuclei and long cilia.

The style rotates and rubs against the gastric shield aiding in mixing and grinding food particles. It also slowly dissolves in the gastric juices and yields digestive enzymes.

Oysters removed from water and left in the air show the style may dissolve in a very short time, a matter of hours. The chemical composition or the style is 87.11 percent water, 12.03 percent solid organic matter and 0.86 percent solid inorganic matter.

The Digestive Diverticular

The digestive diverticular which aids in digestion is made up of a number of blind tubules which empty into large ducts which lead to the interior of the stomach.

The structure of the tubes are usually a lumen in the form or a cross and food vacoules can be seen in them during feeding.

The Midgut

The midgut is the intestine which lies between the rectum and the stomach. It starts at the stomach's ventral wall and continues along the sac, then turns around and runs parallel to its former course. The entire length of the inner wall is made up or a typhlosole. This intestine is filled with ciliated epithelium, where many leucocytes are wandering about and where an abundance of mucous cells are present. A muscular layer is not present in the midgut.

The Rectum

The rectum runs along the dorsal side or the heart and the structure of the rectum is similar to that of the midgut. The difference being the disappearance of a well-developed typhlosole. Its function is to excrete waste and it is unique in having a circular layer of smooth muscles, but they are not involved in peristalsis.

Food and Feeding

The oyster feeds by filtering small particles from the water.

The food of the oyster consists of minute organisms, both plant and animal, which float in the water, protozoa, the egg and larval of marine worms and mollusks, and the spores of algae. Most of the oyster food comprises diatoms, tiny plants usually enclosed in glossy cases which are often etched with intricate designs. In polar seas diatoms swim in such myriads that they import a greenish tinge to the water and even a gritty feeling when rubbed between the fingers.

The oyster feeds by beating the cilia on its complex, lattice like gills. It draws a current or water in at a rate of perhaps two or three gallons an hour. The food particles, caught in mucous strings on these ciliated sieves, are wafted either to the bases or to the free edges of the gills and then forwards to the mouth via the palps which sit either side or it and have a sorting function.

Food ingested by the oyster is moved through the alimentary canal by the ciliary action of the epithelium. The time required for food to pass through the entire intestinal tract can be measured by recording the time between the addition of a suspension or a carmine or yeast to the gills and the appearance of the red or white particles in the feces. The rate of passage really depends on the length of the intestinal tract and the rate off feeding. Digestion and absorption or food in the oyster is an intracellular process which takes place in the stomach where several digestive enzymes are present.

The length of the alimentary tracts are as follows:

In an oyster measuring 11 by 6 cm . . . ..14.5 cm
In an oyster measuring 10.0 by 6 cm. . . .11.l cm
In an oyster measuring 11.5 by 5.5 cm..12.6 cm

Artificial Feeding

Oysters, being a foodshiff of commerce have been the object or feeding experiments. Only a few experiments were successful in producing an increase in weight of the oyster. Artificial enrichment of sea water by adding

commercial fertilizers was the answer to their problem at one time. Since oysters are able to absorb glucose dissolved in sea water, it is necessary to investigate further, this method of feeding.

LESSON PLANS

Purpose To develop a basis for group discussion before the unit is taught. Introduce the unit by getting the students involved immediately in its contents.

Objective By answering items in a questionnaire students will be able to demonstrate as to how much knowledge they have about the oyster.

Strategy Make enough copies so that each student can have one. Go over directions until everyone is certain of what they are to do. Have each student answer each item with no explanation from you. Check and discuss students responses within the class.

The Questionnaire attached consists of ten true or false questions.

Have students look up definitions of the words that are listed on the vocabulary list. Write a research report where applicable.
Invite someone from the Fish Hatchery in Milford, CT to speak to the class on shellfish with major emphasis on the oyster.
Plan a field trip to the Fish Hatchery.
Have students write a report on the field trip.
Divide students into three groups. The first group of students, write five math word problems based upon the data given them by the tour guide on the field trip.
Have the second group check the problems for clarity and whether or not enough information given. They may decide to rewrite the problems. The group should also solve the problems. Have the third group correct the word problems.

QUESTIONNAIRE

Circle T for True and F for False

1. The oyster is an invertebrate? T or F
2. The oyster is covered with a bivalve shell? T or F
3. The rood of the oyster consists or green beans and small fish? T or F
4. The oyster digestive system consist of 6 parts? T or F
5. The esophagus of the oyster is the same as that or a human? T or F
6. The oyster is a sea mollusks and lives in large bodies or water? T or F
7. Oyster shells come in different shapes and sizes? T or F
8. The oyster functions best in its own environment? T or F
9. The principle function of the mantle is the formation of the shell and its calcification? T or F
10. Oysters are considered to be a seafood delicacy? T or F

ACTIVITIES FOR STUDENTS

1. Draw a diagram of the three most important organs of the digestive system. Describe each of their functions.
2. Test for Epithelium cells
    materials
    microscope
    cotton swab
    slides
    dye-optional

Have students take cotton swab and rub the inside of their mouths and place it on a slide to observe the cells. Have them write a short paragraph or their findings.

3. What is a tissue?
    name three tissues in your body

what is an organ

name five organs in your body

4. What is a cell?

how do cells increase in number

what makes cells divide

what makes you grow

How can you tell your body is making new cells all the time

draw a cell and label it

5. Match the definitions in Column A with the words they define in Column B

	Column A	Column B
1. nutrients needed for body	A. Fats	
	building and tissue repair	B. minerals
		C. vitamins
		D. proteins
		E. carbohydrates
2. nutrients that provide “quick” energy		
3. nutrients that provide energy slowly over a long period of time		
4. nutrients needed to build strong bones and teeth and to regulate some body processes		
5. nutrients needed in small amounts for growth and disease prevention		

6. Select the best answer

A. Fruits and vegetables are rich in

a. proteins

b. vitamins and minerals

c. Eats

B. Good sources of iron include

a. oranges and tomatoes

b. milk and cheese

c. vitamin C

d. iodine

C. Milk and cheese are good sources of

a. calcium

b. vitamin C

c. iodine

D. An important nutrient that is not stored in the body, but must be supplied daily is

a. vitamin K

b. vitamin C

c. niacin

E. Nutrients that are stored in fatty tissues if not used up at once are

a. carbohydrates

b. proteins

c. minerals

F. Which nutrients are never stored in the body

a. proteins

b. vitamins

c. carbohydrates

7. The amount of fuel foods you need depends on

a. your size and physical activity

b. your mental activity

c. the size of your stomach

8. Which food is said to be nearly perfect food

a. fish

b. carrots

c. milk

9. Four hundred oysters were placed in racks in 1981. They will reach maturity in 1986. How many years did it take them to reach maturity? How many days?

10. Miss Fox has a large water tank in her backyard to house oysters. It is 8ft. long, 4 1/2ft wide, and 2 1/4ft deep. How much water does the tank hold when it is full? (Use 232 cu. in. for a gallon)

11. Oysters were replanted August 28, 1984. They were left unattended until December 10, 1984. How many days were they left unattended?

12. The oyster shell consists primarily of calcium carbonate, which composes 95 percent of the total weight of the shell. Name the remaining percent that the other chemicals make up?

13. The pH content of the gut and stomach are the following: esophagus 6.6, stomach 5.6, style 5.3, midgut 6.0, and rectum 6.3 What is the average pH?

VOCABULARY LIST

bivalves —a mollusk such as an oyster, that ha a shell which consists of two parts and they are similar
cilia —tiny hairlike structures that project from the surface or certain cells and that are often capable of a sweeping rhythmic motion
epithelium —a thin membrane tissue that covers most of the internal surfaces and organs or an animal body and the outer surface as well
esophagus —the tube of the alimentary canal that connects the throat and stomach mantle—the layer of sort tissue that covers the organs or an oyster and secretes the material that forms the shell
organ —a distinct part of living thing, adapted for a particular function (heart, stomach) gastric
shield —a thin irregularly shaped membrane made or translucent and slightly striated material rich in chromatin
salinity —the degree to which something is salty or containing salt
oyster —a sort bodied sea animal of shallow waters, have a rough, irregularly shaped, double-hinged shell, many kinds of oysters are used as rood
leucocytes —they are small while cells in the blood that kill the germs
stomach —an irregularly shaped, large sac and with several outgrowths or pouches
midgut —the portion of the intestine between the stomach and rectum
typhlosole —a median dorsal internal fold in the intestine of several types of animals, including the oyster.
Figure 1

(figure available in print form)
(figure available in print form)

Figure 2

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(figure available in print form)
Figure 3
(figure available in print form)

Figure 4

(figure available in print form)

BIBLIOGRAPHY

Clark, Eleanor, *The Oysters or Locmariaquer:* Pantheon Books, New York, 1964.

This book is a vivid objective account of how oysters are cultivated.

Galtsorff, Paul S., *The American Oyster:* United States Government Office, Washington, D.C. 1964.

The book is a scientific accurate account or the oyster. It deals with every aspect or the oyster.

Gottlieb, Joan S. *The Human Body* : Steck-Vaughn Company, Austin, Texas, 1977.

This book gives a general review or the human body.