

Oysters

An Introduction to Anatomy, Ecology, and Disease

Pre-visit Materials

Pre-visit Preparation

Welcome to the University of Maryland Biotechnology Institute's (UMBI) SciTech Education Program. We hope that these materials are useful and will help prepare your students for a unique and exciting "hands-on" lab experience. We encourage you to review these pre-visit materials. The teacher background sheets are designed to increase your depth of understanding of this topic. Students will have a richer experience with us if you go over the pre-visit materials with your class before your visit. For more information regarding SciTech, visit our website: www.umbi.umd.edu/~scitech We encourage you to make copies of the pre-visit information for students and visit the Maryland Sea Grant website www.mdsq.umd.edu/oysters for more information about oysters.

Summary of Student Experience

After a guided inquiry about the eastern oyster and a review of background information with the SciTech staff, students will generate a list of questions they have about the eastern oyster. Student investigations will be preformed in the SciTech Education Program Laboratory. Students will work with a live oyster to observe and understand the relationship oysters have with other invertebrates, the process of filtration of food and non-food particulate matter, and the techniques used to identify disease-causing microorganisms. *Because students will be working with a living organism we ask that they treat it with respect and the follow the appropriate guidelines defined by our staff on the day of the trip.* Upon request, a Center of Marine Biotechnology (COMB) scientist will discuss his or her research, personal science career path and respond to student questions about possible careers in science.

Tips for a Successful SciTech Experience

The Oysters lab offers some unique opportunities for students and teachers. The Olympus America, Inc., microscope equipment is set-up so that you can videotape and photograph your favorite parts of the lab activities in the lab while the students are at work. Here are some things you will need to bring along if you would like to do so...

A VHS videotape for recording

A roll of 35 mm film, print or slide film, 400 or 800 speed

Some blank computer discs, for digital pictures, Mac or PC format

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Experimental Design Background

Stating the Question

Every experiment begins with a question that the experiment will be designed to answer. Formulating this question is often the most difficult part of setting up a research project. There are many questions that could be investigated during the exploration of the eastern oyster that range from anatomical structure and function to ecological niche. One such question considering the anatomy could be “How do oysters process food differently from particulate matter in the water”? Hopefully during the lab experience many questions, including the one above, will be answered.

Hypothesis

The clearest way to write a hypothesis is to use “if...then” statements. For example: “If oysters are able to filter food and particulate matter out of the water, then how are these materials processed in the oyster?” The most common hypothesis is the *null hypothesis* that simply means that the variable or experimental situation being tested will exhibit no significant difference from the controls.

Controls

When designing an experiment, it is important to plan ahead so that the method you are testing is compared against a standard. If we are going to investigate how an oyster filters particulate matter from the water then we would need to supply an oyster with some known material that it can filter as well as some material that is under investigation. In our experiment we will use carmine red dye as the particulate matter for the oyster to filter to observe how materials are processed.

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Oyster Background

Classified Information

Mollusks first appear in the fossil record about 545 million years ago in earliest Cambrian time. By late Cambrian time (~520-505 million years ago) most of the modern groups of mollusks can be found in some primitive form as fossils occurring in marine deposits. During the Ordovician (~505-438 million years ago) a major radiation of mollusks occurred, with thousands of species of mollusks appearing in the fossil record of that time. During the Cretaceous period many types of clams and snails appeared and disappeared including the rudists, a group of bivalved mollusks that lived much as modern reef-building organisms do. The disappearance of these marine animals opened up environmental niches to be filled by a radiation of new species of all types of animals at the beginning of the Cenozoic.

The Cenozoic (around 65 million years ago) marks the time period when the modern groups of mollusks evolved, beginning with the marine clams and snails following the end of the Mesozoic. During the last million years land and fresh-water mollusks have evolved rapidly, occupying the terrestrial realm to an extent never seen in their fossil record.

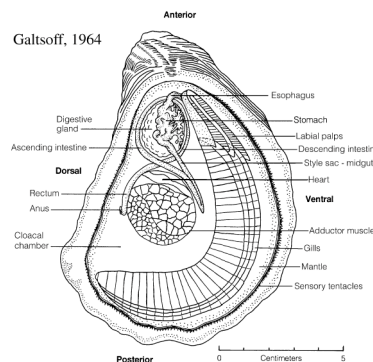
The eastern oyster, *Crassostrea virginica*, can be classified as:

Kingdom Animalia
Phylum Mollusca
Class Pelecypoda or Bivalvia
Order Lamellibranchia
Family Filibranchia
Genus *Crassostrea*
Species *virginica*

Classification from

Brusca, R.C., and G.J. Brusca. 1990. Invertebrates. Sinauer Associates, Sunderland, Massachusetts.

Anatomically Speaking



An important characteristic of most mollusks is the “head-foot” region. Most mollusks have a well-developed head that houses a mouth and a concentration of nervous and sensory functions. Adjacent to the head is a large, muscular foot used primarily in locomotion in most species, the surface of the foot is sometimes ciliated and laden with numerous mucous glands. The eastern oyster has a foot that it uses when it is in a larval stage “looking” for a spot to attach itself. Once attached, it remains sessile throughout adulthood. An adult eastern oyster has a large muscle in

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the center of the shell for opening and closing known as the adductor muscle. The strength of this muscle is well documented by those who have devised ways to open or “shuck” an oyster.

Another characteristic of most mollusks is the mantle. This layer of tissue is formed from the dorsal body wall. It surrounds the mantle cavity, which houses the gills or lungs if they are present, and its surface may assist in gas exchange. The mantle also secretes the calcareous shell in mollusks that possess one. Internally, mollusks have a simple digestive system, with a mouth in the head and the anus emptying into the mantle cavity. The eastern oyster is a filter feeder and is able to pump water into and out of the mantle cavity for feeding and respiration. Mollusks have an open circulatory system (except cephalopods, in which it is closed), complete with a heart, blood vessels, and hemolymph. Gas exchange in the eastern oyster is performed by sets of gills that are located between the layers of mantle tissue. Of course, all of this is more interesting once you are actually looking at a live oyster or contemplating whether or not to try one for the first time!

Ecology 101

The eastern oyster, *Crassostrea virginica*, has been an ecologically and economically important species in Chesapeake Bay since the days that John Smith described the navigational difficulties that the oyster bars posed in colonial days. Ecologically oysters are unique because they build a structure known as a bar or reef by attaching to one another over a long period of time. This reef-like structure in turn provides other animals with essential habitat for shelter, breeding, and finding food. The reefs also benefit other oysters as they attach themselves to the structure and avoid the struggle of living on the bottom of the Bay in the sediment.

Oysters are well known for their filtering capacity by many people, although oysters do not eat all the materials that they filter. Huh? Oysters have the ability to separate particulate matter from food material and while food passes on through their primitive digestive system, particulate matter is packaged up in mucus and deposited back out through the mouth and is termed pseudofeces. This process helps remove sediment suspended in the water column but does not remove it from the water. The pseudofeces sink to the bottom where they are temporarily deposited. As you may have heard before, researchers estimate that, at the end of the 19th century, oysters in Chesapeake Bay could filter a volume of water equal to the whole system in about 3 days. Now that same process, due to the decline in oyster populations, may take over a whole year.

Disease Problems

Economically, the importance of the oyster in the Chesapeake dates back to the mid 1800s. The combined oyster harvest for Maryland and Virginia reached an all time high

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around 1890 topping out at nearly 20 million bushels. Today oyster harvests are only a shadow of the former years and the industry is basically non-existent. What factors caused this decline? Long-term over-harvesting and diseases are the two main factors. Warnings of excessive harvests were documented as early as the 1890s by a Johns Hopkins University researcher William Brooks. Even after decline was evident after the turn of the century there was no incentive to practice conservation only a drive to land the largest catch as possible from this public fishery. Not until the 1960s did an active “repletion program” by Maryland allow the fishery to stabilize for a short period of time at 3-4 million bushels per year.

However, disease was about to start playing a major role in the oyster population of the Chesapeake. In the 1960s MSX, a protozoan, started to become more prevalent in adult oysters and increased mortalities. In the 1970s another protozoan called Dermo began to kill large oysters as well and mortalities increased once again. Both diseases still exist in Chesapeake Bay today and remain a threat to the eastern oyster, which is unable to defend itself against these protozoan organisms. Researchers within the University System of Maryland and other institutions have been focusing on oyster disease research in an effort to help us understand the mechanisms of these diseases more fully so new approaches to oyster restoration can be developed. Most recently the work of Dr. Gerardo Vasta and his team of research scientists at the Center of Marine Biotechnology have developed PCR techniques that can detect a single cell of the disease causing dermo, *Perkinsus marinus*, in just a 30 mg sample of oyster tissue. This technique allows for rapid and accurate disease detection that has been hampered by other slower less definitive techniques. For more information on this research read the article on the web from the document Restoring Oysters to US Coastal Waters, <http://www.mdsg.umd.edu/oysters/disease/tools/>.

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Book References

Brooks, William K. The Oyster. Reprinted 1996, original 1891. Johns Hopkins University Press, Baltimore, MD.

Hickman, C.P. Invertebrate Zoology. 1982. The CV Mosby Company, St. Louis, MO.

Kennedy, Victor S., Roger I.E. Newell, and Albert F. Eble, Eds. The Eastern Oyster. 1996. Maryland Sea Grant College, College Park, MD.

Lippson, Alice Jane and Robert L Lippson. Life in the Chesapeake Bay. 1985. Johns Hopkins University Press, Baltimore, MD.

Web References

Maryland Sea Grant

<http://www.mdsg.umd.edu/MDSG>

Chesapeake Bay Program

<http://www.chesapeakebay.net>

Oyster Diseases and Parasites and other oyster links

<http://nas.er.usgs.gov/diseases/oyster.dis.htm>

Restoring Oysters to US Coastal Waters

<http://www.mdsg.umd.edu/oysters/disease/tools/>

Tree of Life, Animal Classification, University of Arizona

<http://phylogeny.arizona.edu/tree/eukaryotes/animals/mollusca/mollusca.html>

Mollusks page from USGS

<http://geology.er.usgs.gov/paleo/mollusks.shtml>

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Glossary

Abiotic All non-living factors within an environment, including physical, chemical, and temporal (time) components.

Adductor Muscle A prominent organ situated in the posterior region of the oyster body, consisting of an anterior translucent part and a smaller, white crescent-shaped region. It functions to close the oyster shells (relaxation of the adductor muscle allows the shells to gape open).

Biotic All living factors within an environment.

Bivalve Marine or freshwater mollusk that has two shells.

Cilia Hair-like structures used for motility (in some protozoa) and for the movement of particles or fluids in certain cells of more advanced organisms.

Commensal Organisms Organisms that rely on a host for a benefit but does not harm or benefit the host (i.e., an oyster bar provides protection for crabs and a hard substrate for barnacle settlement).

Digestive Gland The gland responsible for the production of digestive enzymes.

Gills The gills are the largest organ in the oysters body and consists of four folds of tissue. Along with the mantle it is the chief organ of respiration. They create water currents, collect food particles, and move food particles to the labial palps for further sorting. Also serve to separate masses of eggs released from the ovary during spawning into individual ova for efficient fertilization.

Hermaphroditic An organism that possesses physiologically functioning male and female reproductive organs.

Mantle Two fleshy folds of tissue that cover the internal organs of the oyster and are always in contact with the shells but not attached to them. Its principal role is the formation of the shells and the secretion of the ligament as well as playing a part in other biological functions (i.e., sensory reception, egg dispersal, respiration, reserve stores, and excretion).

Mollusk Organisms in the phylum Mollusca - invertebrate animals with soft unsegmented bodies usually enclosed in a calcareous shell.

Parasitic Organisms Organisms that rely on a host for resources and as a result are harmful.

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Phytoplankton Diverse group of minute plants that drift freely within the water column.

Protandrous Hermaphrodites The development of maleness before the female phase with the ability to change sex throughout their life cycle.

Protozoa Single celled eukaryotic organisms belonging to the kingdom Protista.

Psudeofeces Particles which are not sorted as food and are rejected through the mouth.

Valves The two shells of the oyster.

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Maryland State Department of Education Core Learning Goals

The following Core Learning Goals link directly to the UMBI SciTech Education Program and the Oysters lab. Take a few moments to review the specific goals, expectations, and indicators below so that you may prepare your students appropriately in conjunction with the pre-visit materials. If you do not have a Core Learning Goals document or CD talk to your department chair or contact your science supervisor.

Core Learning Goals- Science

Goal 1- Skills and Processes

Expectation 1.2 - The student will pose scientific questions and suggest experimental approaches to provide answers to questions.

Indicator 1.2.1-

The student will identify meaningful answerable scientific questions.

Indicator 1.2.3 -

The student will formulate a working hypothesis.

Indicator 1.2.4 -

The student will test a working hypothesis.

Indicator 1.2.5 -

The student will select appropriate instruments and materials to conduct and experiment.

Indicator 1.2.6

The student will identify appropriate methods for conducting an investigation and affirm the need for proper controls in an experiment.

Indicator 1.2.7

The student will use relationships discovered in the lab to explain phenomena observed outside the laboratory.

Expectation 1.3 - The student will carry out scientific investigations effectively and employ the instruments, systems of measurement, and materials of science appropriately.

Indicator 1.3.1

The student will develop and demonstrate skills in using lab and field equipment to perform investigative techniques.

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Indicator 1.3.2

The student will recognize safe laboratory procedures.

Indicator 1.3.3 -

The student will demonstrate safe handling of the chemicals and materials of science appropriately.

Indicator 1.3.4 -

The student will learn the use of new instruments and equipment by following instructions in a manual or from oral direction.

Expectation 1.4 - The student will demonstrate that data analysis is a vital aspect of the processes of scientific inquiry and communication.

Indicator 1.4.2

The student will analyze data to make predictions, decisions, or draw conclusions.

Indicator 1.4.3

The student will use experimental data from various investigators to validate results.

Indicator 1.4.6

The student will describe trends revealed by data.

Indicator 1.4.7

The student will determine the sources of error that limits the accuracy or precision of experimental results.

Indicator 1.4.9

The student will use analyzed data to confirm, modify, or reject an hypothesis.

Expectation 1.5 - The student will use the appropriate methods for communicating in writing and orally the processes and results of scientific investigation.

Indicator 1.5.1

The student will demonstrate the ability to summarize data (measurements/observations).

Indicator 1.5.2

The student will explain scientific concepts and processes through drawing, writing, and/or oral communication.

Indicator 1.5.4

The student will create and/or interpret graphics (scale drawings, photographs, digital images, etc.).

Indicator 1.5.6

The student will read a technical selection and interpret it appropriately.

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Indicator 1.5.9

The student will communicate conclusions derived through a synthesis of ideas.

Expectation 1.6- The student will use mathematical processes.

Indicator 1.6.1

The student will use ratio and proportion in appropriate situations to solve problems.

Expectation 1.7 - The student will show that connections exist both within the various fields of science and among science and other disciplines including mathematics, social studies, language arts, fine arts, and technology.

Indicator 1.7.1

The student will apply the skills, processes, and concepts of biology, chemistry, physics, and earth science to societal issues.

Indicator 1.7.2

The student will identify and evaluate the impact of scientific ideas and/or advancements in technology on society.

Indicator 1.7.4

The student will recognize mathematics as an integral part of the scientific process.

Indicator 1.7.5

The student will investigate career possibilities in the various areas of science.

Indicator 1.7.6

The student will explain how development of scientific knowledge leads to the creation of new technology and how technological advances allow for additional scientific accomplishments.

Goal 3 - Concepts of Biology

Expectation 3.2 - The student will demonstrate an understanding that all organisms are composed of cells that can function independently or as part of multi-cellular organisms.

Indicator 3.2.2 -

The student will conclude that cells exist within a narrow range of environmental conditions and changes to that environment, either naturally occurring or induced, may cause death of the cell or organism.

Expectation 3.5- The student will investigate the interdependence of diverse living organisms and their interactions with the components of the biosphere.

Indicator 3.5.1

The student will analyze the relationships among organisms and between organisms and abiotic factors.

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Indicator 3.5.2

The student will analyze the interrelationships and interdependencies among different organisms and explain how these relationships contribute to the stability of the ecosystem.

Indicator 3.5.3

The student will investigate how natural and man-made changes in environmental conditions will affect individual organisms and the dynamics of populations.

Indicator 3.5.4

The student will illustrate how all organisms are part of and depend on two major global food webs.

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