

Squid Lab

Traveling Outreach Program
Pre- and Post- Visit Activities

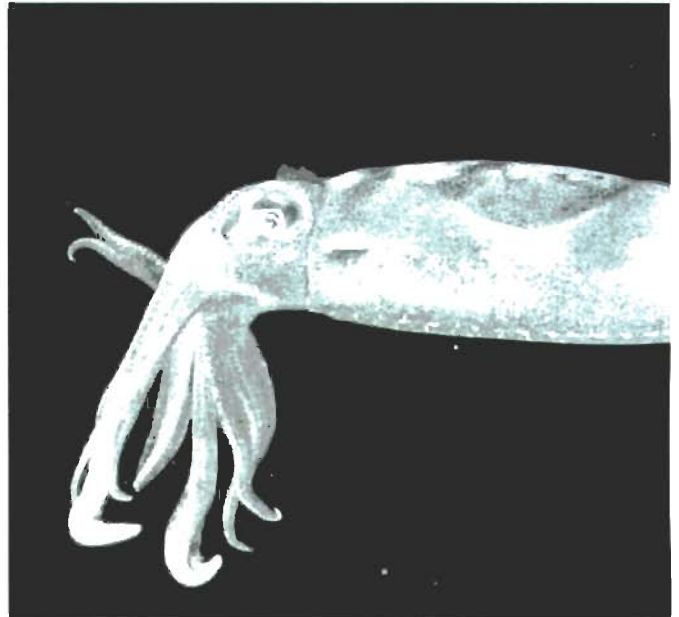


 NATIONAL AQUARIUM IN BALTIMORE.

The educational goals of the National Aquarium in Baltimore are supported by funding by the Jacob and Hilda Blaustein Aquatic Education Endowment Fund.

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Animal Planet **AUSTRALIA**
WILD ♦ EXTREMES



This booklet was prepared by the Conservation Education Department at The National Aquarium in Baltimore.

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September, 2005

Squid Lab

A 45-minute to one hour program for Grades 6-12

Program Description

The Squid Lab class begins with an overview of the cephalopods, with a particular emphasis on squid. The overall anatomy of the squid is also discussed to provide students with a preview of what they will see when the dissection begins. Students will learn about the adaptations, defense mechanisms, feeding habits, predators and reproductive strategies of squid. Step by step directions will be given to guide the students through the fascinating dissection.

Planning for the Program

The **Squid Lab** is an ideal means to introduce your students to the anatomy and physiology of invertebrates as well as the dissection of a large animal. Squid may be a little smelly, but most students soon overcome this aspect to discover the unusual adaptations that these animals possess. Through this hands-on experience and accompanying introductory lecture students gain an understanding of squid and their cephalopod relatives.

Pre-Outreach Program

The day before your program read the Teacher Background information and share this information with your students. Then complete Activity 1: Preparing to Dissect, Step A - Clam Dissection and Step B - Mollusc food scavenger hunt.

Day of the Outreach Program

The Squid dissection program is a 45 minute to one hour program. The Outreach Staff will arrive to your school approximately 15 minutes before the start time listed on your contract. The outreach staff can move materials between classrooms; however, it is preferable to have one dedicated classroom for all classes to use for the squid lab. The outreach staff requests that you allow at least 10 minutes between each dissection to clean up and set up for the next class. The outreach staff also requests a one hour break at midday for lunch. Please have a copy of the day's schedule available for Aquarium staff upon arrival. If you

AAAS Benchmarks

5A-6-8#2

Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.

5A-6-8#3

Similarities among organisms are found in internal anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.

MD Voluntary Curriculum

SCIENCE - 1.0 Skills and Processes
Grades 6-8, A-1: Design and carry out simple experiments and formulate appropriate conclusions based on data obtained.

SCIENCE -3.0 Life Science.

Grade 7, A-1: Compile evidence to verify the claim that features of organisms connect or differentiate them.

would like the Outreach staff to review your schedule, please fax it to 410-659-0116 ATTN: Outreach, or email to outreach@aquaria.org.

Although parent volunteers are not required for this program, parents are welcome to take part. Volunteer information is included with your teacher packet.

Post-Outreach Program

The day after your visit complete Activity 2 - Squid Jeopardy.

Teacher Background

Squid and their relatives are classified as molluscs. Molluscs are invertebrates whose soft bodies are usually covered with hard shells. Clams, oysters and snails are familiar members of this phylum. More specifically however, the squid and similar animals are in the Class Cephalopoda. The cephalopods are unusual invertebrates because most lack a hard shell. The chambered nautilus is the only type that has a complete shell. The squid and cuttlefish have small shells that are located inside of the body, rather than outside. The octopus, on the other hand, has lost its shell completely. All of the cephalopods are marine animals and all are carnivores.

While cephalopods appear to be very different from other classes of molluscs, they have the same basic body plan. All molluscs have a soft body with a special covering called the mantle. The mantle encloses all of the body organs such as the heart, stomach, and gills. This tough skin-like layer is also responsible for making the shell, if it is present. Most molluscs have a muscular foot to aid in movement and a feeding structure called a radula. In the cephalopods, instead of one muscular foot, there are at least eight arms projecting from the head region. Perhaps that is why scientists named them the "cephalopods," which translates to head-footed! In this class, the mantle is present but the body is more elongated. There is also a distinct head area with well developed eyes in most. The main feeding structure in most cephalopods is a horny beak. They do not always have a radula. If it is present, it acts as a tongue and helps to direct food into the mouth.

Cephalopods have unique abilities which most molluscs lack. They are able to change the color of their skin so that it blends with the surroundings. They are also known for their ability to squirt a potential predator with "ink" and escape backwards by forcing water from a siphon near the head. This is called jet propulsion. Cephalopod eyes have received a lot of attention because they are much more developed than other invertebrate eyes. They are more

similar to vertebrate eyes because they have a cornea, lens, and retina. The eyes of the chambered nautilus do not have lenses. Cephalopods can see images, an ability that is not found in molluscs or any other invertebrate. Finally, these animals reach the largest size of any invertebrate. Of the 650 living species of cephalopods, the giant squid, Architeuthis, which lives in the North Atlantic is the biggest. It may reach 56 ft in length (17 m) and weigh 3 tons. This length includes the tentacles which may measure 20 ft (6 m). In an animal this size the eye is 1 ft across (30 cm).

Squid

Whereas octopuses are known for their intelligence, squid are known for their speed and agility. They swim, usually backwards, using jet propulsion. They have been known to move as fast as 20 knots (23 mph). There are 375 species of squid, with the largest being the giant Architeuthis. The North American squid, Loligo pealei, however, is only 8-20 in long (20-50 cm). Squid live from 1.5-3 years, depending on the species. The North American squid prefers shallow water, although many species inhabit deeper, offshore waters.

The squid, unlike their octopus relatives, are not solitary creatures. They swim in schools and will frequently follow the schools of fish on which they feed. Their cigar-shaped bodies are well suited for swimming. Two fins help to stabilize or balance the body when swimming and the internal shell, called a pen, gives support to the muscular mantle. Squid cruise along at constant speeds or dart about in quick jerky movements. Some have been known to jet 12 ft. (3.5 m) out of the water and land on boat decks.

Squid have ten arms, two of which are called tentacles. The tentacles are longer than the arms and have flattened ends like a spatula. Suction cups are on the underside of all the arms and only on the flattened ends of the tentacles. The tentacles are used for feeding. The suction cups, which may have hooks, help to capture small fish and shrimp, which are quickly torn apart by the beak.

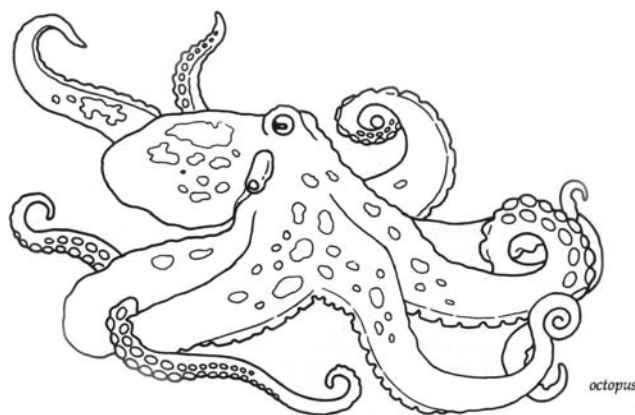
The quick moving squids are eaten by a variety of predators. The smaller species are food for sea otters, sea birds, dolphins, large fish and humans. For protection against predators, squids use the same methods as other cephalopods: camouflage coloring, ink clouds and speed. Their pale bodies can become almost transparent if necessary or take on the coloring of nearby rocks or seaweeds. The ink cloud emerges in the shape of the squid, thus forming a false target for the predator.

Also, some deep sea squids have bacteria in the ink which makes it glow in the dark. They may also have special light organs which not only frighten away predators, but also help to attract food or a mate in the permanent darkness of the deep sea.

The giant squids are eaten by sperm whales. When a whale is caught, it is not unusual for a huge squid to be found inside of its stomach. People, on the other hand, concentrate on the smaller varieties for food, like the North American squid. The catch may be as much as 700,000 metric tons per year. Japan alone may catch 650,000 tons. In many countries squid are eaten, but they may also be used as fish bait.

Most squid are caught during breeding season, when they gather by the millions to spawn. From November to April, the waters off the coast of California become packed with millions of Pacific squid, Loligo opalescens. After mating, the females produce 10-50 egg strings, each containing hundreds of eggs. These are attached to the ocean floor. Many females attach their egg strings at the same location, forming a "mop." The eggs are left to develop without any care and hatch about 10 days later. The adult squid then leave the spawning ground and die soon afterwards.

Besides using squid for food, humans are also very interested in their nervous systems. The giant nerve fibers in the North American squid have been used for many years in studies of the nervous system. By studying these fibers, scientists may one day understand why Alzheimer's disease causes nerve cells in the brain to die. This may help them to find a cure for many other neurological diseases.



Resources

The *National Aquarium in Baltimore* website.

<http://www.aqua.org>

Nebraska Scientific offers a wide variety of educational science supplies to schools, colleges, and universities throughout North America. Nebraska Scientific is a division of Cyrgus Company, Inc., one of the nation's leading processors of preserved biological materials, preserved materials destined for use in science classrooms around the world.

Nebraska Scientific
3823 Leavenworth Street
Omaha, NDE 68105-1180
1-800-228-7117
<http://www.nebraskascientific.com>

Delta Biologicals has provided the highest quality of preserved specimens for over 30 years. Delta Biologicals believes that dissection under teacher supervision is a powerful learning experience that instills knowledge, respect and provides benefits to our society. Experts agree that with classroom dissection, students learn basic anatomy in a "hands-on" manner that cannot be duplicated.

Delta Biologicals
PO Box 26666
Tucson, AZ 85726-6666
1-800-821-2502
<http://www.deltabio.com/PreservedSpecimens.html>

Carolina Biological Supply provides a variety of tools to be used in a classroom setting including specimens and instruments used in dissections.

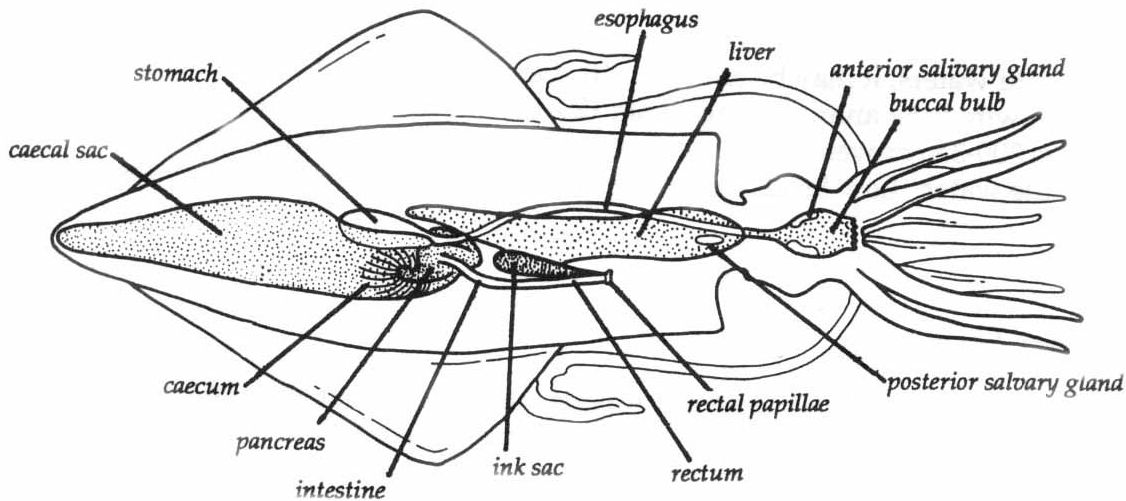
Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215
1-800-334-5551
<http://www.carolina.com>

Shape of Life: A revolutionary eight-part television series that reveals the dramatic rise of the animal kingdom through the breakthroughs of scientific discovery. The Shape of Life website features activities and resources, animal facts, and scientist biographies.

<http://www.shapeoflife.org>

A Closer Look at Squid: An Introduction to Anatomy and Physiology

A brief description of each organ system of the squid is given below.



Digestive System

The organs of digestion in squid include the jaws, radula, salivary glands, esophagus, liver, stomach, intestine, and anus. Squid typically eat twice a day. Food is grasped in the horny jaws and gripped by the radula, which is like a tongue with teeth. The radula transfers the food to the throat, from which it passes to the esophagus. The esophagus connects the mouth to the stomach. The esophagus receives digestive juices from salivary glands. Some glands may secrete a toxin as in select species of octopus. In squid, the juices of the digestive gland are not harmful to people. The esophagus empties into the stomach. The stomach is a small, shiny white sac that connects to the stomach pouch or caecum.

Digestion begins in the stomach. The caecum also performs some digestion and is the primary site of absorption of nutrients in squid. Digestive enzymes are added by the liver (a large oval, brownish organ) and the pancreas. Enzymatic secretions may be added to the stomach or caecum in separate phases. (In other cephalopods, the liver and pancreas are considered one combined digestive organ and acts as the site of absorption.) The stomach and caecum are usually found behind the liver. The stomach pouch dumps its contents into the intestine, a narrow tube adjacent to the stomach pouch. The intestine empties into the rectum and finally, the terminal end of the digestive system, the anus. The anus empties into the funnel or siphon, which is the exit for all waste products.

This description is somewhat simplified. The digestive system of squid contains a complicated series of ducts and valves which regulate the flow of digestive enzymes and the absorption of

various food components. Most books point out that the terms liver and pancreas are not exact because these organs do not have identical functions in cephalopods and vertebrates. The dissection and illustrations will show that the sac is closely associated with the digestive system but does not function as an organ of digestion.

Respiratory System

Seawater, that contains oxygen, enters the mantle cavity near the head. The water swirls around the paired gills, which have a feathered appearance due to the presence of gill filaments. Squid may have 20-80 filaments on each side. Oxygen diffuses from the water into the gills and is transported to the gill hearts by the many blood vessels that serve the gills. Respiration or ventilation in squid is measured by the number of times the mantle cavity contracts to take in water. Respiration rates in squid vary from 20-30 movements per minute, when at rest. In cold waters, it may be as low as 10. Open water squid may show 65-85 movements while slow swimming animals range from 120-180 per minute. When swimming quickly, the rate is 300-350 movements per minute. Squid are known to be very sensitive to oxygen levels in the water. Low levels of dissolved oxygen cause them to quickly lose strength and die.

Circulatory System

Cephalopods, like most molluscs and arthropods, have blood that has a bluish tint. This is due to the presence of a pigment that contains copper, rather than the iron that is found in humans. Squid have three hearts. There is one heart at the base of each gill. These hearts receive blood that is rich in oxygen from the blood vessels that serve the gills. The gill or branchial hearts pump blood to the third heart, known as the systemic heart. The systemic heart serves the internal organs and the mantle. It is located between the branchial hearts, just slightly anterior to them. The systemic heart pumps blood to the blood vessels that serve the mantle, head, digestive organs and kidney.

Nervous System

The nervous system of cephalopods is far more intricate than that of other molluscs and invertebrates in general. In squid, the brain is enclosed in a cartilaginous head capsule. The brain mass is the same as fish, but it is less than that of birds and mammals by body weight. Faster squid have larger brains. Up to 80% of the brain is devoted to processing visual information; that information is then used to assist in fast swimming. As previously mentioned, scientists like to study the giant nerve cells and fibers found in squid and cuttlefish. It has also been found that some nerve cells in squid

contract, a characteristic that is usually found only in muscle cells. The stellate (star-shaped) ganglion found in the mantle are studied for those contractile abilities.

Finally, it was pointed out that octopuses have the ability to learn. They have good memories and can be trained as well as rats. A few squid have also demonstrated an ability to learn, but in general the deepwater oceanic squid show no capacity for learning.

Senses

Vision

Although most cephalopods have monocular vision, meaning they can use their eyes independently, cuttlefish and squid are capable of binocular vision. Initially it was thought that all cephalopods were color-blind, although behavioral studies indicate that they may be able to detect color. They do have the ability to see images. Certain varieties of squid have been found to have one large eye and one small eye. It has been postulated that the large eye is used to look up and receive light from above. The small eye is used to look down and forward. Some cephalopods also have light sensitive vesicles in their brains. Their function varies from species to species, but it is thought that they help the animal to determine the amount of light present in the surrounding water. In squid, this information may be used to regulate the intensity of the special reflecting cells in the mantle and aid with camouflage. The vesicles may also help detect bioluminescence in deepwater animals. Not much is known about the light sensitive vesicles.

Smell

Over 100 years ago, scientists discovered a sensory organ located behind the eyes in squid that was thought to be associated with smell. It seems to help the animal monitor the water quality by detecting chemicals in the water and passing that information on to the brain. When noxious substances are in the water, this causes the squid to activate the escape jetting mechanism.

Hearing

Some squid have been shown to react to sound. Pacific squid are able to produce sound when eating and swimming fast. They also react to the crunching sounds made by other squids and can be killed by the intense blast of sound generated by toothed whales.

Although they do not have ears, cephalopods do possess specialized structures called statocysts. They are located in the brain and are thought to help regulate balance.

Taste and Touch

Taste receptors are located on the rims of suction cups and on the mouth region. Their tasting ability is two to three times more sensitive than people for some chemicals. They detect objects in the environment with tactile receptors that are also located on the suction cups. Although they can "feel," squid are unable to determine the difference between light and heavy objects.

Reproductive System

Cephalopods engage in sexual reproduction. In squids, it is not always possible to distinguish males from females externally. The fourth arm in males in some species is modified slightly to assist with reproduction. Either the left or right arm in this position has smaller suckers that are used to transfer the sperm from the male to the female.

The mantle cavity of male squids has a single cigar shaped gonad, the testis, located on the left side of the mantle. It is usually white and has a series of tubules and ducts associated with it that comprise the male reproductive system. Sperm produced in the testis pass through the vas deferens and then the seminal vesicle. In the seminal vesicle the sperm is encased in a spermatophore composed of several tunics or outer coatings. Specialized glands provide additional structures including a cement body, ejaculatory organ and cap which aide in fertilization. The completed spermatophores are shaped like baseball bats and pass into Needham's sac for storage. There may be 400 or more capsules stored in this structure.

In female squid, the eggs are produced in the ovary. The ovary looks like a bunch of grapes and is shaped like an ice cream cone. It rests in the mantle cavity between the gills. Squid have a shell gland, the nidamental gland, which provides the outer coating for the eggs. Females can also be distinguished by the bright orange accessory nidamental glands, whose function has not been fully elucidated. In some species, the nidamental gland produces a jelly-like coating that surrounds the entire egg mass, after each individual egg has been covered by secretions of the oviductal gland.

Fertilization can take place either inside or outside of the female's mantle cavity. During copulation, the male removes spermatophores from Needham's sac with the specialized arm and places them inside of the female's mantle cavity near the oviducts. In some species, spermatophores are expelled from the penis and

exit the mantle cavity by way of the funnel. (Needham's sac becomes the penis.) The cement body glues the spermatophore in place. In *Loligo*, the spermatophore may be placed in a seminal receptacle, found beneath the mouth. In either case, when the spermatophore is removed from Needham's sac, the cap is torn off. Once exposed to seawater and placed inside of the female, the ejaculatory organ turns inside out resulting in release of the mass of sperm. The female simultaneously releases eggs from the mantle cavity and holds them with her arms so that they can be fertilized by the sperm. Once the eggs are exposed to seawater, the coating hardens and the egg capsules swell. The female then attaches the egg strings to the ocean bottom. Sperm and egg maturation in squid is typically regulated by environmental factors such as temperature, light, and available food. Spawning in mature animals is usually stimulated by the onset of longer days in those animals that reproduce during spring and summer. However, cephalopods living in tropical regions may reproduce year round.

Ink Sac

The ink sac is found in nearly all squid and consists of an ink gland and a sac. The ink gland produces the ink, composed of melanin granules in a clear liquid. The sac acts as a reservoir, storing ink until it is needed for ejection. Once ejected, the ink enters the intestine and pours out through the anus. Ink can not only irritate the eyes of a potential predator, but it also temporarily prevents the target animal from smelling. Human eyes are also irritated by squid ink. Finally, recent research has shown that squid ink has the ability to kill certain kinds of bacteria.

Activity 1 - Preparing to dissect

Step A: Clam Dissection

Description

Who would've guessed that clams and squid are related? That's right, they are both in the Phylum Mollusca; soft-bodied with a hard shell. If you think that your students are squeamish about squid, then prepare the class by dissecting something a little smaller, such as the clam. Even though clams are not as specialized as the cephalopods, they still exhibit a high degree of organ system development, not found among other invertebrates. Fresh specimens purchased at local seafood suppliers are acceptable for this study although preserved specimens from biological supply houses are also a good resource.

Procedure

1. Purchase clams from a seafood market or a biological supply company for your class.
2. Using dissecting equipment, have 2 students work on one specimen.
3. You can order dissection materials and guidelines through several biological supply companies. See resources section.
4. Review overall anatomy of a clam. Discuss what makes them related to the squid and go over the squid anatomy provided in the teacher background section.



Activity 1 – Preparing to dissect

Step B: Mollusc food scavenger hunt

Description

Have a mollusc food scavenger hunt. Clams, mussels, oysters, scallops, conch, octopus, and squid are harvested for human consumption. Have students search in grocery stores, restaurants, seafood markets, and oriental and specialty stores for all the different types of molluscs which are consumed. How many edible molluscs can you find? Which kind are the most popular? Unfortunately, some types of seafood are so overharvested that their populations are decreasing. Which molluscs are being overharvested?

Procedure

1. Engage students in a discussion about types of molluscs. Refer to mollusc classification sheet.
2. Have students visit restaurants, seafood markets and specialty stores to discover the types of molluscs which are consumed. What was the most common mollusc that your students found?
3. Have students identify an important mollusc that lives in the Chesapeake Bay. What has happened to the population of these animals over time? Why?



cuttlefish

Activity 2 - Squid Jeopardy

Description

Squid Jeopardy is a fun follow up to the Squid Lab program that will challenge your students as well as review the information that they have learned. Questions and answers relating to the information the students have learned through this program are provided. You can either use the format that is provided or feel free to make up your own.

Procedure

1. Break students into 3 or 4 groups depending on class size. These groups will compete in Squid Jeopardy.
2. Photocopy Table #1 onto a overhead transparency. Project the table onto a screen to begin the game. (If overhead projector is not available, write the table onto the chalkboard). Decide which group will go first. They will pick a letter/number combination to determine which answer they will have to answer in the form of a question. If they get it correct, record the number points that team won. Each statement is given a point value according to the difficulty of the question. A-D, 1 are each worth one point, A-D, 2 are each worth 2 points, A-D, 3 are each worth 3 points, etc.
3. If a group correctly provides the question to the answer, they can pick a letter/number combination and continue to win points. After 3 correct answers, move onto the next group. Continue the same process until all the questions have been completed.
4. There is also another option to go along with the game and to make it a little more challenging. For the questions relating to anatomy, hand out the external and internal diagrams of a squid, found in the back of the booklet. Students will have to write/draw in where that part of the squid is located. So, not only are they identifying what the function of that part is, but also they are also demonstrating that they know where the part is located.

Activity 2 - Squid Jeopardy: Table #1

	1	2	3	4	5
A	Squid use these to grasp their prey.	This internal shell gives support to the muscular mantle.	This cephalopod may reach 56 feet in length.	This organ is like a tongue with teeth.	The blood of cephalopods has a bluish tint due to the presence of this element.
B	These organs help squid to breath under-water.	A tasty dish made from squid.	Squid, octopuses, nautiluses, and this animal are in the class Cephalopoda.	These structures aid in changing the color and texture of a squid's skin.	This heart serves the internal organs and the mantle.
C	They swim backwards using jet propulsion.	This group of animals has a soft body usually covered with a hard shell.	Giant squids are preyed upon by this species of whale.	Due to the presence of these structures, cephalopods have the ability to see images, unlike other mollusks or invertebrates.	80% of the brain is devoted to processing this type of information.
D	The mouth attaches to this structure, which brings the food to the stomach.	This structure ejects a dark liquid in order for the squid to evade their predators.	This organ is enclosed in a cartilaginous head capsule.	There are three of these present in a squid.	This special gland in female squid provides an outer coating for the eggs.

Activity 2 - Squid Jeopardy: Answer Key

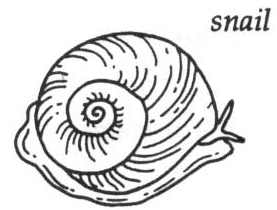
	1	2	3	4	5
A	What are the tentacles?	What is the pen?	What is a giant squid?	What is a radula?	What is copper?
B	What are the gills?	What is calamari?	What is a cuttlefish?	What are chromatophores?	What is the systemic heart?
C	What are squid?	What are mollusks?	What is a sperm whale?	What are the cornea, lens, and retina?	What is visual?
D	What is the esophagus?	What is the ink sac?	What is the brain?	What is the heart?	What is the nidamental gland?

Mollusc Classification

There are seven living classes of molluscs. They are as follows:

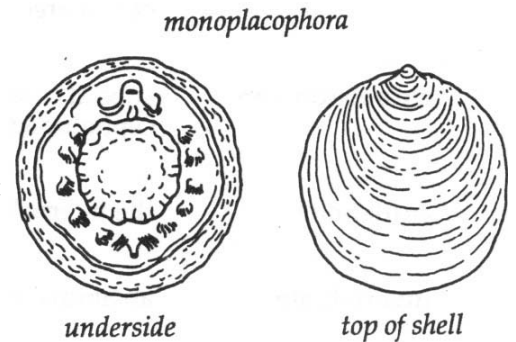
1. Class **Gastropoda** (Gastropods)

This group includes freshwater, marine and land snails, most of which have one asymmetrically spiralled shell. Some, such as sea slugs, lack shells. Gastropods include limpets, cowries, whelks, sea hares, sea slugs and sea butterflies.



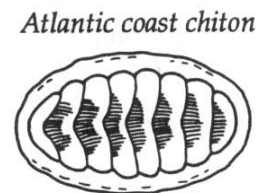
2. Class **Monoplacophora**

The few living specimens in this class possess a single shell, which varies from flattened to cone shaped. They are related to deep sea molluscs that lived 500-600 million years ago. Some scientists believe that they are ancestors of gastropods, bivalves and cephalopods.



3. Class **Polyplacophora** (Chitons)

This class contains chitons, molluscs whose shells consist of eight overlapping plates. These animals live in intertidal zones and have a muscular foot that is adapted for gripping hard surfaces.

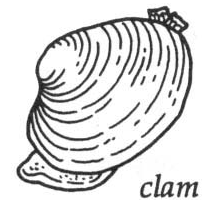


4. Class **Aplacophora** (Solenogasters)

There are approximately 250 species of animals in this group which lack the shell, mantle and foot typically seen in molluscs. Solenogasters are worm shaped and may burrow in mud bottoms or live on hydroids and corals.

5. Class **Bivalvia** (Bivalves)

Bivalves are molluscs with two shells such as clams, mussels, oysters, cockles, scallops, woodboring shipworms, and razor clams. Many are adapted to burrow on soft substrates and are filter feeders. Some are able to bore holes into hard materials such as wood, rocks, shells and coral.

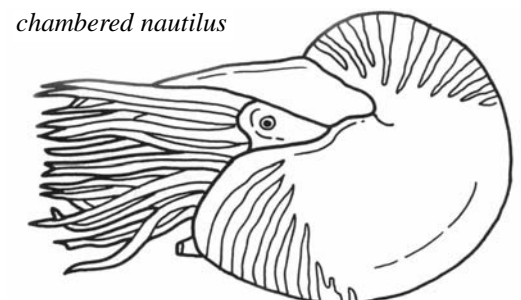


6. Class **Scaphopoda** (Tooth/Tusk Shells)

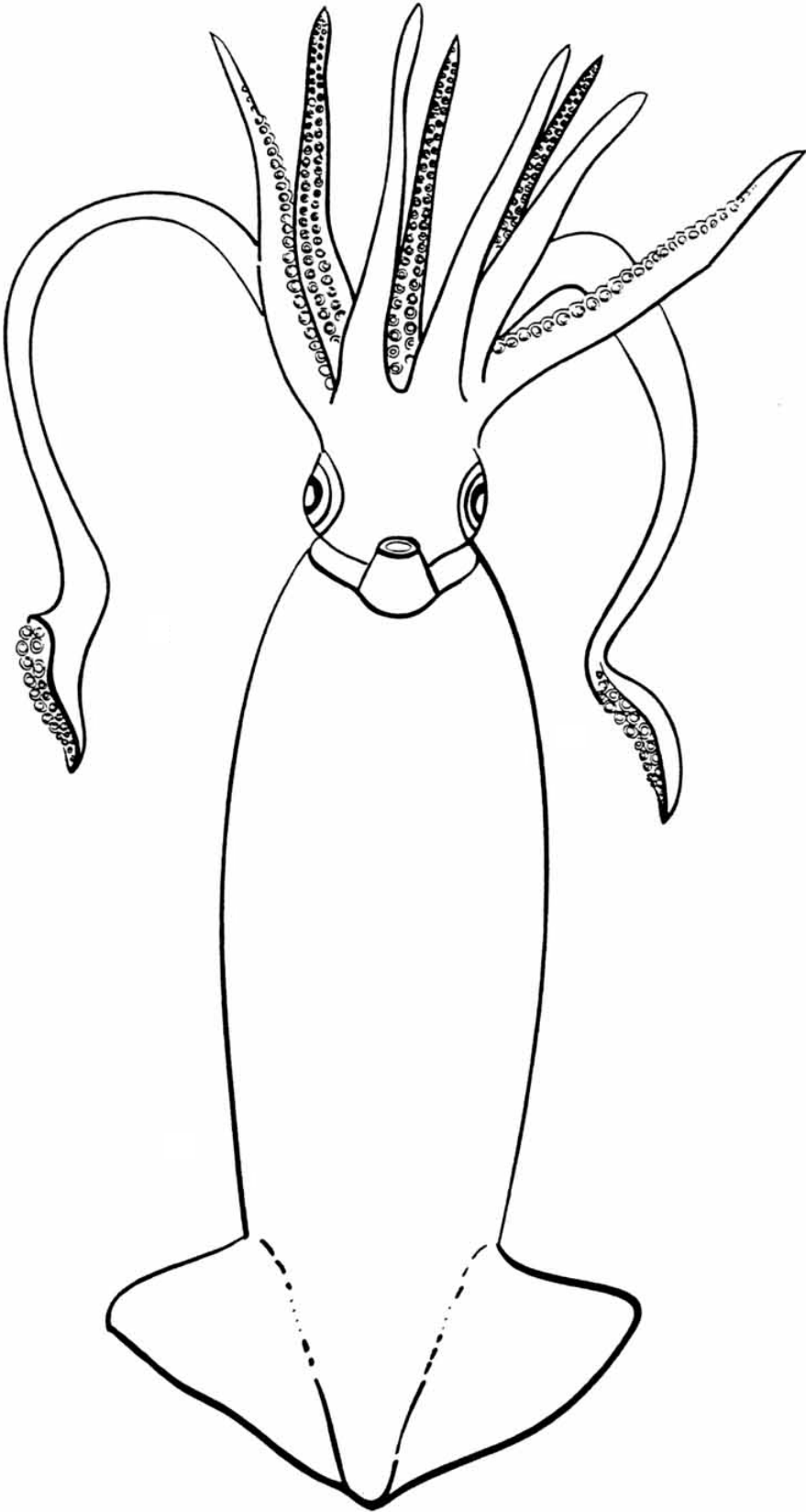
Scaphopods are burrowing molluscs with cylindrical shells. They are most closely related to bivalves. There are about 350 species.

7. Class **Cephalopoda** (Cephalopods)

Cephalopods include octopuses, squid, cuttlefish and nautilus. There are approximately 650 living species and 7500 fossil species. This group is adapted for swimming and reach the largest of any mollusc in the form of the giant squid, Architeuthis. The nautilus has external shells, while most other cephalopods either possess an internal shell or none at all.



External Anatomy



Internal Anatomy

