SQUID DISSECTION

FOR THE TEACHER

Discipline
Biological Science

Theme
Scale and Structure

Key Concept
The investigation of the structure and function of an open ocean animal like the squid can be used to study adaptations for a completely pelagic existence.

Synopsis
Students work in pairs to dissect a squid and investigate its structure and how all the parts function together to allow the squid to survive and thrive in its open ocean environment. The squid is then honored as the students participate in a Squid Feast.

Science Process Skills
observing, communicating, comparing, classifying, relating

Social Skill
Checking for Understanding

Vocabulary
benthic, cephalopod, invertebrate, mollusc, pelagic, planktonic

MATERIALS

For INTO the Activities:
Monterey Bay Aquarium Video Collection, "Seasons of the Squid" segment (Available for check-out from the ***MARE*** library or for purchase from Monterey Bay Aquarium)

Anticipatory Chart #1 and #2 (see charts below) copied on large flip chart paper or on the board:

For THROUGH the Activities:
For each pair of students and one for yourself:
One Squid. ***Available in grocery stores frozen in 3 lb. boxes for about $1 - $1.50/lb. There are about 32-35 squid per box or enough for two classes. Squid are also available fresh in fish markets. Frozen squid are the number one choice, but if only fresh are available, choose the largest and freshest ones and make sure they haven't been cleaned. Keep them in the freezer until the morning you are going to use them. They will thaw under running, cold water.***

One pair scissors, two toothpicks, two stacked paper plates (the underneath plate will be used to put the cleaned squid on), one paper towel, handlens.
Note: if you will be cooking the squid after the dissection, (which we strongly suggest!), then each student must wash their hands with soap and water before the dissection and the scissors must be washed and disinfected before use.

Squid charts (3) copied onto the board or large flip chart paper and colored pens

For Chart #1, draw an outline of the "External Squid"; for Chart #2, draw an outline of the "Internal Squid" and Chart #3, draw an outline of the squid to use as a Review: "What We Learned"

Small jar with lid (like a baby food jar, half filled with water), to place ink sac in to show ink dispersal.

Student worksheet copied for each student (distribute at the end of the dissection).

For cooking the squid:
"Fry Daddy" or other deep fat fryer, oil, tempura batter mix (the just-add-water kind), bowl, spoon, knife, cutting board, paper towels.

Optional:
Mollusc and Crustacea Poster ***(available for check-out from the MARE library).***
Microscope and small dish of water in which to place parts of the squid for closer inspection (gills, eye lens and etc.).

INTRODUCTION

Our knowledge of squid goes far back in history. Squid were even known to Aristotle and illustrations were made as long as 4,000 years ago. Sailors described them in their yarns and legends, most often as monsters of the sea or "Kracken". Jules Verne wrote about a giant squid which captured his submarine, the Nautilus in **20,000 Leagues Under the Sea**. Modern biologists don't know much more about giant squid than researchers did in the 1800's because most giant squid which have been studied have washed ashore as pieces rather than the whole animal. Nobody knows how big they get, the largest one ever found was from the stomach of a sperm whale and it measured 65'. Scientists speculate that they may measure up to 100' long and weigh more than 2 tons. These squid live 1000 - 3000 feet deep so it is no wonder they are difficult to study. Squid don't have to be giant to be excellent predators. The most ferocious is the Humboldt Squid which lives off the coast of South America and reaches a length of 12' and 300 lbs. They travel in schools and attack their prey en masse. These squid have even been known to attack scuba divers.

Squid are distributed world wide and come in many sizes and shapes from less than 1" to greater than 70'. They have no backbone and therefore are classified as an invertebrate. Giant squid are the largest invertebrates in the world. Squid are related to the octopus, cuttlefish, clam and the snail - all classified as Phylum Mollusca. Squid characteristics found in other molluscs include the bilaterally symmetrical, soft body, the foot (here modified into greatly expanded tentacles), the mantle which surrounds the organs of the body, the ribbon-like teeth called the radula (missing in the clams) and a shell (which is greatly reduced or missing in some). Squid are in the Class Cephalopoda meaning "head-foot" along with octopus and cuttlefish. There are about 400 living and about 10,000 fossil species.

Cephalopods have the most highly developed nervous systems to be found in invertebrates and the most complex behavior. Their sense organs, brain and excellent swimming ability allow them to compete with vertebrates for food and territory in the same habitat. Squid are adapted to a completely aquatic way of life having gills, a streamlined body, reduced shell and a siphon for speedy movement. Squid are considered to be a pelagic animal meaning it spends its life living in the water column. Squid need those specialized adaptations that allow it to be camouflaged and yet move freely and fast through the water under its own power. Other pelagic animals include fish and marine mammals. Two other ways of life include the planktonic and the benthic. Planktonic animals are those that are at the mercy of the wind, waves and currents. These animals are weak swimmers and have developed adaptations that prevent them from sinking to the bottom. Some of these adaptations include oil droplets, spines or forming together into colonies. The larva of most invertebrates as well as adult jellyfish, krill and copepods are considered to be

planktonic. The third group, the benthic animals, live on the bottom and have adapted in many different ways to capture food and escape being eaten. Clams bury themselves in mud or sand, stick up their siphon to obtain food and oxygen and have a thick shell to discourage predation.

Scientists are studying the squid's ability to learn and remember, and how its tentacles are used for touching and identifying different objects. Researchers are also studying the squid's giant axon. An axon is the long stringlike extension by which a nerve sends its electric signals - signals that tell muscles to contract and glands to secrete hormones and that relay information from the sensory organs to the brain. A squid's axons, about the width of a pin, are up to 100 times larger in diameter than in humans. The large size makes them ideal for study and much has been learned about the human nervous system from studying the squid. The squid's jet-propulsion system lets it move at blazing speeds and this method of locomotion explains why the nerves that activate the mantle muscles have evolved such big axons.

The Pacific Coast market squid (**Loligo opalescens**) is captured in large numbers off the coast of California as they form into mating swarms. There are two main fishing grounds in California; Monterey Bay where they are caught during the summer months and the Channel Islands in Southern California where they are caught in the winter. In both areas the squid are caught with large nets. A different species of squid is caught by Japan which takes 80% of the world's catch. Squid are eaten by many different predators and are an incredibly important food source throughout the world's ocean. Sharks, pilot whales, porpoises, sperm whales, elephant seals, sea lions, sea otters, salmon, swordfish, and marine birds like auks, penguins and terns all depend to different extents on the squid for food.

Squid are also a very important food resource for people around the world. This in turn makes them an excellent dissection animal. It is better to dissect something that can be eaten afterwards because otherwise it may encourage a casual attitude towards life. We need to discuss with students that we are not simply going to throw away this once living being after we are done with it, nor are we experimenting for experiments sake.

INTO THE ACTIVITIES

Anticipatory Chart #1

Have students sit in small groups where they can quietly discuss the video they are about to watch. Have one student in each group act as the recorder and count the number of people in their group who answer yes, no or maybe to each of the questions below.

ANTICIPATORY CHART #1
What do you think?
YES
NO
MAYBE
Squid don't change their color
Squid are usually solitary
Male and female squid look just the same on the outside
Squid have 10 arms that all look alike
Squid use fins for locomotion
Squid chase and catch fish
Squid lay single, individual eggs
Young squid look just like their parents except smaller
Squid jet through the water with their tentacles trailing behind

Turn on the video (turn down the sound completely) and encourage the students to discuss the questions with each other as the recorder counts their answers. ***Remind the students that they may not be able to answer the questions based just on what they see in the video.***

At the end of the video segment and after each group has had a chance to complete the questions, lead a class discussion and record the group's ideas on a class chart poster. Refer back to the chart throughout the activity.

Anticipatory Chart #2 and "Think, Pair, Share"
Have students each take a piece of paper and divide it lengthwise into 3 columns and label them as shown below. Have each student "**Think**" about each of the first 2 columns ("What we think we know" and "What we would like to find out") and jot down and/or illustrate some of their ideas.

ANTICIPATORY CHART #2
"What we think we know about squid"
"What we would like to know about squid"
"What we know to be true about squid"

Now have each student "**Pair**" up with another and compare/discuss their ideas. They can add to their lists after discussions with their partner if they like.

Finally, have each pair "**Share**" their answers with another pair of students. Again, lead a class discussion and record the group's responses on the class chart poster. Discuss that as questions are answered, the third column will begin to be filled in.

Assessment
Participation in each of the class discussions of the Anticipatory Charts and completion of Anticipatory Chart #2 lists in words or drawings.

Observation of Checking for Understanding

THROUGH
THE ACTIVITIES

Relationship to Other Molluscs
You may want to start this part of the activity with a brief description of the Mollusc Phylum and the relationship of other molluscs to the squid. Use the Mollusc and Crustacea Poster for reference. This is also a good time to describe the characteristics of animals living in the different zones of the ocean e.g. planktonic, pelagic and benthic. See the **FOR THE TEACHER** section for information. Use the following Advanced Organizer for the students to organize their notes in words or illustrations:

- Advanced Organizer
- PELAGIC
- PLANKTONIC
- BENTHIC
- Example animal
- Where they live
- Swimming ability
- How they capture food
- How they escape predators

Prelude to Any Dissections
Before the squid or tools are distributed, discuss with students the sanctity of life, referring back to the video and the activities they saw the squid engaging in and their beauty as they swam. Stress that all of your instructions must be followed exactly so that they can get the most out of the dissection and see all of the parts. Also, no one is to use a tool until directed to do so, and under no circumstances should they poke the squid. Do not make any student participate in the dissection if they are really concerned or squeamish. You might want to make a group of three if that is the case and give the student the opportunity to jump in as they feel ready.

Place the squid on the plates so that the siphon and the lighter side of the body is facing up. Distribute the squid and tools to each pair of students. Remind them to not touch their tools yet.

External Anatomy
As each structure is introduced, draw the part on the Squid Chart #1 and label it. You may want to have the student pairs draw the structures and label them on their own chart along with you. Teacher note: refer to the labeled squid diagram attached to locate all of the parts as you are preparing to teach this activity.

1. Have the students count the **arms** or **tentacles** and determine if they are all the same, or if not, how they differ from one another. This is a good time to use the handlenses to get a good look at the **suckers**. Notice all the small teeth in a ring around the suckers and how the suckers are actually on a short stalk. The students can use the toothpicks to spread out the arms-tentacles if they are not yet ready to touch it with their fingers. ***There are eight shorter arms lined with batteries of suckers and two longer, thinner tentacles with smaller suckers located only on the tips. Squid capture their prey with the two long tentacles, and then bring it close to their body where the eight, suction-cupped covered arms can hold it tightly as the prey struggles. Squid consume up to 20% of their body weight in shrimp and fish per day.***

2. The mouth with its horny **beak** can be found within the circle of the arms-tentacles. The beak looks like a black speck, but upon closer examination using the toothpicks to push back the tissue surrounding it (called the **buccal mass** or **cavity** - kind of like our mouth) one can see that there are actually two halves to the beak, much like a parrot's beak. Before food is swallowed it is torn to pieces by these powerful jaws. Use the toothpicks to remove first one half of the beak and then the other. Alternatively, the whole buccal mass can be pulled out with the beaks inside and then the beaks can be removed. Attached to the beaks you may see the **radula** which is a file-like tongue which shreds the pieces of food torn apart by the beak. As the buccal mass is removed, one can see a long tube attached to it. This is the **esophagus** which was connected at its other end to the stomach. You may also see a small knob connected near the top of the esophagus and a little lower down, two more knobs. These are the **salivary glands** which secrete mucus and digestive enzymes.

3. The **eyes** are structurally much like our eyes with a cornea, iris, pupil, lens, retina and optic nerve. The lens is shaped quite differently however, the squid lens is elliptical, whereas our lens is convex (like a contact lens). The eye can be carefully snipped open and the lens can then be found and removed with your fingers as it is the only hard part of the eye. Look at the lens with the handlens or under the microscope. The squid can tell the difference between light and dark and between blue and yellow and forms a complete image of whatever it is looking at.

4. The main part of the body which is the variously dotted and colored envelope surrounding all of the internal organs is called the **mantle.** The mantle is covered in pigment cells called **chromatophores** (colored carriers) each surrounded by a circle of muscles under nervous control. This means that the squid can rapidly change colors based on its emotional state to distract enemies, camouflage to match the background, attract mates and to communicate with one another. As the circle of muscles contract, the chromatophores become larger, spreading the color out and the animal appears darker in color. Conversely, as the muscles relax, the chromatophores become smaller and the animal appears darker.

Squid, like many open ocean animals including fish, seabirds and whales, are lighter on their underside or belly and darker on their back. This is called **countershade coloration**. If a predator hunting for a meal is below the squid, it sees the lighter underside of the squid which looks like the sunlit portion of the ocean and if the predator is above the squid it sees the darker back on its prey which looks like the darker bottom of the ocean. Hence the squid is camouflaged in midwater.

Squid have two **fins** on the mantle near the pointed end of their body. These fins are used as stabilizers and to propel the squid with dainty motions at relatively slow speeds and to guide sudden turns.

5. The **siphon** is a short tube with one opening up near the eyes and the other end just under the mantle collar. Have the students stick the toothpick in one end of the siphon and see it come out the other. ***The opening near the eyes can be seen most easily if the siphon is carefully pinched so that it opens***. The siphon works to propel the squid through the water in the opposite direction to which the siphon is pointing, much like jet propulsion. It works as follows: the squid takes in a large amount of water into the mantle cavity through the large opening of the mantle and then closes off the mantle opening by "zipping up" two **articulating mantle ridges**, one present on each side of the inside of the mantle, to a corresponding **articulating cartilage "valley"** present on each side of the siphon. These are like knobs that fit into sockets. This articulation closes off the mantle so the only way that the water can escape is through the much smaller diameter of the siphon. The mantle muscles contract and the water comes out with enough force to propel the squid through the water at about 7 feet per second or 20 miles per hour! They are the fastest swimming invertebrates in the ocean.

The squid is shaped very hydrodynamically and therefor can attain rapid speeds to escape predators and capture speedy prey. Notice that the animal is shaped to cut through the water as it is propelled backwards. However, it doesn't have to go directly backwards when propelled by the siphon because the siphon is connected to **retractor muscles** which can direct it from side to side. The siphon is very flexible and allows the squid to move in any direction. We will see these muscles upon cutting open the mantle.

Internal Anatomy

The squid should again be placed on the plate so that the lighter side and the siphon are both facing directly up and both fins are flat against the plate. This placement is necessary to insure that everyone cuts open the squid in the same manner so that they can be compared to one other and no vital organs are cut through. Use the Internal Squid Chart and as each part is presented, add the corresponding structure and vocabulary.

Cut open the mantle of the squid directly down the midline starting at the mantle opening, called the **collar,** next to the siphon and continuing down to the pointed tip of the body. Be careful to cut just the mantle and not the underlying organs. To help with this, one student can hold up the mantle and the other can use the scissors to cut it. Once the squid is cut open, have the students spread back the sides of the mantle and compare their squid with other squid at their table.

1. **The Reproductive system.**

The first question asked by students is usually how do you tell the difference between male and female? The **gonads**, the **ovary** in females and **testis** in males, containing either eggs or sperm, respectively, are located from near the very tip of the body up to about the midpoint of the mantle. (Overlaying the gonads and about the same size is a large organ called the caecum - see #2 Digestive System below for a description).

Females: **eggs** are light yellowish in color and feel gelatinous. Depending on the reproductive stage, the eggs may be plentiful and visible as tiny spheres or as a much reduced area of diffuse gelatin.

The females have a system of paired **egg shell glands** called **nidamental glands** which put a protective coating on the eggs before they are laid. This protective coat swells and hardens upon contact with the seawater when the eggs are laid. The nidamental glands are the large, oval, white, organs located at about the midpoint of the mantle cavity. Females also have an **accessory nidamental gland** located near the top portion of the nidamental gland. This accessory gland is in close association with the ink sac and is pinkish in color (students tend to think it is the heart because of its color).

Eggs leave the ovary and pass into the oviduct passing through the **oviducal gland.** This organ is a whitish, oval organ located on the right side of the mantle cavity near the bottom of the nidamental gland. This gland puts a coating around the eggs after they leave the ovary. Eggs are moved out as egg clusters and the nidamental glands then add their protective capsules to the eggs.

Males: the **sperm** is white in color and more diffuse and watery than the eggs. The sperm leaves the testis passing freely into the area surrounding the testis and then find their way to an area called the sperm bulb. From here, the sperm pass through the coiled tube called the **vas deferens** and into the **spermatophoric gland** which appears as a small sac with many intertwining circles within it. This gland adds substances to the sperm to make it into a spermatophore or sperm packet. From the gland the spermatophores exit to the seminal vesicle or **spermatophoric sac**, where they are stored. From here the spermatophores travel up the **penis** and out the genital opening into the mantle cavity.

Reproduction takes place as schools of squid come together in shallow water for mating. Males swim alongside the females and grasp them near their heads with their arms and hold them in close (refer to the video footage). The males then reach into their own mantle cavity with a modified arm (called the hectocotylus) scooping up a sperm packet and placing it within the mantle cavity of the female. The sperm fertilizes the eggs and after the nidamental glands add their protective coating, the eggs are laid in packets of about 180 - 300 eggs, each packet about the size of your index finger and then glued to plants or rocks on the bottom. Each female lays up to 20 capsules per day for 3 days. Both the males and females die after mating. The young hatch in about 1 month and are about 1/10th of an inch long. They look just like small adults at this time.

2. **Digestive System**

The digestive system starts with the beak and radula within the buccal mass and then continues down through the esophagus (all of which we have already seen) to the stomach. The **stomach** is an oval structure (sometimes difficult to find) about 1/2 inch long hooked to the side and near the top portion of the **caecum.** The caecum is located next to the gonads and both are about the same size and shape. The stomach is the major site for digestion and the caecum increases the surface area for digestion of food.

Waste products leave the caecum by way of the **rectum** or **intestine**, a long tube emptying out through the **anus**. The anus opens up into the siphon so as water is released in jet propulsion, the waste products are also jettisoned out of the body.

3. The siphon can be pointed in different directions by the **siphon retractor muscles.** These muscles, along with cephalic retractor muscles are located up near the siphon and feel like strong tendons - a much different consistency from the rest of the squid's soft body. These muscles are situated on each side of the diffuse, yellowish **liver** which provides digestive enzymes to the stomach and caecum.

4. **Ink sac**

The **ink sac** is located on the rectum and looks much like a small silver fish or sometimes like a thin black line depending on how much ink is located within the sac. Have the students carefully remove the ink sac by snipping both ends. ***Warn the students to be very careful not to puncture or cut the ink sac itself because the ink is very messy and will flow out over the organs making it difficult to distinguish all of the parts of the squid.*** Have the students place the ink sac on the paper plate where they can cut it in half with the scissors.

The function of the ink is to camouflage the squid when it is being chased by a predator. The black ink is jettisoned out the siphon at the predator and acts as a smoke screen to camouflage the direction of the squid's escape or as a squid shaped blob that acts as a decoy to confuse the predator. The ink is also thought to anesthetize the predators olfactory sense which makes it more difficult to follow the squid in pursuit. You can pierce an ink sac and place it in the small jar of water to watch how it diffuses through the water. Don't use one of the students ink sacs because they will want to use their ink to write with later. The ink is the pigment melanin which artist's call sepia ink.

5. **Respiratory and Circulatory System**

The **gills** are two white, feathery structures located within the mantle cavity and surrounded by water from which they remove oxygen. The muscular movements used in filling and emptying the mantle for locomotion serve to aerate the gills. At the base of each gill is a **branchial heart** (also called the gill heart) which pumps the blood from the body up to the gills to be oxygenated. These are the auricles. Each of these hearts is quite small and slightly yellowish in color. ***The hearts are more difficult to see in the females because the nidamental gland overlays them (this gland may be removed in the females if so desired)***. Squid actually have three hearts! The third heart is larger and located between the two branchial hearts. This is called the **systemic heart** and pumps oxygenated blood from the gills to the rest of the body. This is the ventricle. The blood contains the oxygen carrier hemocyanin which is blue when oxygenated and colorless when without oxygen.

6. The squid is supported as it speeds through the water by a chitinous structure called a **pen**. This structure is a remnant of the shell which supports and protects other molluscs, such as the chambered nautilus and clams. The pen is located underneath all of the organs we have been investigating. To

locate the pen, lift up the head and place it down over the top of the organs of the body. Underneath where the head was lying on the plate, you will now notice a pointed area touching the plate right along the midline of the body. This is the tip of the pen. Grasp hold of this tip and start to pull, thereby sliding the pen out from the mantle. The pen is as long as the length of the mantle and shaped like a transparent feather. (The pen looks much like a thin piece of clear plastic). Have the students use this "pen" to write their name or initials with the ink from the ink sac.

Have students prepare the squid for cooking (see below) and as someone cooks the squid, you can continue on with the next part of the activity.

Preparation of the squid for eating:
Grasp the squid's head in one hand and pull it down over the body towards the pointed end. In this manner, most all of the internal organs will be pulled off in one piece. The gills will have to be removed separately, however. Now turn the mantle over and peel off all of the colored skin. You will now be left with the cleaned white mantle. The arms and tentacles are also eaten and are cut off between the mouth area and the eyes keeping all of the tentacles-arms joined in one large ring. Students may keep the pen and the lenses of the eye, **however discard all other internal organs**.

Have students place the cleaned mantle and the tentacles on the clean plate and have someone collect all of the cleaned squid. Have another student discard all of the internal organs on the dirty plates into a plastic bag.
All students can now wash their hands and clean off their tables.

For the Cook:
Wash off the mantle and tentacles with plenty of water and pat dry. Slice the mantle crosswise into strips about 1/2 inch wide and place into a bowl with the prepared tempura batter (follow the directions on the box).

Fry the squid for about 30 seconds until it is just browned (if it is cooked too long, it becomes rubbery). Drain on a paper towel and serve.

After the Dissection
Have students complete the last squid chart, "What we Learned" taking turns drawing in parts of the squid. These can be parts the students choose or ones you request they draw based upon a hint about the function of that part.

Watch the video again having students take turns narrating what they know to be happening in each scene, pointing out parts of the body and how it is using it to be successful.

Revisit the Anticipatory Charts and "Think Pair Share" again. As a whole class decide if there are any answers they would like to change. Complete column 3 of Anticipatory Chart #2.

Assessment
Distribute the student worksheets and have the students fill in as many of the blanks as they can. Be sure to keep all of the charts and information up around the room so they can be used as references.

Have students do "Tape Recorder Dyads" reporting on what their partner tells them about: "Everything you know about parts of the squid" and then trade places and have the other student report on "Everything you know about behavior of the squid".

Think Pair Share of Anticipatory Charts revisited.

Observation of Checking for Understanding

BEYOND
THE ACTIVITIES

Research how squid are caught by different countries and where the major fishing grounds are located. ***(Reprint available from National Marine Fisheries Service, Southwest Fisheries Center, Tiburon Lab, Tiburon, CA 94920)***

Collect and try squid recipes from many different cultures.

WHAT IF? How would squid need to change in order to adapt to a benthic existence? to a planktonic existence? Have any relatives of the squid done this?

Learn about the different species of squid including vampire and giant squid.

Write a story or myth about a giant squid using what you know about the market squid or any research you have done on the giants.

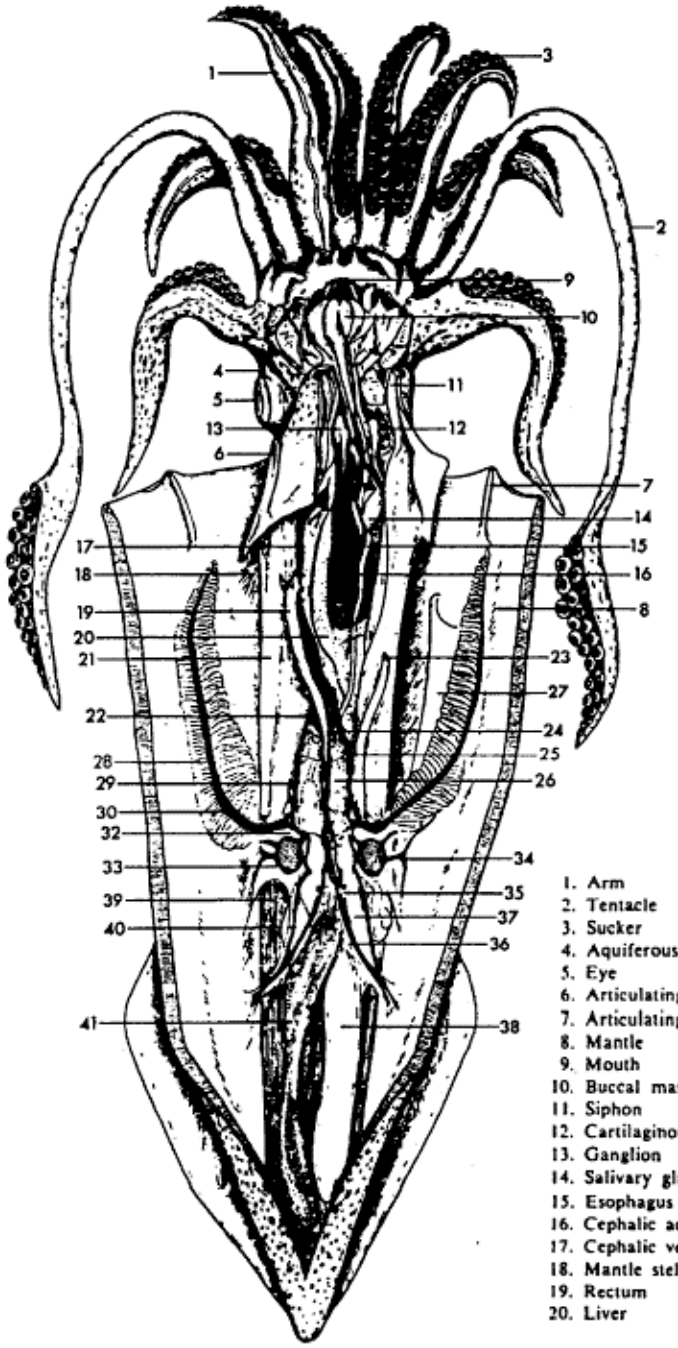
If there were giant squid in the numbers of these market squid, predict what the ocean would be like for other animals and for people? Do we know for sure that there aren't that many? Why or why not? How do scientists find out information about giant squid? How would your students? If they saw a giant squid, what do they think it would be doing. Describe some of its behaviors.

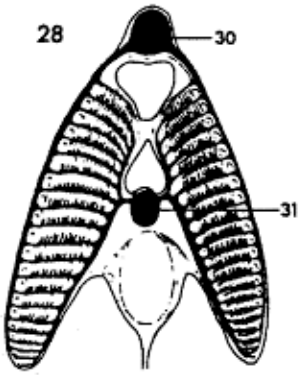
Have students debrief their favorite/least favorite part of the activity. What did they learn the most from? What was a waste of time? How would they change

the activity if they were the teacher? Would they like to do more dissections or could they have learned enough from the other parts of this activity?

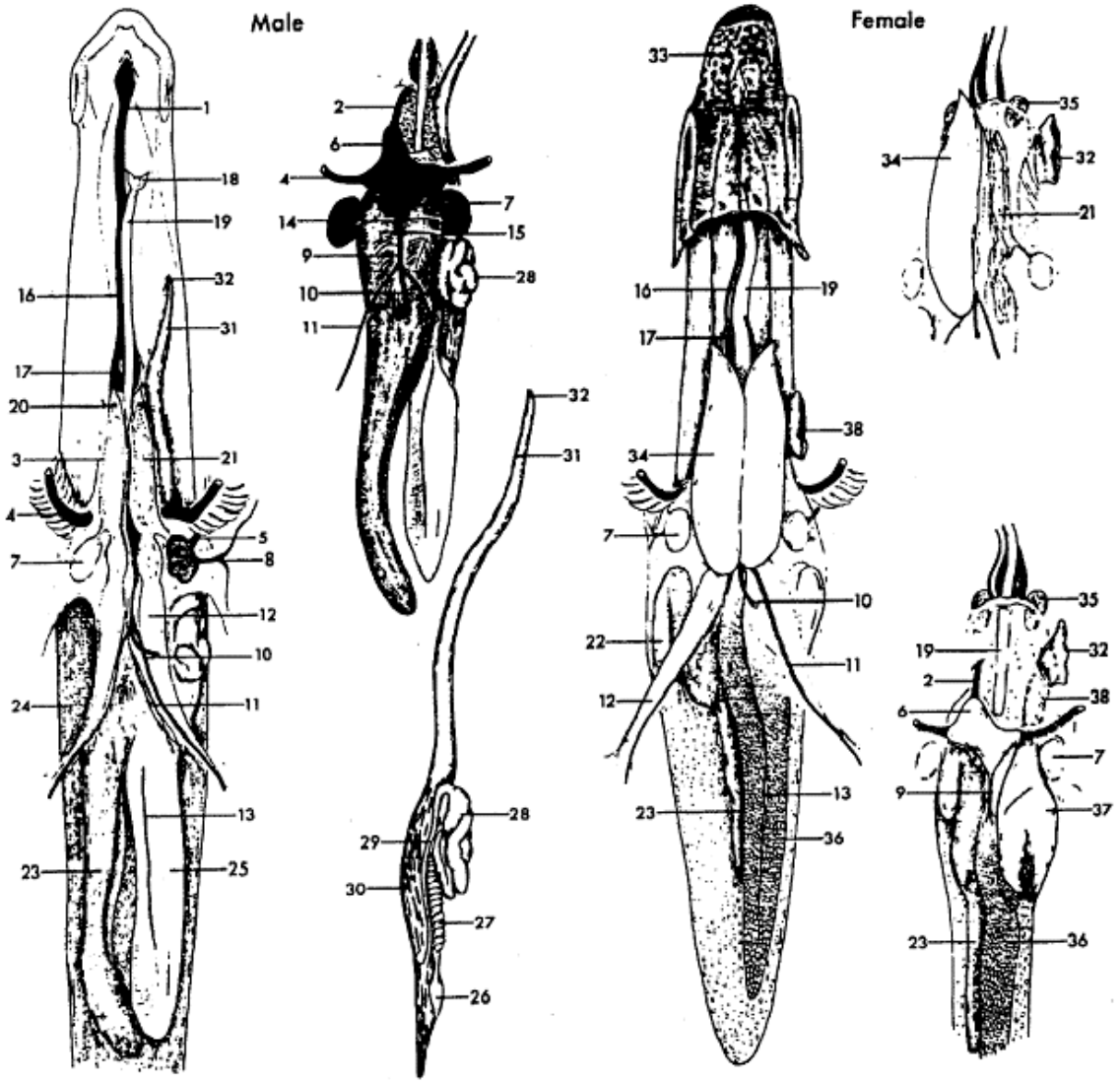
Have your students teach the activity to another grade level or another 5th grade class- be sure to have them include the parts they think helped most with the learning process.

Compare squids and humans. How are they alike? different? Use words or pictures and label the drawings.

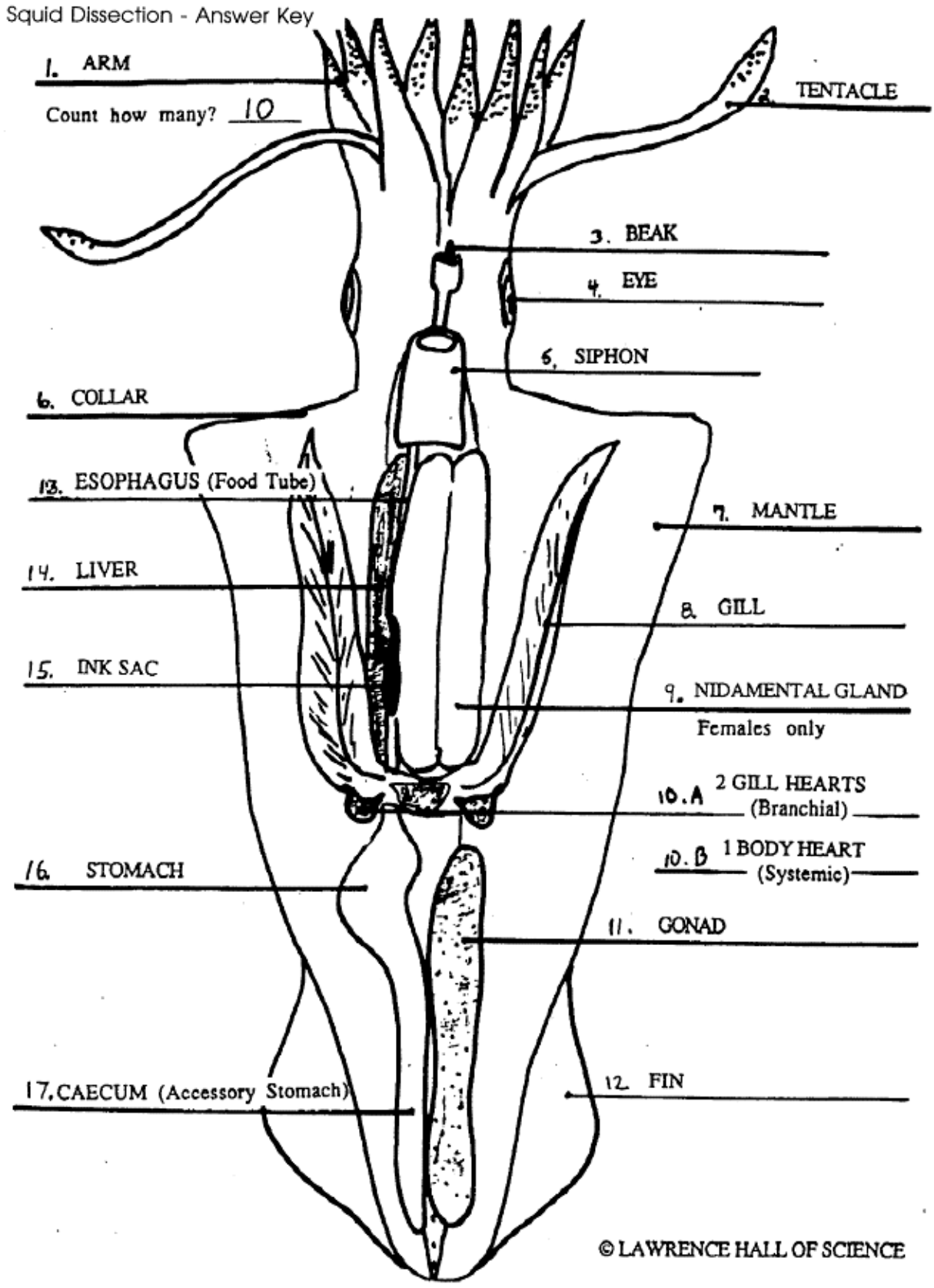




1. Arm
2. Tentacle
3. Sucker
4. Aquiferous pore
5. Eye
6. Articulating cartilage
7. Articulating ridge
8. Mantle
9. Mouth
10. Buccal mass
11. Siphon
12. Cartilaginous body (skull)
13. Ganglion
14. Salivary gland
15. Esophagus
16. Cephalic aorta
17. Cephalic vena cava
18. Mantle stellate ganglion
19. Rectum
20. Liver
21. Siphon retractor muscle
22. Ink sac
23. Genital opening
24. Nephridiopore
25. Kidney
26. Pancreas
27. Gill-mantle membrane
28. Gill
29. Vena cava (nephridial)
30. Efferent branchial vein
31. Afferent branchial artery
32. Systemic heart
33. Branchial heart
34. Median mantle vein
35. Medial mantle artery
36. Lateral mantle artery
37. Posterior vena cava
38. Gonad
39. Pen
40. Stomach
41. Caecum



1. Cephalic vena cava
2. Cephalic aorta
3. Nephridial portion of vena cava
4. Efferent branchial vein
5. Afferent branchial artery
6. Systemic heart
7. Branchial heart
8. Median mantle vein
9. Posterior aorta
10. Medial mantle artery
11. Lateral mantle artery
12. Posterior vena cava
13. Genital artery and vein
14. Artery to branchial heart
15. Artery to gonoduct
16. Ink duct
17. Ink sac
18. Rectal papilla
19. Rectum
20. Nephridiopore
21. Kidney
22. Stomach
23. Caecum
24. Pen
25. Testis
26. Sperm bulb
27. Vas deferens
28. Spermatophoric gland
29. Spermatophoric duct
30. Spermatophoric sac
31. Penis
32. Genital opening
33. Siphon
34. Nidamental gland
35. Accessory nidamental gland
36. Ovary
37. Oviducal gland
38. Oviduct



Squid Dissection