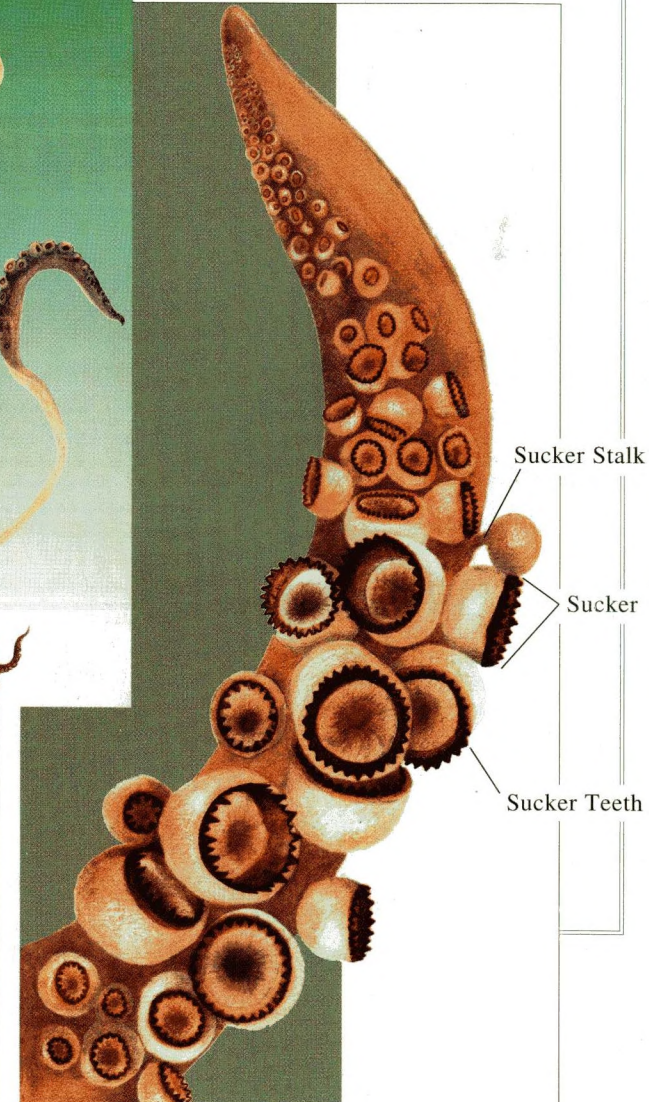


An Illustrated
Mini Dissection Guide
To The...

Squid



by David H. Hall
and Peter Reinthal

Figure 3. Underside of a tentacle...

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Illustrated by Glen Folsom
Cover designed by
Omer Claiborne

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Squid

A small school of mackerel swim together as they migrate to new feeding grounds. Suddenly from above and below, torpedo shaped animals jet among the fish and strike. The mackerel quickly scatter in different directions and in seconds the attack is over. In the end, two of the fish have been captured by a pair of squid which quickly subdue them with a poisonous bite. Squid are swift and agile marine predators that are, in turn, preyed upon by larger predators such as whales. Squid have well developed eyes and a brain with the capacity to learn. They are the epitome of mollusc development and to the uneducated it is hard to believe that snails and clams are related to this hunter of the deep.

For this dissection the student will need:

- 1 squid specimen
- 1 dissection tray with a pinning substrate
- 1 dissection scissors
- 6 - 8 T-pins
- 1 magnifying glass or dissection microscope

Squid belong to the class of molluscs called Cephalopoda. This class also contains the octopuses and nautiloids. Cephalopods represent the most advanced group of the phylum Mollusca. Molluscs are the first group to have a true coelomic body cavity. The shared characteristics of squid with other mollusc groups are not at all readily apparent because of the advanced cephalopod features. All molluscs, however, share the following body features.

1. An unsegmented body that is bilaterally symmetric with a reduced or absent body cavity and a specialized muscular foot.
2. Body covered by a thin tissue layer fold of the dorsal wall called the mantle (or pallium). The mantle secretes the exoskeleton or the shell (which may be well developed as found in clams, reduced as found in squid, or, totally absent as in octopuses).
3. An open circulatory system with a well developed pumping heart consisting of one or two atria and one ventricle.
4. Presence of a radula, a rasp-like organ used for food scraping in snails and food manipulation in squid. Molluscs that are bivalves, such as clams, do not have a radula.

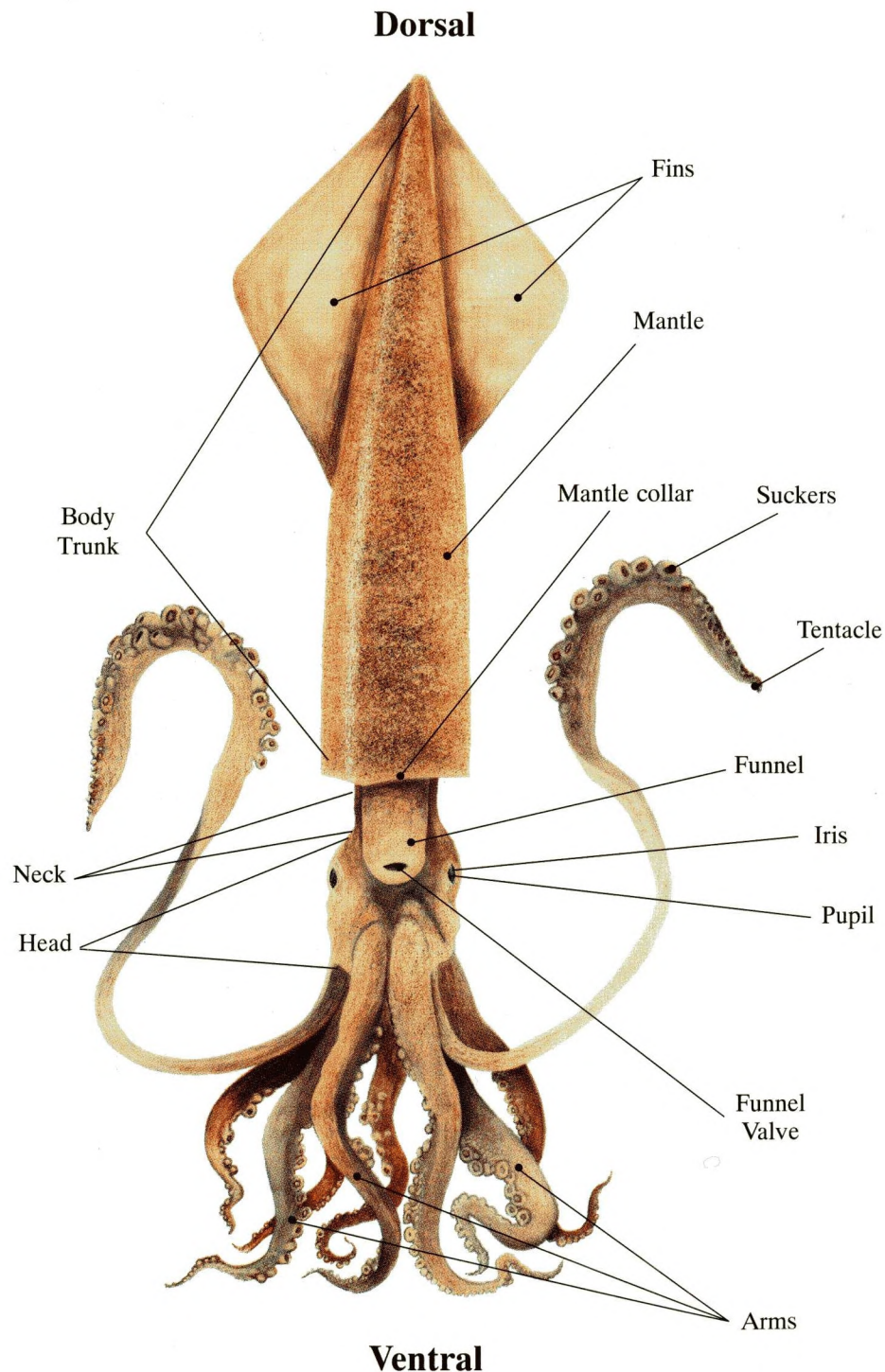


Figure 1. External anatomy of the squid. View of posterior side.

Cephalopods are characterized by possessing the following advanced features:

1. Distinct head with large well-developed eyes and well developed brain.
2. Head projects into a crown or group of flexible, well muscled, arms.
3. Mouth with well developed jaws and a hard parrot-like beak for tearing off food pieces.
4. All are active, quick, predators that are found only in marine habitats.
5. All cephalopods can swim rapidly by expelling water from their mantle cavity.

External Anatomy

Position your squid specimen on your dissection tray so that it is in the position shown in Figure 1 where the funnel is on top. This is the posterior view of the squid based on morphology. Note how the squid is divided into three regions, the head, neck, and body trunk. Find and identify the body features listed in Figure 1 on your specimen.

Arms: there are four pairs (eight) arms on the squid. Note the two rows of stalked suckers which line the underside of each arm. Arms manipulate and hold food while it is being eaten. In males, the fourth arm is used for the transfer of spermatophores.

Tentacles: these are two (one pair) long appendages with suckers restricted to pads on the distal ends. Tentacles are used to grasp prey and pull it to the arms. Tentacles are a modification of the foot found in other molluscs.

Mouth (Figure 2): the mouth is located in the center of the circle of arms. You will have to spread the arms apart in order to view the mouth. Note the hard horny jaws of the squid beak which are used to tear off pieces of food for swallowing. The mouth is surrounded by the peristomial membrane that is surrounded by a buccal membrane. The buccal membrane has projections with suckers on them.

Eye: Squid possess very advanced eyes which are more similar to vertebrate eyes than they are to any invertebrate eye. Note the black pupil and light colored iris. The squid eye is discussed in more detail later in this text.

Funnel: This muscular tube extends out from the mantle collar. The funnel directs water that is expelled from the mantle cavity. Water is expelled with such force that the squid can propel itself with jets of water. In addition, the funnel is flexible and can be aimed in a wide array of directions. If the funnel is directed backward the squid is propelled forward. Conversely the squid is propelled backward when the funnel is directed forward. Wastes and ink are also expelled through the funnel valve.

Mantle: A thick cone of muscular tissue which covers and protects the visceral mass and mantle cavity. At the apex or tip of the mantle are two fins the squid uses for swimming. Currents of water enter the mantle cavity through the mantle collar.

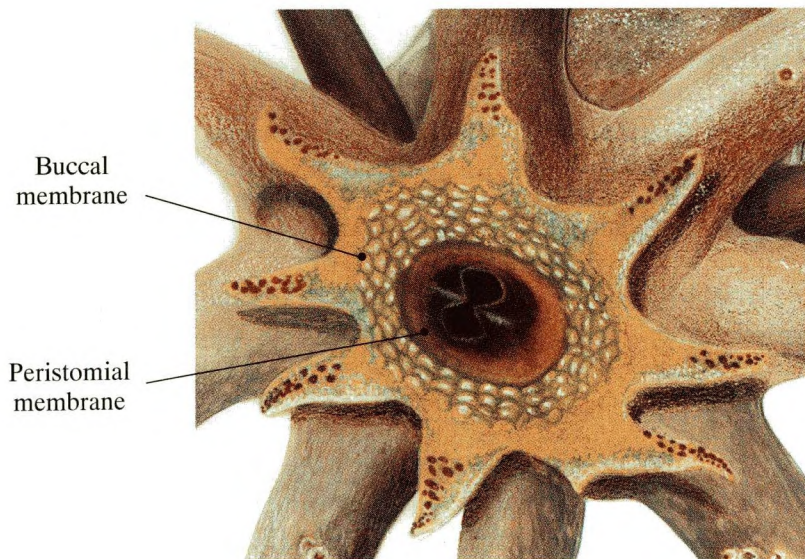


Figure 2. The mouth and beak.

Suckers

Take a tentacle of your squid and pin it to the dissection tray bottom so that you can examine the suckers with a hand lens or dissecting microscope. Compare your specimens tentacles with Figure 3. Note how each sucker has a set of teeth. These teeth grab the skin of prey or attach on an object and by pulling with the arms a suction is created. This suction aids in holding the object. The stalk connects the sucker to the tentacle or arm. It is flexible and muscular which aids in securing prey.

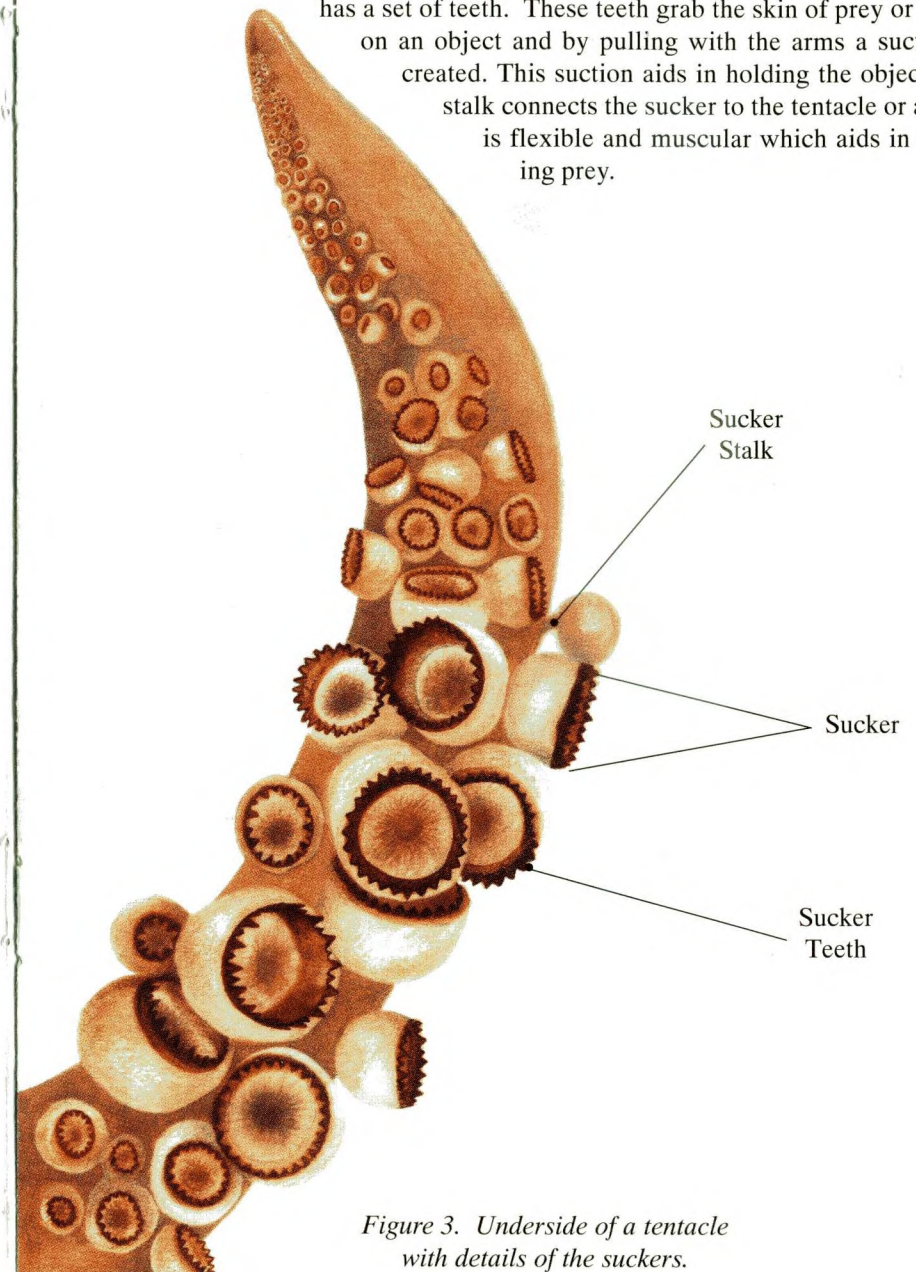


Figure 3. Underside of a tentacle with details of the suckers.

Internal Anatomy

In order to reveal the internal organs, an incision through the posterior view of the mantle must be made. This reveals the organs of the visceral mass. The incision should be made from the base of the funnel to the apex, or tip, of the mantle (see Figure 4). Use a pair of dissection scissors with one blunt tip in order to prevent cutting any of the internal organs. Use a dissection tray in order to pin down the two mantle flaps on either side of the visceral mass. Compare your specimen with the one illustrated in Figure 5. Find and familiarize yourself with the organs identified and listed below:

Esophagus: This muscular tube transports food from the mouth through the liver and pancreas to the stomach by muscle contraction. Look at the mouth for the chitinous jaws and find the tongue-shaped cartilage with the radula.

Anus and Rectum: The rectum collects food wastes from the intestine, compacts them and expels them via the anus. The fecal mass is expelled with water out through the funnel.

Intestine: The intestine is located in the upper end of the rectum.

Ink Sack: Located underneath the intestine, this dark pouch holds a quantity of ink which the squid can release into the surrounding water to obscure itself and escape from enemies.

Kidneys: Two small whitish triangular organs located on either side of the upper intestine.

Gills: Two feather shaped gills are located on each side of the body interior. The afferent and efferent vessels transport blood to and from the gills.

Branchial Hearts: One of these hearts is located at the top end of each gill. They are round circular organs which pump blood into the gills.

Anterior Aorta: Located in between each kidney, this vessel carries blood from the heart to the anterior body regions and head.

Systemic Heart: Located between each branchial heart.

Posterior Vena Cavalas: These triangular shaped vessels are rather large and dark colored. They carry collected blood from the posterior body regions into the branchial hearts.

Posterior Aorta: This vessel is located directly behind the systemic heart.

Stomach: This large round organ lies between the two mantle arteries.

Gonad: Usually filling the entire posterior mantle cavity, this whitish organ is filled with reproductive materials. Squid for dissection are generally caught during the reproductive season resulting in the large size of this organ.

Cecum: This yellowish organ is found underneath the gonad and stomach. It is a digestive organ directly connected to the stomach.

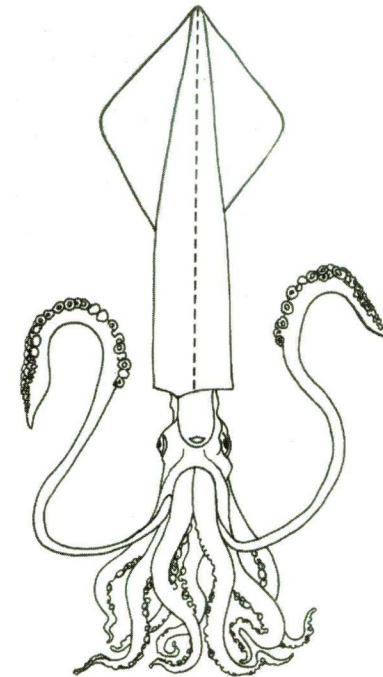


Figure 4. Make an incision as shown (dotted line) on your specimen.

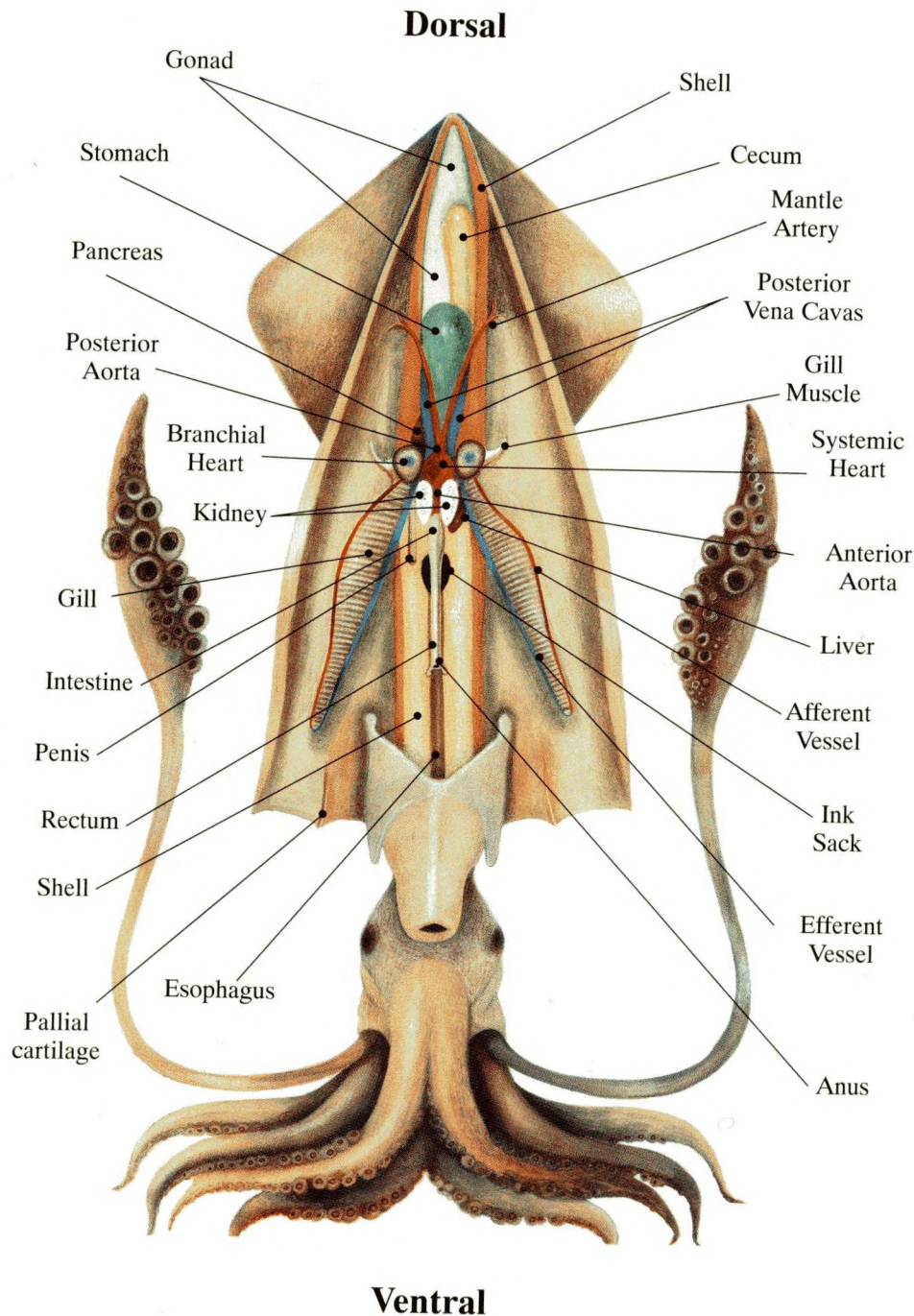


Figure 5. Interior anatomy of the squid (posterior).

Circulatory System

The squid has a well developed closed circulatory system. It includes a vast capillary system that reaches all body tissues. In addition, the vessels are lined with epithelial tissue throughout. This circulation system allows for rapid replenishment of nutrients and gas exchange that the squid requires for its active predatory existence. The blood pumping system of the squid consists of three separate hearts, the systemic heart and two gill hearts. Blood returning from the body tissues is pumped into the gills by the gill hearts. This forces the blood under high pressure into the thin capillaries of the gill by the mantle muscles. Gas exchange, carbon dioxide passing into the water and oxygen passing into the blood, occurs here. Oxygenated blood is collected and passed to the systemic heart, where it is pumped to body tissues via the arterial system.

Digestive System

Food is bitten off into pieces by the parrot-like beak in the buccal cavity. One pair of salivary glands produces digestive enzymes and mucus, the other pair produces a poison. This poison flows into bitten prey and subdues it. Food is mixed with saliva and is passed to the stomach by a long esophagus. The stomach is a very muscular organ that kneads the food with digestive secretions produced by the pancreas and liver. After the food has been mixed and kneaded, it passes into the cecal sac. Here the digested food particles are sorted from non-digestible particles. The digestible items are absorbed through the cecal walls. The non-digestible waste is returned to the stomach where it is passed into the intestine. Some absorption takes place in the intestine before the waste is expelled through the anus and out the funnel. The digestive modifications found in the squid are adaptations for rapid digestion of food that supports the squids' active carnivorous existence.

Excretion

There are two compact, sac-like kidneys in the squid. The kidneys are enclosed in a sac that also includes the pancreas. Through the middle of each kidney is a large systemic vein that leads to one of the gill hearts. The interface of the kidney with this vein is where waste is transferred from the blood. The waste is primarily ammonia and is excreted into the mantle cavity through the renopericardial canal. There is no bladder and the waste passes out of the squid with water being expelled out through the mantle funnel.

Nervous System

Squid have a highly developed nervous system, the complexity of which is attained only in a few invertebrate groups such as bees and spiders. The squid brain is composed of the typical molluscan ganglia that have fused and concentrated together to form a rather large brain mass. The brain is segregated into various ganglion regions that encircle the esophagus (Figure 6). These ganglia regions are so well differentiated that scientists have been able to distinguish various centers responsible for various functions. For example feeding, swimming, and sucker control is all under the direction of the cerebral ganglion. This region is also the largest and most prominent of the brain regions.

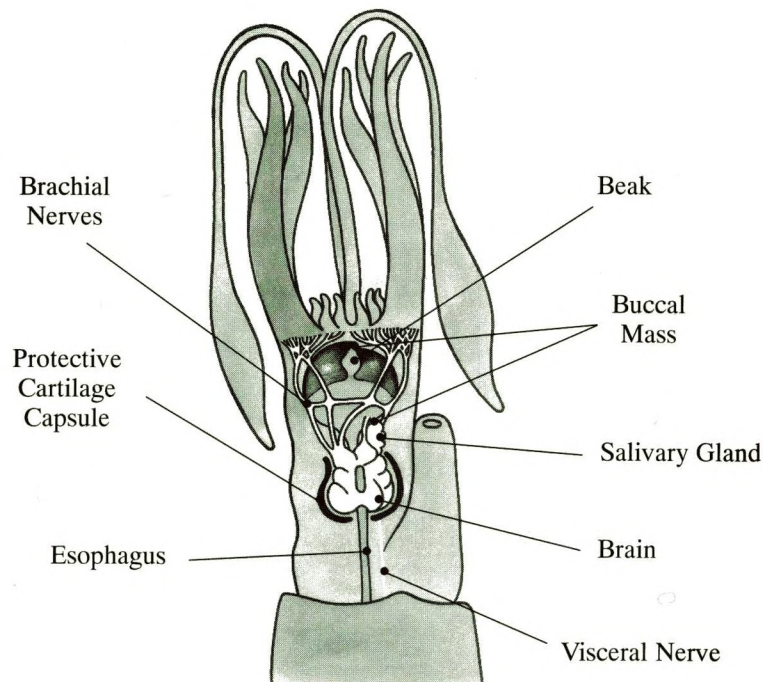


Figure 6. Cross section of the squid buccal mass and brain.

Other brain regions include the brachial ganglion that receives nerve inputs from the arms and tentacles, the visceral ganglion that receives and processes input from body organs and the pedal ganglion. The optic nerves from both eyes are also very large and serve as conduits to the cerebral ganglion for optical input. The long nerves of the mantle form giant neurons that are so large they are used extensively by scientists to study nerve function. Experiments with squid have demonstrated that they have a surprising amount of learning ability that is unique to the invertebrates. This learning is credited to their possession of a sophisticated brain. The brain is protected with a cartilage "skull" or capsule.

The eyes of the squid are also highly developed. Squid possess eyes that are similar to vertebrate eyes where a single transparent lens is used to focus light onto a light sensitive retina. The focus can be rapidly controlled by ciliary muscles that move the lens back and forth (a system also found in some vertebrates). The eyes are surrounded and protected by a series of cartilage plates that form a protective capsule. External muscles attached to the eye provide movement. Squid eyes and vertebrate eyes are an often cited example of convergent evolution.

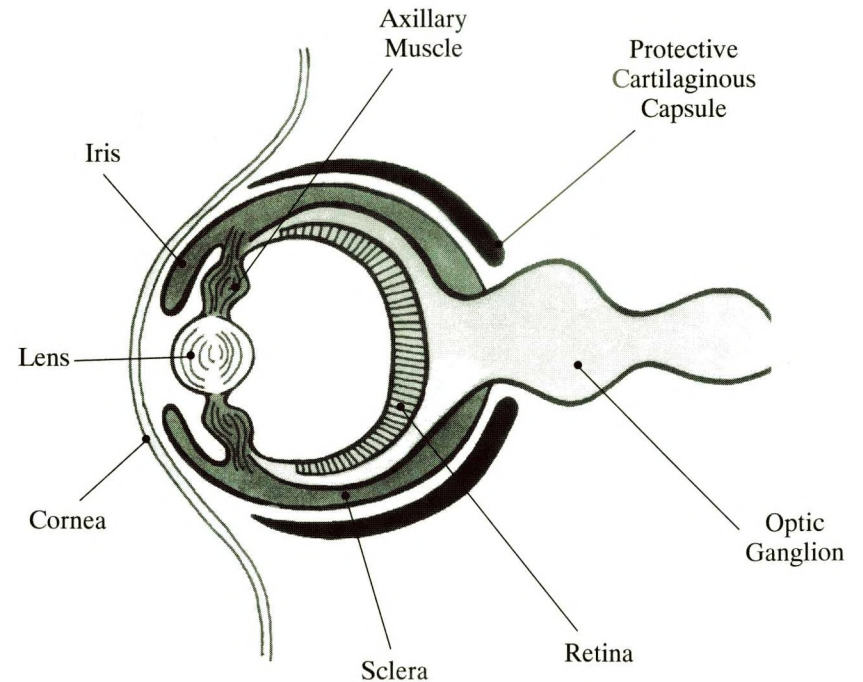


Figure 7. Cross section revealing the interior anatomy of the squid eye.