NAME: _____ PER: _____ DATE: _____

SQUID DISSECTION: ALTERNATE ACTIVITY

Directions: Complete the following activities:

1. Complete the computer activities for the squid from the *BioLab Invertebrate* CD-ROM.
2. Read and complete the attached squid coloring sheet
3. Complete the squid crossword puzzle.
4. Complete the attached squid test.

All materials are to be handed in with other students' materials.

MOLLUSCAN DIVERSITY: SQUID AND OCTOPUS

The squid and the octopus are two highly developed members of the class Cephalopoda. While the chambered nautilus relies on the ancestral molluscan shell for protection and buoyancy, the squid has only a thin shell remnant within its mantle, and the octopus has lost the shell entirely.

Begin by coloring the large illustration of the squid.

The muscular *mantle* of the squid and the mantle cavity it houses are strengthened by an outer collagen sheath that maintains the mantle's shape and size. The squid swims by inflating its mantle cavity with water and forcing it out through the *funnel* in a jet-propulsion fashion. Normally the squid swims backwards, and its tapered body and broad, stabilizing *fins* make the squid a highly effective swimmer. Over short distances, squids are among the most rapidly moving of all marine organisms. Large squids can attain speeds of 24–32 kilometers (15–20 miles) per hour.

Squids may also swim forward by directing the moveable funnel posteriorly. When swimming forward, the squid extends its eight *arms* together like the streamlined prow of a ship to allow it to move smoothly through the water. Squids are also capable of hovering motionless in the water or sculling along slowly by undulating their fins. The combination of jet propulsion and fin undulation allows the squids to be highly maneuverable and very graceful in their movements. Many species of squid swim in schools, and their synchronized movement, and tight, rapid turns further attest to their superior swimming prowess.

Color the enlargement of the front view of the squid and the drawing of the beak. Also color the enlargement of the suckers, showing their shape and relative size.

Its swimming ability, coupled with its image-forming *eyes*, gives the squid great advantage as a predator. It can swim into a school of fish and quickly capture one with its long, sucker-tipped *tentacles*. The fish is dispatched with a bite behind the head from the *beak* of the squid. The beak is located in the center of the circle of arms, protruding from the mouth. The squid cuts its prey into small pieces with the beak and then pulls them into its mouth with its radula (not shown).

Located on the arms are stalked, adhesive discs, or *suckers* (see circled enlargement), which, in some species, are reinforced by horny rings or hooks. Contraction of the muscles attached to each sucker creates suction when the suckers come in contact with something solid. The tentacles, twice as long as the arms, have suckers only on their flattened ends.

Color both illustrations of the octopus. Note that the beak is not shown here.

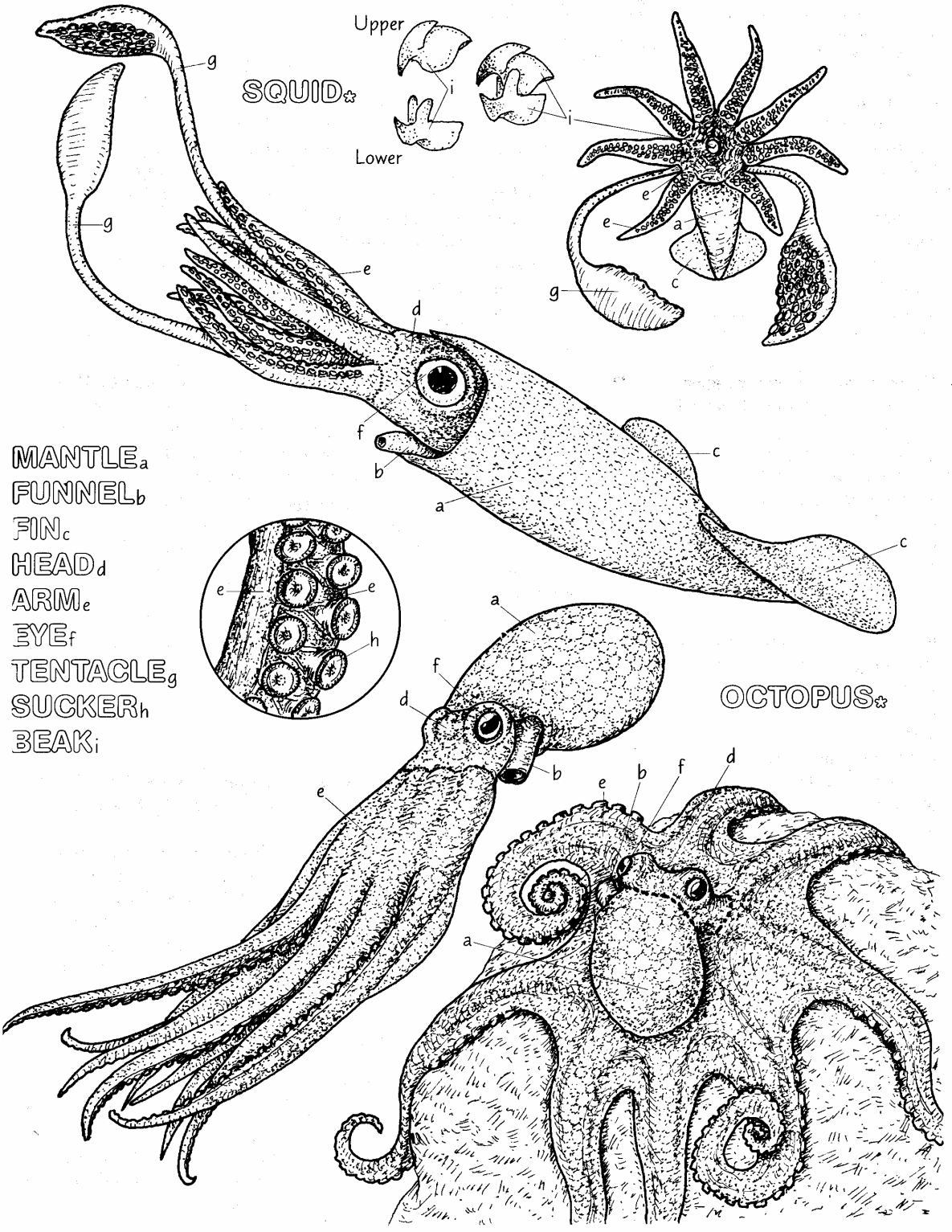
The octopus does not normally swim about in the water. It will swim however, if threatened. It swims with its bag-like mantle held in the direction of movement, and its head and eight arms trailing behind. The funnel is directed rearward and the octopus moves in typical cephalopod fashion, propelled by inflating the mantle cavity with water and forcing it out the funnel in a propulsive jet.

The octopus lacks the streamlining that makes the squid such a successful swimmer; it prefers to remain in contact with a solid structure, pulling and pushing itself along using the suckers on its arms. It moves with a nimble quickness.

In most octopus species there are about 240 suckers on each arm, usually arranged in double rows. The suckers lack the stalk, the horny rims, and the hooks possessed by the squid. Octopus suckers vary in size from a few millimeters to 7 cm (2.75 in) in diameter. This range in sucker size provides the octopus with impressive dexterity, allowing it to manipulate even small objects with precision. A sucker 2 cm (0.75 in) in diameter requires a pull of 170 g (6 oz) to break its hold, so one can imagine the strength it would take to break the hold of two thousand suckers!

The octopus is generally a solitary dweller and seeks shelter or a permanent den in a cave or under rocks (Plate 104).

SQUID AND OCTOPUS



SQUID: I EXTERNAL STRUCTURE

Color A through G and their related titles. Then read below.

Understanding the orientation (and the assignment of terms for such orientation) of the clam, and especially the squid and octopus, can be perplexing. This confusion is largely created by the significant modifications seen in the ventral surfaces of these molluscs. You have repeatedly colored bilaterally symmetrical animals in which the dorsal surface is above; the ventral surface is below; the anterior surface is in front; and the posterior surface is in back (when the animal is positioned upright on a horizontal surface). Notice in the snail that some typical conditions exist: The head of the animal is *anterior* and the *foot* (which travels along the ground) is *ventral.*

The orientation of the clam is a bit more difficult to comprehend, as there is no recognizable head. However, the *foot* of the *clam* is embryologically the same structure as (homologous with) the *foot* of the *snail.* Thus, the side of the *clam* with the *foot* process is the *ventral surface,* and the opposite side is the *dorsal surface.* The clam moves forward by burrowing with its *foot* process so that the *anterior surface* relates to the front of the *foot,* which goes forward (and downward) during locomotion. The opposite *posterior surface* bears the siphons.

The orientation of the squid can be even more confusing. Some help comes from recognizing that the *arms* and *tentacles* of the *squid* are homologous, in part, with the *foot* of the *clam* and the *foot* of the *snail.* The tentacle side, then, would be the *ventral surface.* The *dorsal surface* would be at the opposite end. The problem is that the squid does not move forward and backward on its *tentacles* (like a *foot*). It moves along the *tentacle* axis, that is, dorsoventrally. This *locomotor axis (direction of movement)* is different (by 90°) from all other bilaterally symmetrical animals, whose *locomotor axis* is along the anterior-posterior axis. To differentiate the *anterior surface* from the *posterior surface* of the squid, it may be helpful to remember that the digestive tract terminates posteriorly in many animals, and the squid is no exception. Just as the excurrent siphon on the *posterior surface* of the *clam* conducts waste to the outside, so the siphon on the *posterior surface* of the squid conducts wastes to the outside.

Some zoologists consider the direction of movement or long axis of a bilaterally symmetrical animal as the definitive anterior-posterior axis, embryology notwithstanding. Thus, in some circles, the tentacle-fin axis of the squid is anterior-posterior. In many cases, the vessels and nerves running along the long axis of the squid are prefixed with anterior and/or posterior, that is, anterior aorta instead of ventral aorta.

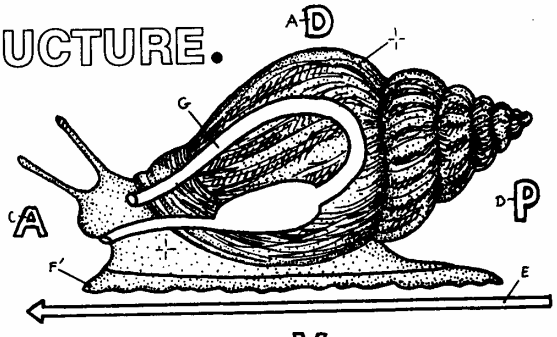
Color the external structures of the squid and related titles H through M. Note the unfilled squares with arrows pointing to the various surfaces of the squid. Fill in these squares with the appropriate color employed in the upper drawing A through D to reinforce learning the identification of surfaces of the squid. After coloring, read below.

The *head* region of the squid (here represented by *Loligo opalescens*) bears two *eyes* laterally and is continuous ventrally with eight short *arms* and two longer retractile *tentacles,* all of which surround the mouth. One surface of the *tentacles* bears suckers. One surface of the *arms* bears suckerlike adhesive discs.

The squid has no external shell. The vestige of the shell is represented by a flexible, flat stiffener or pen embedded in the upper or anterior aspect of the *body* wall. The *body* wall consists of a muscular mantle, the ventral boundary of which (collar) is fitted around the *head.* Water can flow into the mantle cavity under the collar (note arrows), circulate around the visceral mass, pass over the gills, and exit via the tubular *siphon* (arrow). The muscular *siphon* can be bent 180° and squirt water dorsally. The jet stream exiting from the *siphon* provides the main locomotor power of this animal.

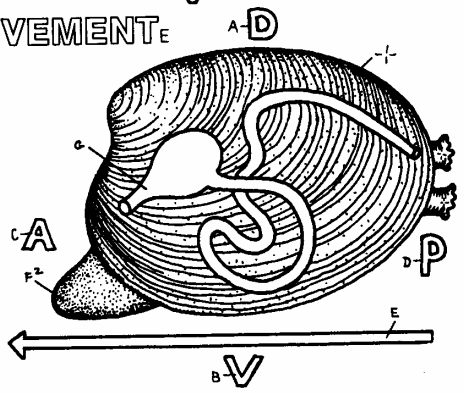
SQUID: I EXTERNAL STRUCTURE.

ORIENTATION OF SQUID BODY FORM TO OTHER MOLLUSCS★

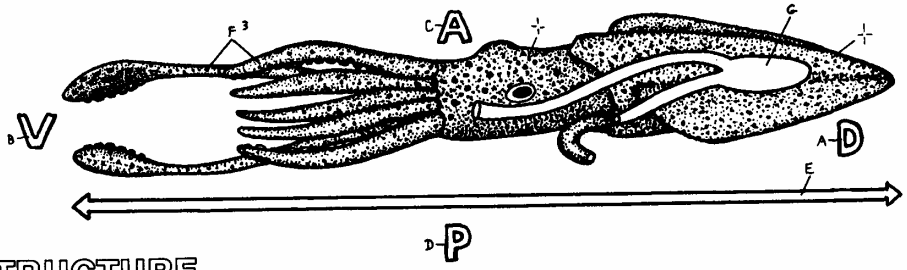


DORSAL SURFACE$_A$
VENTRAL SURFACE$_B$
ANTERIOR SURFACE$_C$
POSTERIOR SURFACE$_D$
LOCOMOTOR AXIS/DIRECTION OF MOVEMENT$_E$

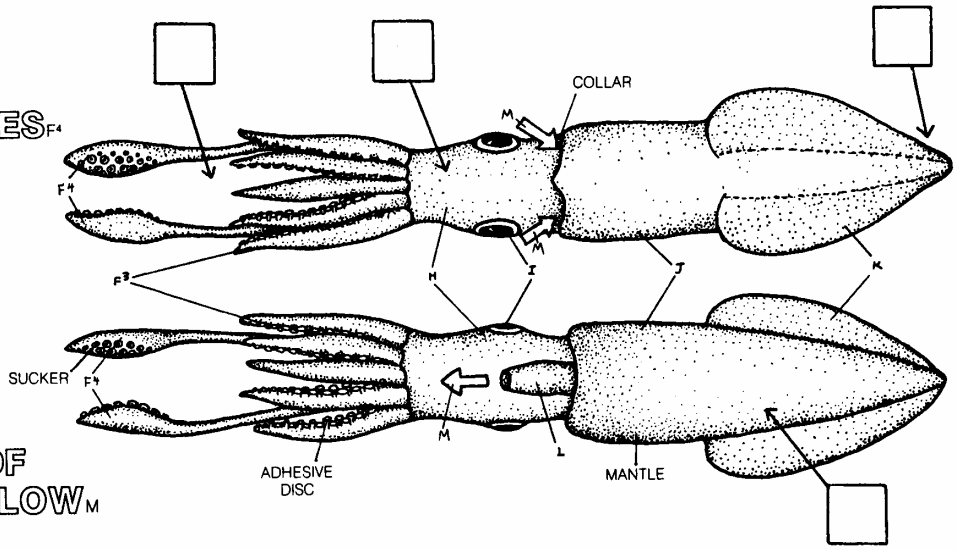
HOMOLOGOUS STRUCTURES$_F$
FOOT OF SNAIL$_{F1}$
FOOT OF CLAM$_{F2}$
TENTACLES/ARMS OF SQUID$_{F3}$



ORIENTATION OF DIGESTIVE TRACT$_G$



EXTERNAL STRUCTURE★
HEAD$_H$
EYES$_I$
ARMS$_{F3}$/ TENTACLES$_{F4}$
BODY$_J$
FIN$_K$
SIPHON$_L$



PATTERN OF WATER FLOW$_M$

SQUID: II INTERNAL STRUCTURE

Color the structures of the digestive system in the upper illustration. Then read below.

In the center of the base of the tentacles and arms is a *mouth* opening into a *buccal cavity.* Within this cavity are located two large, pincerlike *jaws* with pointed tips, and a tonguelike *radula.* These *jaws* are operated by powerful muscles and are used to bite and incise organisms brought to the *mouth.* Also opening into the *buccal cavity* are two pairs of *salivary glands* that secrete enzymes for initial digestion of captured prey. Macerated food is conducted backward through the long tubular *esophagus* to the *stomach.*

The *stomach* is a muscular sac from which projects (via a duct) a large diverticulum called the *cecum.* This structure fills the dorsal third of the visceral mass. Located in front of and below the *stomach* are two digestive glands: a large *liver* and a smaller *pancreas.* The *pancreatic duct* joins the *liver duct,* which proceeds backward to merge with the *duct* between the *stomach* and the *cecum.* Enzymatic secretions from the *liver* and from the *pancreas* pour into the *stomach* to assist in chemical digestion of the food. This, as well as the mechanical digestion created by the peristaltic activity in the muscular *stomach* wall, breaks down the food into absorbable units. Absorption of nutrients into the blood occurs in the *cecum.* Undigested residues and larger particles pass through the tubular *intestine* and are discharged through the *anus* to the mantle cavity, where it is washed out through the siphon.

An *ink sac* located just above the *intestine* secretes a highly pigmented fluid that is released (at a time of peril) through a *duct* into the *intestine* near the *anus* and out through the siphon. This ink may interfere with a predator's ability to find the squid, act as a decoy, or desensitize some of the predator's sensory receptors.

Color the circulatory system of the squid following the order of titles precisely so as to better understand the flow pattern of the circulation. The right gill and vena cavae and related vessels are not shown. After coloring, read below.

The circulatory system of the squid (and octopus) is probably the most elaborate of all invertebrate circulatory systems. It is a closed pattern in which there is a continuous network of vessels, and blood fluid leaves the circulation only by diffusion. This kind of pattern is associated with the high-speed, active life-style of the cephalopod, in contradistinction to the life-style of other molluscs and their distinctly different open circulatory patterns.

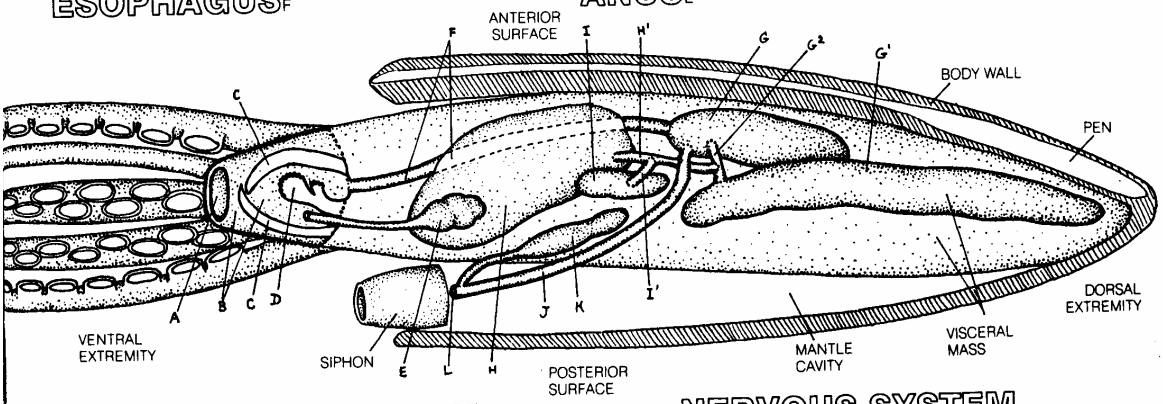
Blood is pumped to the front and back parts of the body from the *ventricle* of the *systemic heart* through the *ventral* and *dorsal aortas.* The *ventral aorta* conducts blood to the head region and tentacles. The *dorsal aorta* supplies the dorsal visceral mass and mantle. Many of the arterial branches *(brs.)* of these vessels are capable of rhythmic contractions. Blood reaches the tissues by diffusion from smaller capillary vessels. Unoxygenated blood is returned by tributaries *(trib.)* to two pairs of dilated *ventral* and *dorsal vena cavae* just below the *systemic heart (ventricle* and *auricles).* Blood is shunted to the *branchial heart* on each side (one shown here) via a short *lateral vena cava.* Each contractile *branchial heart* directs blood through the *afferent branchial vessels* within the gill (suspended in the mantle cavity), where gaseous exchange occurs. Oxygenated blood is collected by an *efferent branchial vessel* that conducts the blood to the *auricle* of the *systemic heart.*

Now color the structures of the nervous system and read below.

The brain consists of paired *cerebral ganglia,* two *pedal ganglia* located on either side of the esophagus below the *cerebral ganglion,* two *brachial ganglia* extending forward toward the head from the *pedal ganglion,* a pair of *visceral ganglia* located immediately behind the *cerebral* and *pedal ganglia,* and a pair of *stellate ganglia* supplying motor nerves to the mantle. The *cerebral ganglion* is the overall control center of the brain; yet each of the subordinate ganglia has its own control function. *Cerebral ganglia* receive *optic nerves,* which conduct visual impulses from the large eyes of the squid. The *pedal ganglia* give motor nerves to the muscular siphon. The *brachial ganglia* supply nerves to the muscular tentacles and arms. The *visceral ganglia* give nerves to the visceral structures, nerves to the gills via branchial glanglia (not shown), and a connective of nerves to the *stellate ganglia* in the mantle. These *ganglia* send nerves (some of them giant axons) to the mantle muscles so important in locomotion and respiration. When water is drawn into the mantle cavity through the collar, it is forced out through the siphon in a complex and coordinated series of mantle muscle contractions that begin dorsally and progress ventrally.

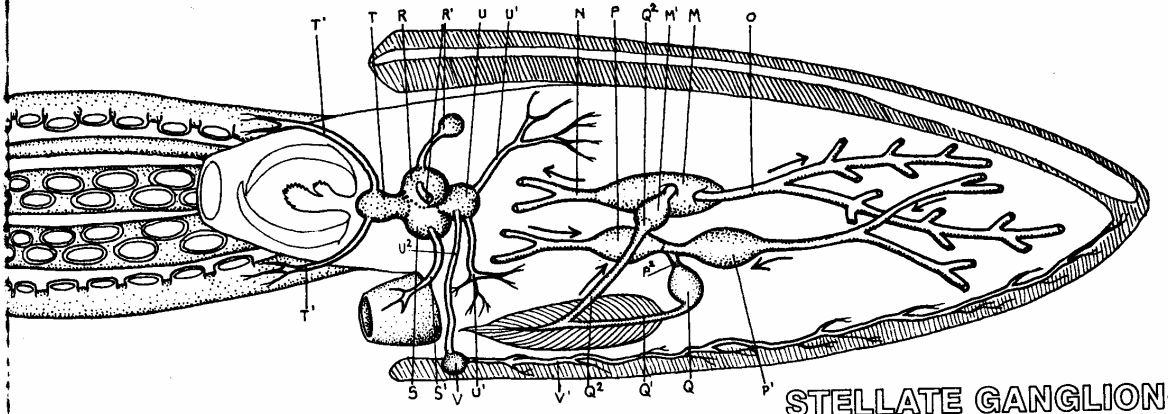
SQUID: II INTERNAL STRUCTURE.

DIGESTIVE SYSTEM ★
MOUTH$_A$
BUCCAL CAVITY$_B$
JAW$_C$
RADULA$_D$
SALIVARY GLAND/DUCT$_E$
ESOPHAGUS$_F$
STOMACH$_G$
CECUM$_{G'}$/DUCT$_{G^2}$
LIVER$_H$/DUCT$_{H'}$
PANCREAS/DUCT$_{I'}$
INTESTINE$_J$
INK SAC/DUCT$_K$
ANUS$_L$



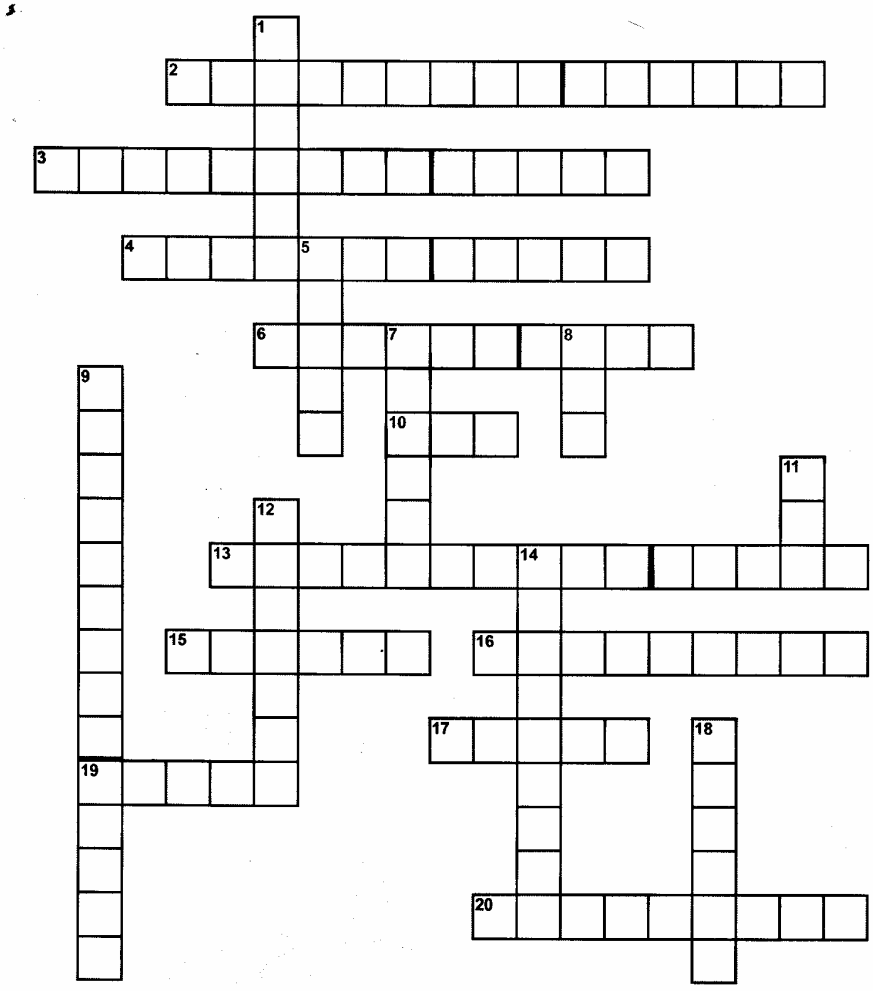
CIRCULATORY SYSTEM ★
VENTRICLE (SYS. HEART)$_M$
VENTRAL AORTA/BRS.$_N$
DORSAL AORTA/BRS.$_O$
VENT./DORS. VENA CAVA/TRIB.$_{P, P'}$
LATERAL VENA CAVA$_{P^2}$
BRANCHIAL HEART$_Q$
AFF. BRANCHIAL VESSEL$_{Q'}$
EFF. BRANCHIAL VESSEL$_{Q^2}$
AURICLE (SYS. HEART)$_{M'}$

NERVOUS SYSTEM ★
BRAIN ★
CEREBRAL GANGLION$_R$
OPTIC NERVE$_{R'}$
PEDAL GANGLION$_S$
N. TO SIPHON$_{S'}$
BRACHIAL GANGLION$_T$
N. TO TENTACLE$_{T'}$
VISCERAL GANGLION$_U$
N. TO VISCERA$_{U'}$
CONNECTIVE$_{U^2}$



STELLATE GANGLION$_V$
N. TO MANTLE$_{V'}$

Invertebrate Puzzle - Squid



Across

2. Pump blood oxygen-poor blood through the gills.
3. It has receptors for detecting chemicals.
4. Pumps oxygen rich blood to all parts of the body.
6. A mass of muscle that houses the two beaks.
10. Structurally they are similar to ours.
13. Produces the egg case that covers the eggs.
15. The siphon.
16. Transports undigested food from the caecum to the rectum.
17. Produces eggs.
19. Where gas exchange takes place.
20. Transports food from the buccal mass to the stomach.

Down

1. The body tube.
5. Has a beak inside.
7. A large sac that is the main organ of absorption.
8. Used to help hold prey.
9. Secretes digestive enzymes into the caecum.
11. May be used as rudders and horizontal stabilizers
12. Responsible for removing nitrogenous waste from the body.
14. Has suckers only at the end.
18. Produces a dark cloud behind which the squid can escape from predators.

Squid Test

Select the term that best answers or completes the statement.

1. The squid has two long tentacles and ___ shorter arms.
   A. four B. six C. eight D. ten

2. Inside the squid's mouth ___ that helps it break up its food.
   A. is a beak B. is a tongue C. is a caecum D. is a siphon

3. The squid moves by forcing water out of its...
   A. caecum B. tentacles C. gills D. siphon

4. The ___ helps the squid escape from predators.
   A. caecum B. tongue C. buccal mass D. ink sac

5. Most of the absorption of food takes place in the...
   A. caecum B. intestine C. buccal mass D. siphon

6. The squid has ___ hearts.
   A. two B. three C. four D. five

Mark T for true or F for false next to each statement.

_____ 7. The eyes of the squid are very similar to ours.

_____ 8. The arms of the squid only have suckers at the their tips.

_____ 9. The tentacles are used to capture food.

_____ 10. The caecum is used to remove metabolic waste.

_____ 11. The squid's liver secretes digestive enzymes into caecum.

_____ 12. Each female squid produces about ten eggs a year.

_____ 13. The systemic heart pumps blood to the gills.

_____ 14. The nidamental gland produces the egg case that covers the eggs.

_____ 15. The squid is one of the most intelligent invertebrates.