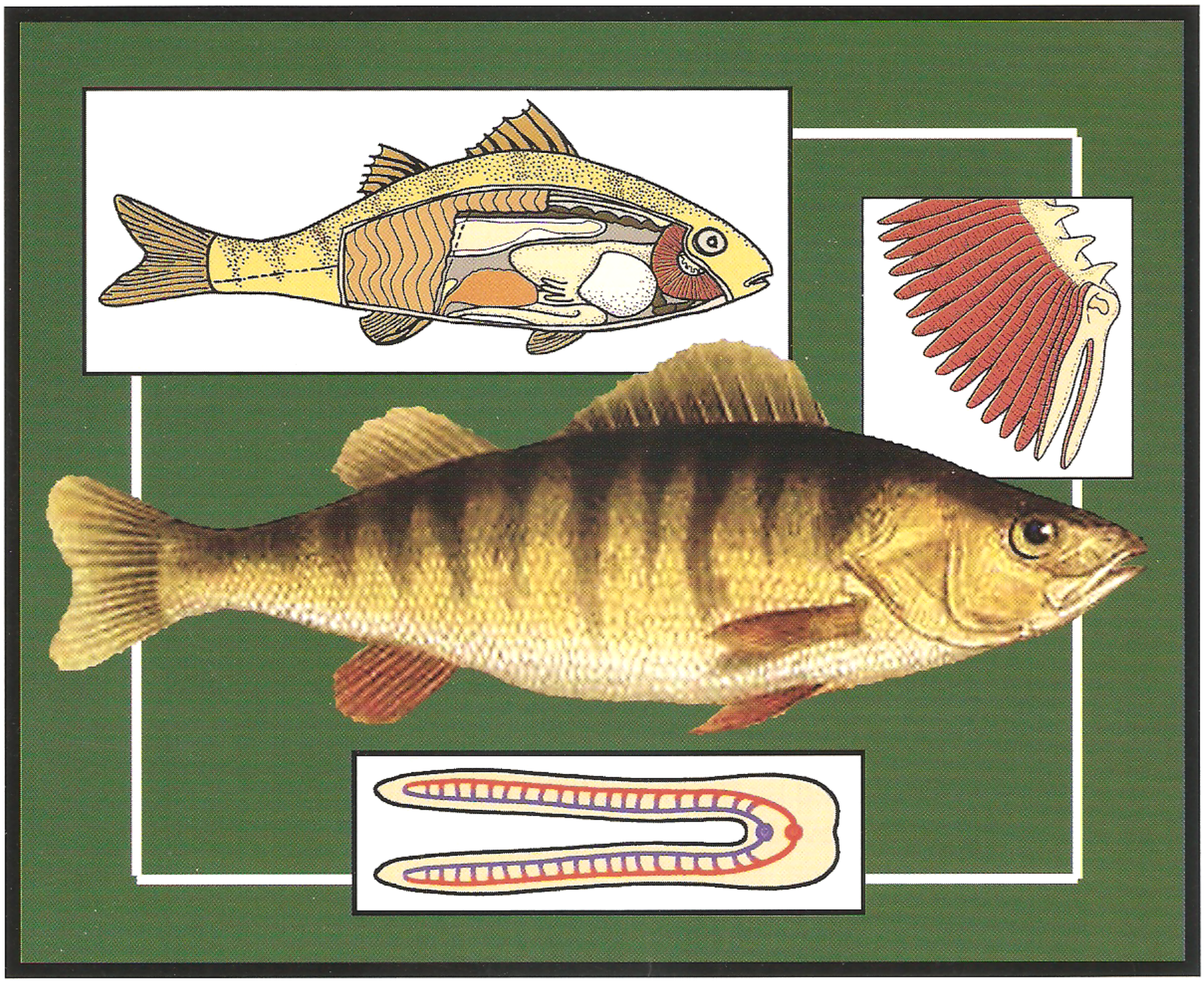
The Taxonomy & Physiology of the

Perch

A comprehensive, step-by-step dissection guide complete with photographs & illustrations



Text, photographs, and illustrations by Lisa K. Hyatt

How to use this guide:

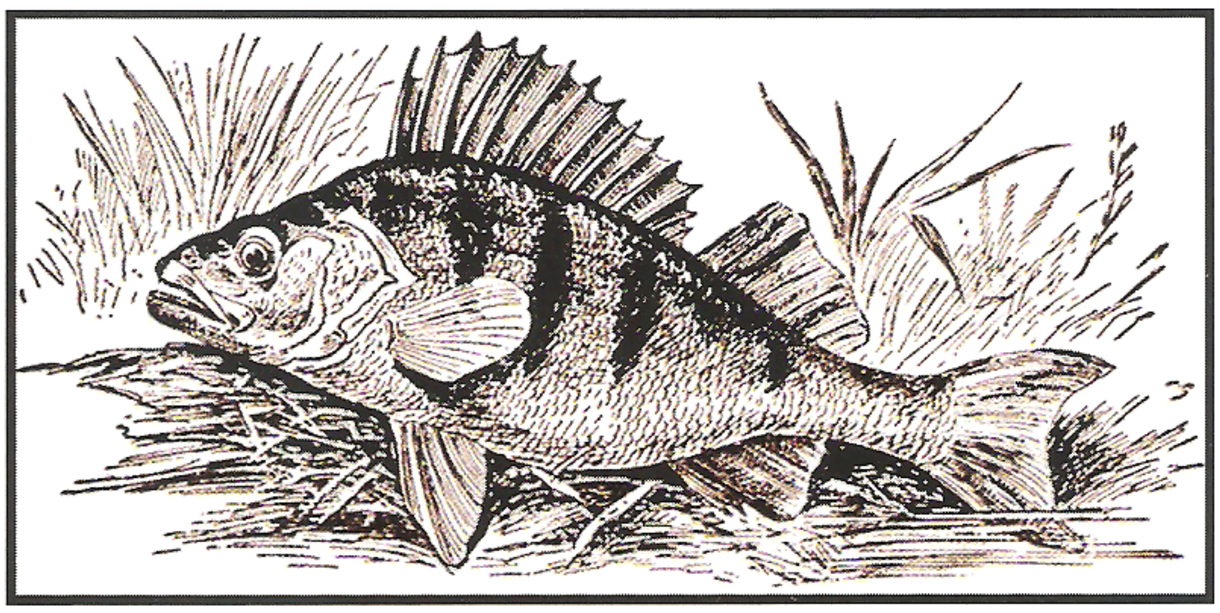
This guide is intended to introduce the taxonomy of the perch and to guide the student through its dissection in a step-by-step manner. Dissection instructions are in italics. In general, the photographs may not show all structures because they are too small to be seen, but will show those that are prominent and easily identified. Illustrations are provided that will aid in identification. These figures are designed in a self-quiz manner in which the student may cover up the answers to the numbered structures. Perch systems are summarized throughout the guide. Anatomical terms and key terms are listed in the back of the guide.

Note: The taxonomy in this guide was current as of 2003. However, due to discoveries in genetics, taxonomic categories may change in the future.

PerchTaxonomy

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Superclass : Gnathostomata
Class: Actinopterygii
Subclass: Neopterygii
Order: Perciformes
Family: Percidae
Genus: *Perca*
Species: *flavescens*
Full scientific name: *Perca flavescens*
Common name: yellow perch

figure 1 - Perch with extended fins



Phylum Chordata

The perch is just one of the many animals that belong to Phylum Chordata, which contains some of the most intelligent animals in Kingdom Animalia. Phylum Chordata includes the protochordates (tunicates & lancelets), and the vertebrates (fishes, sharks, amphibians, reptiles, birds, and mammals). They inhabit marine, freshwater, and terrestrial environments and are distributed worldwide.

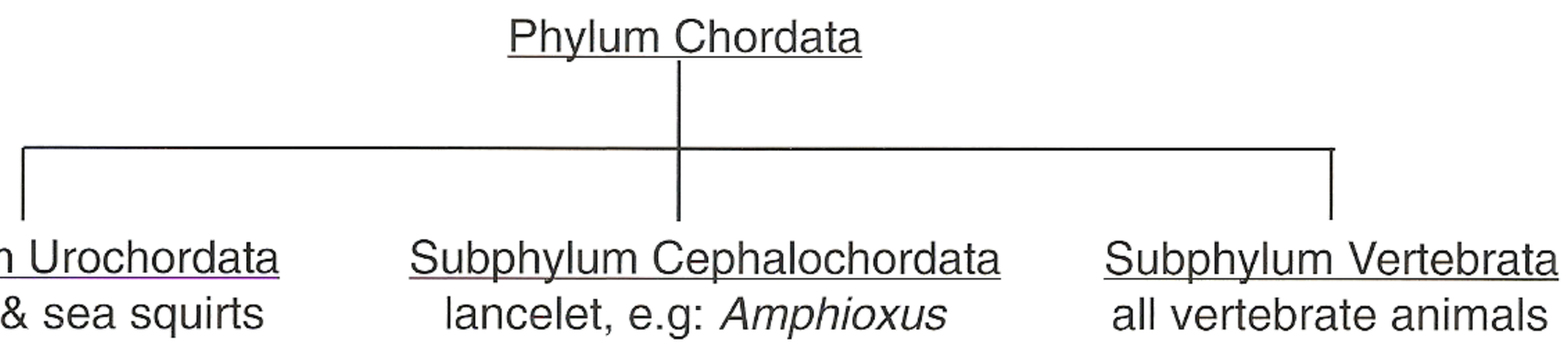
Although there are differences between these animals, all chordates share the following characteristics at some point in development:

1. **Notochord** – Considered a precursor to the modern vertebrate endoskeleton. In most animals, it becomes the cartilage within the vertebrate column.
2. **Dorsal hollow nerve cord** – A fluid filled nerve that transmits impulses and helps form the central nervous system. Most animals retain the nerve cord into adulthood.
3. **Pharyngeal gill slits** – Move water through the pharynx. In many animals, the slits never actually perforate the pharynx but form vestigial pouches. In the perch, the pharyngeal gill slits are retained into adulthood.
4. **Post-anal tail** – Generally provides motility in an aqueous environment. In humans, the post-anal tail is a vestigial structure called the coccyx.

All four characteristics are usually only present during the embryonic stage. The embryo of a perch looks almost identical to the embryo of a human. This similarity gives clues to a shared chordate ancestor. One of the few animals that retains all four characteristics during adulthood is the lancelet of Subphylum Cephalochordata.

Subphylum Vertebrata

The animals of Phylum Chordata are currently grouped into the protochordates and the euchordates. The protochordates consist of two subphyla and the euchordates consist of one subphylum:



Typically, the protochordates lack a cranium to protect the brain. They also lack an endoskeleton of vertebrae. In the lancelet, the notochord serves as the endoskeleton. Tunicates lack the classic endoskeleton, but have a tunic or test that provides support. All vertebrates possess an axial skeleton and a cranium. Vertebrates include lamprey, hagfishes, sharks, rays, fishes, amphibians, reptiles, birds, and mammals.

In addition to the specific four features listed previously, vertebrates also share the following characteristics:

- **Cephalization**
- **Bilateral symmetry**
- **Metamerism**
- Presence of a true **coelom**
- **Endoskeleton**
- **Striated muscles**
- **Integument**
- **Paired limbs**
- **Deuterostome** development
- **Triploblastic** development
- **Organ system** level of organization
- **Closed circulatory system**
- **Complete digestive system**
- **Advanced nervous system**
- **Excretory system** of **kidneys**
- **Endocrine system**

All vertebrates exhibit **bilateral symmetry**, in which the animal can be divided into an equal mirror image, called the sagittal plane. Other anatomical planes are the **frontal plane** and the **transverse plane** (figure 2).

figure 2 - Anatomical planes

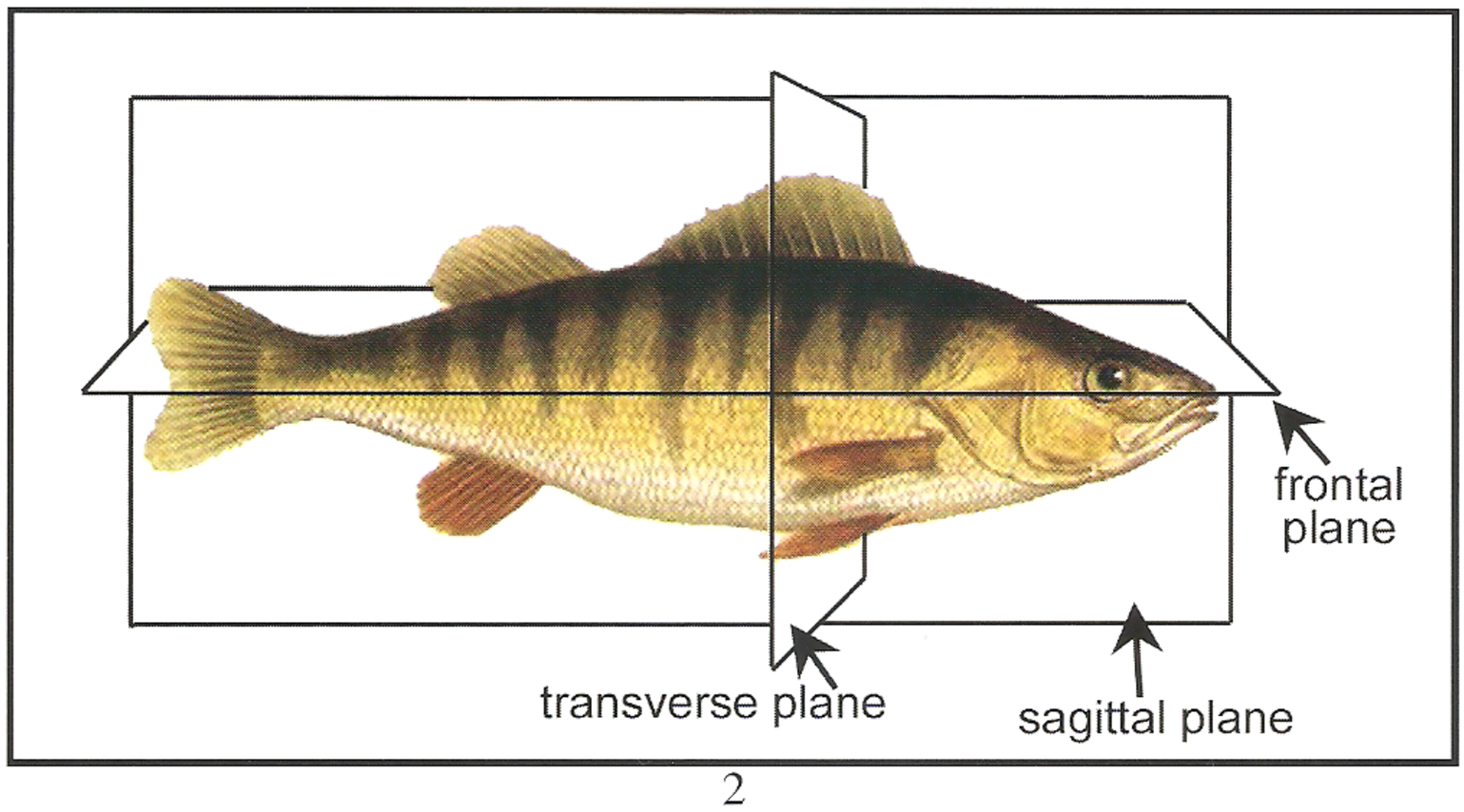
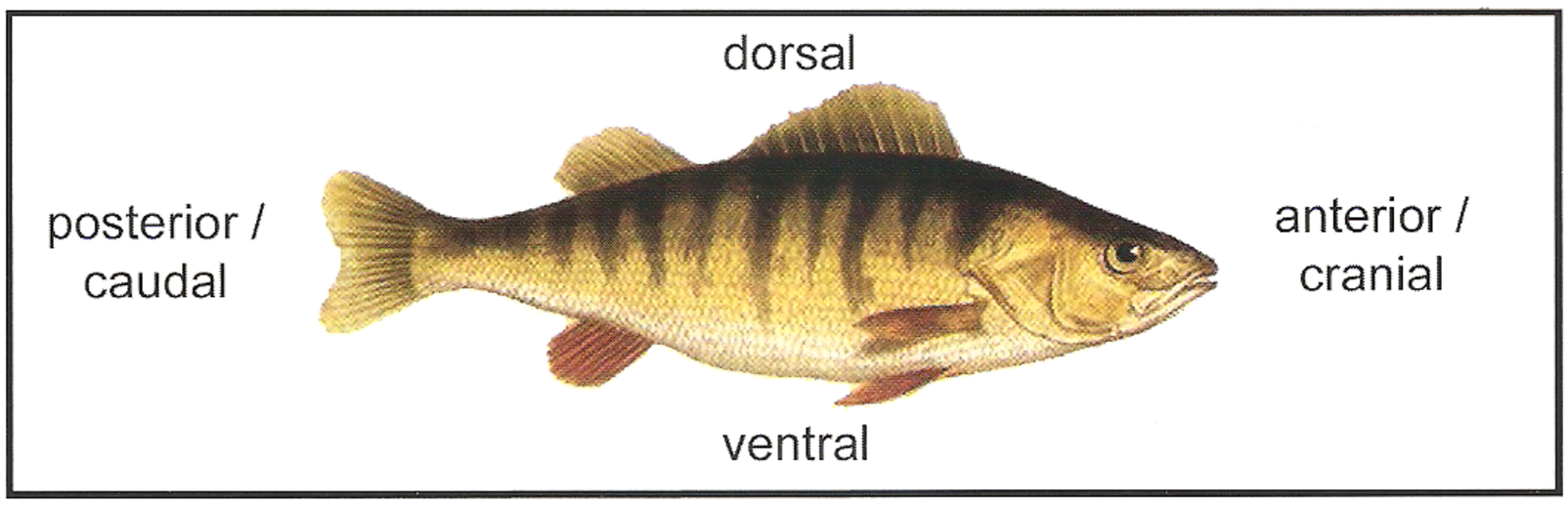


figure 3 - Symmetry terms



When referring to an animal that is bilateral, you should know the following terms:

- Anterior / cranial – refers to the head region
- Posterior / caudal – refers to the tail region
- Dorsal – refers to the upper surface
- Ventral – refers to the under surface

Commonly, animals that exhibit bilateral symmetry also show varying degrees of **cephalization**. Cephalization is defined by a gathering of ganglia, or nervous tissue, in the anterior end of the animal. In complex animals, the nervous tissue forms the brain.

Like some other animals from other phyla you may have studied previously, vertebrates share some characteristics in development and organization. They exhibit **metamerism**, which is the repetition of body segments. Metamerism enables the animal to specialize regions of the body for movement and other functions. Chordates are considered **deuterostomes** that undergo **triploblastic** development. They possess a true **coelom**, which is a body cavity that is completely lined with mesoderm tissue. All chordates have an **organ system** level of organization. This means that cells are gathered into tissues, which are then gathered into organs to function in specific ways.

All vertebrates are supported by an **endoskeleton** that is attached to a network of **striated muscles**. The advantage of a living endoskeleton is that it allows for continuous growth and for large body sizes. The world's largest animals are all vertebrates. The body of a vertebrate is protected by **integument** in two layers: the outer epithelium derived from the ectodermal tissue and the inner dermis derived from the mesodermal tissue. This skin covering not only protects but has also been modified by many animals into features such as scales, feathers, claws, and hair.

Vertebrates generally have a **body plan of a head, trunk, and tail**. For many terrestrial animals the **neck** is part of this body plan. They all have **paired limbs**. These limbs may manifest as legs, arms, wings, and fins. In the case of some reptiles, limbs are expressed only as vestigial skeletal structures.

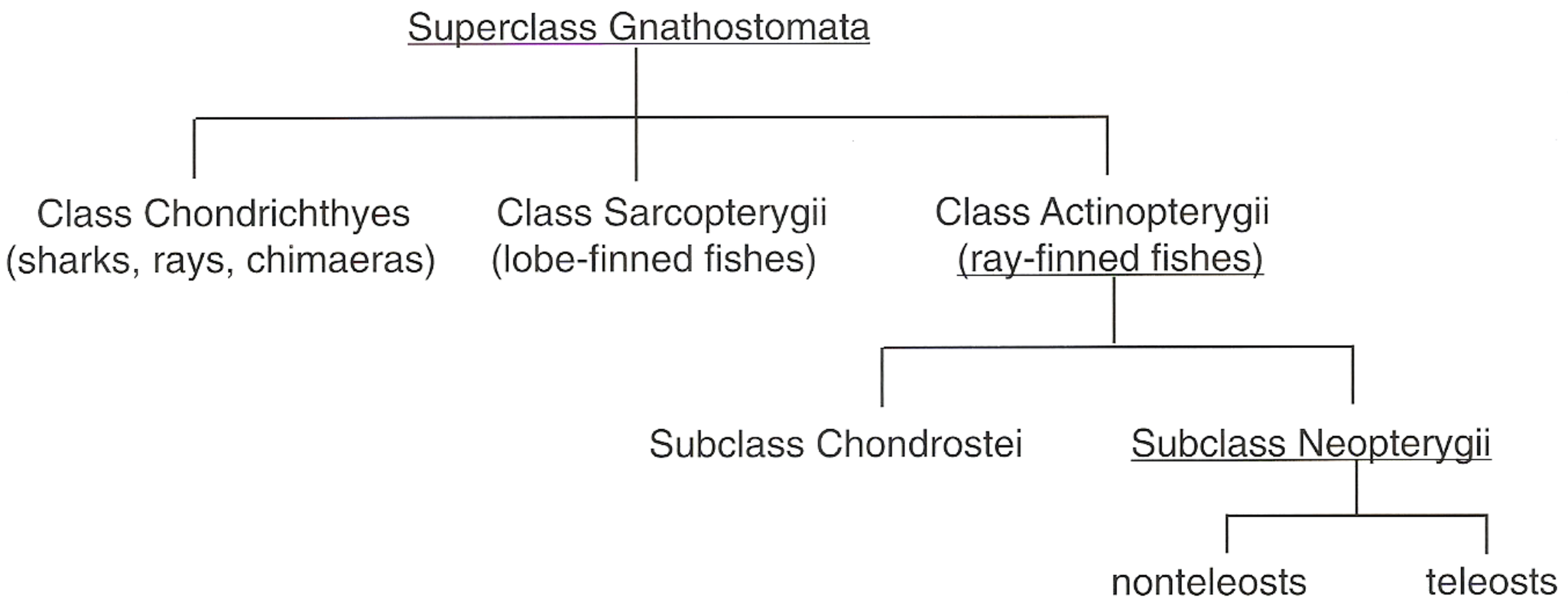
Vertebrates have **closed circulatory systems** where all the blood is enclosed in vessels for transport and is powered by a muscular heart. They have **complete digestive systems** that consist of an entryway (the mouth) and an exit way (the anus). Having this type of system enables the animal to digest food continuously. Their **advanced nervous systems** make them some of the most intelligent and adaptive animals known. The switch from a rudimentary type of chemosensory system to the complexities of the chordate system probably came about due to a predatory life style. Vertebrates have an **excretory system** of paired **kidneys** that effectively remove wastes. They have an **endocrine system** that facilitates secretions throughout the body.

Superclass Gnathostomata

Superclass Gnathostomata consists of all jawed fishes and other tetrapod vertebrates. Usually paired appendages are also present. This group consists of the following classes:

- Class Chondrichthyes – sharks, skates, rays, and chimaeras.
- Class Actinopterygii – ray-finned bony fishes (previously called Class Osteichthyes).
- Class Sarcopterygii – lobe-finned bony fishes (previously called Class Osteichthyes).
- Class Amphibia – amphibians: frogs, toads, salamanders, newts, etc.
- Class Reptilia – reptiles: snakes, lizards, crocodiles, alligators, turtles, etc.
- Class Aves – birds (body covered with feathers).
- Class Mammalia – mammals, including humans.

The fish within Superclass Gnathostomata can be divided into three major groups:



Class Chondrichthyes includes those fishes whose skeletons are composed of cartilage. Sharks, rays, and chimaeras belong to this group. *Note: If you would like to learn more about Class Chondrichthyes, a guide on the shark is available from the Bio Company.*

Class Sarcopterygii includes the lobe-finned bony fishes. Most of the fishes in this group are currently extinct. The living representatives consist of three species of lungfishes and the coelacanth, which is considered a "living fossil" (figure 4).

figure 4 - The coelacanth, *Latimeria chalumnae*

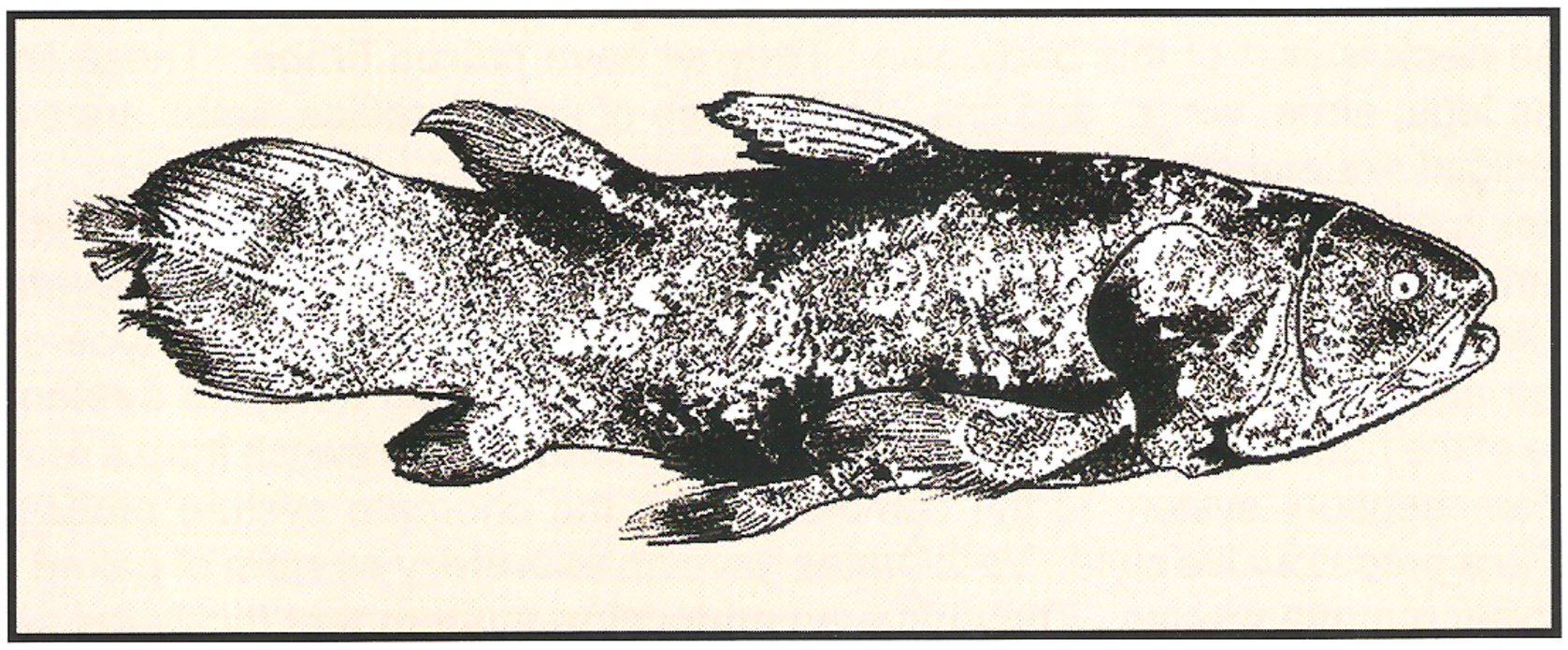
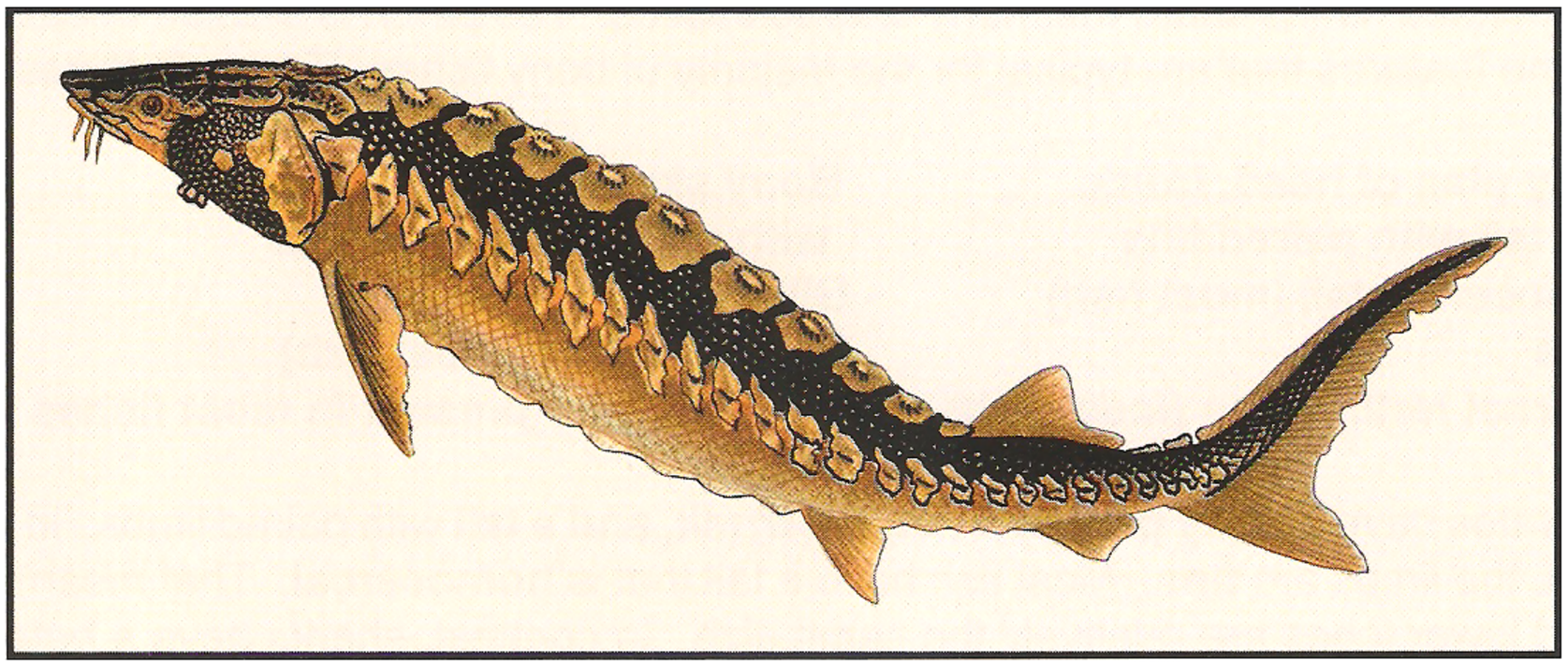


figure 5 - The sturgeon



Class Actinopterygii includes the ray-finned bony fishes. It is divided into two subclasses: Subclass Chondrostei and Subclass Neopterygii. The members of Subclass Chondrostei have skeletons composed of cartilage with some bone. There are two extant orders in this class which include the birchir, paddlefish, and sturgeon (figure 5). Subclass Neopterygii contains the majority of the world's fishes. Fish in this group have skeletons composed primarily of bone. They are divided into two general categories: the nonteleosts and the teleosts. The nonteleosts are the bowfin and the gars, which are contained within two orders. In contrast, the teleosts make up 96% of all the world's fishes. There are currently 38 orders of teleost fish within Subclass Neopterygii. This includes Order Perciformes, which includes the perch.

About the Yellow Perch

The yellow perch, *Perca flavescens*, is also called the lake perch, the blue fin perch, and the raccoon perch. Distinguishing characteristics include a body of yellowish coloration punctuated by triangular dark stripes, ctenoid scales and two dorsal fins. All the fins are composed of a membrane separated by bony spines.

The perch typically inhabits temperate lakes, streams, ponds, and rivers. Young perch feed on small copepods, crustaceans, and insect and fish larvae. Adult typically feed on small fish, molluscs, worms, and crayfish.

Perch play an important role in the ecosystem. In addition to feeding on the various animals in the environment, perch are prey to many predatory fish such as walleye, northern pike, and muskellunge.

A perch lives 7-9 years and can get as large as 11 inches. To some degree, the age of a perch can be determined by its size. Typically, females attain a larger body than the males. *If your specimen is large, chances are that it is a female.* Use the table below to determine the approximate age of your perch.

Write down the size and age of your perch: size:_____inches; age:_____

age	size (inches)	age	size (inches)
1	3.0	5	9.2
2	5.0	6	10.0
3	6.5	7	10.5
4	8.0	8	11.0

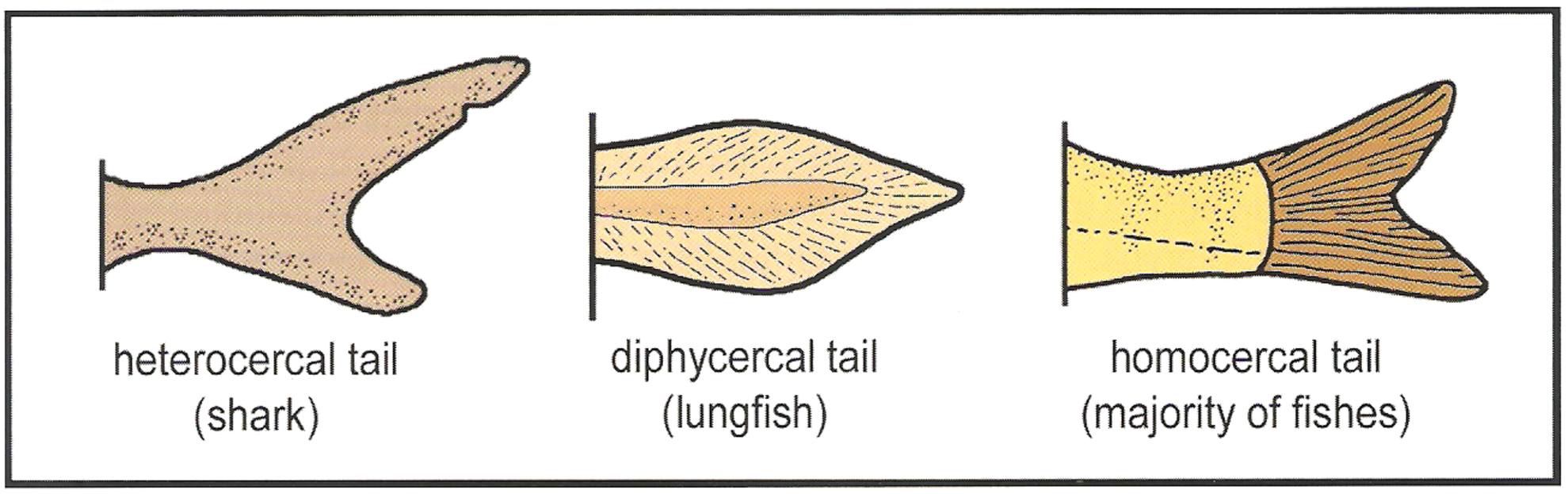
External features

Most ray-finned fishes share the many characteristics. The perch is studied because it has many of the features that are typical for the majority of bony fishes. These features include:

- **Body plan of head, trunk, and tail with paired fins**
- **Homocercal tail (most fish)**
- **Jaws**
- **External fertilization (most fish)**
- **Bony skeleton with numerous vertebrae**
- **Gills**
- **Dermal scales (most fish)**
- **Swim bladder present in most fishes**

All vertebrates have a **body plan of a head, a trunk, and a tail** with paired limbs. In the case of the fish, the limbs are **fins**. Most fish have a tail that is **homocercal**. That means that the upper and lower lobes are relatively the same size. In contrast, sharks have a heterocercal tail in which the lobes are different sizes and the lungfish has a tail that consists of only one lobe (figure 6).

figure 6 - Types of caudal tails



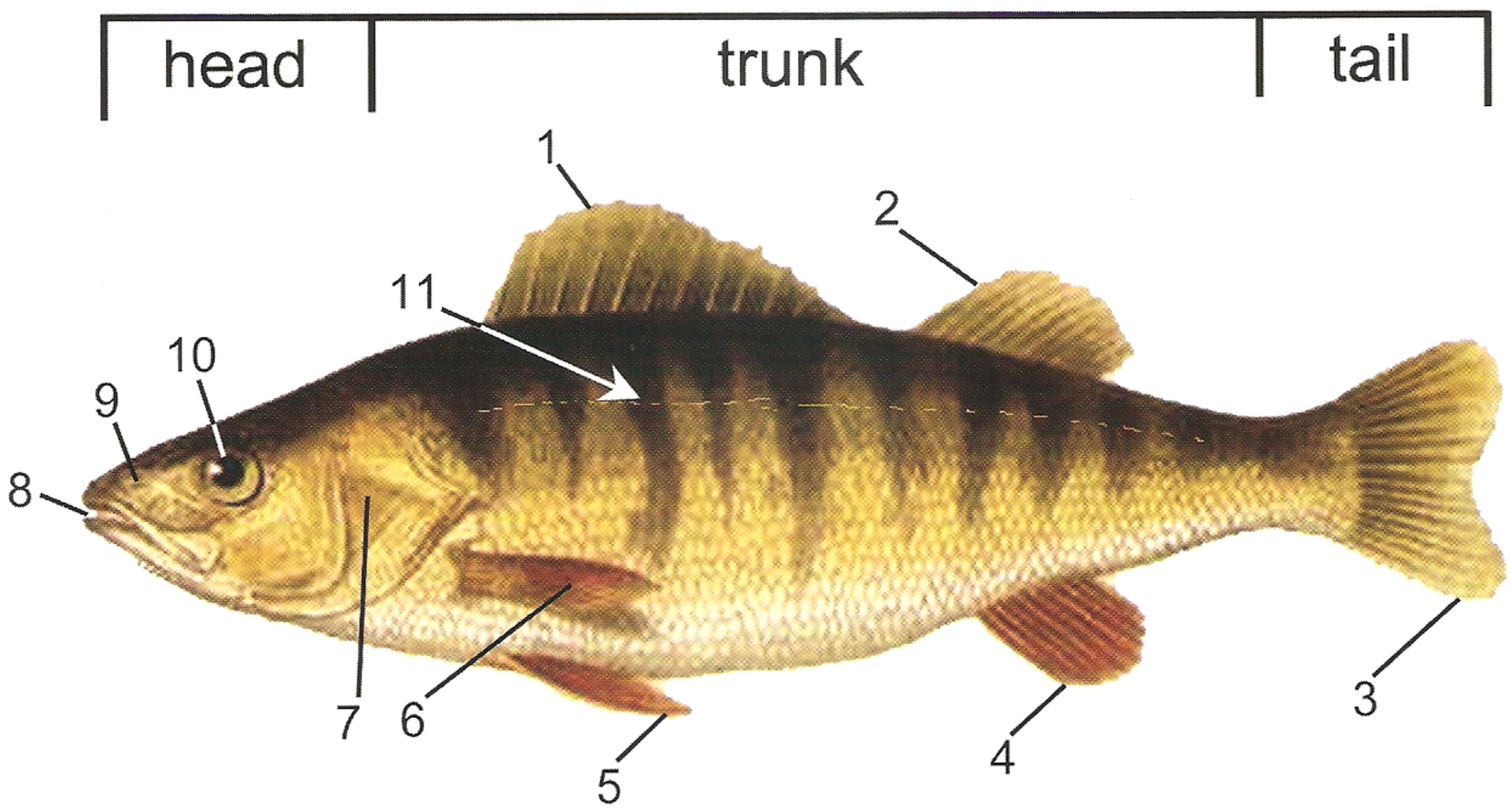
All modern fish belonging to Class Actinopterygii have **bony jaws** and a **bony skeleton with numerous vertebrae**. The body is usually protected by **dermal scales**. *Pull off one of the scales and inspect it closely.* The dermal scales on the perch are called **ctenoid scales**. They are flexible and light but still provide protection.

The following corresponds to the numbers in figure 7:

Fins:

1. **First dorsal fin** – The fins help maintain orientation in the water and provide stability for movement. *Notice the hard spiny **fin rays** supporting the **fin membranes** on the fin.*
2. **Second dorsal fin** – See description #1.
3. **Caudal fin (homocercal fin)** – The powerful caudal fin provides the thrust to propel the fish's body. A perch's caudal fin is called **homocercal**, since the dorsal and ventral lobes are relatively symmetrical. This is in contrast to the caudal tail of a shark, which has an asymmetrical tail. It also differs from the one-lobed tail of a lungfish.
4. **Anal fin** – The anal, pectoral, and pelvic fins help maintain orientation in the water and provide stability for movement.
5. **Pelvic fin** – See description #4.
6. **Pectoral fin** – See description #4.

figure 7 - External features



fins: 1-first dorsal fin; 2-second dorsal fin; 3-caudal fin (homocercal tail); 4-anal fin; 5-pelvic fin; 6-pectoral fin;
other external features: 7-gill operculum; 8-mouth; 9-nostril; 10-eye; 11-lateral line

Other external features:

7. **Gill operculum** – These series of hard plates protect the gills. By moving the operculum, a fish can move oxygenated water through the gills without swimming.
8. **Mouth** – Two types of mouths occur in bony fish: surface feeding fish have superior mouths that face upward; bottom dwelling fish have inferior mouths that face downward.

*What type of mouth does your perch have?*_____

9. **Nostril** – The nostril detects odors in the water. They lead to an olfactory bulb located in the brain.
10. **Eye** – The eye receives visual images. Fish eyes vary according to the depth in which they live.
11. **Lateral line** – The lateral line enables the fish to detect temperature and pressure changes and senses water currents.

The Skeletal System

Note: The skeleton of a perch is fragile and difficult to isolate. It is not recommended that you use your specimen to study the skeleton of the perch.

The skeleton provides support to the body and gives the muscles an attachment point. The skeleton of an animal from Class Actinopterygii is composed primarily of bone. This is in contrast to the sharks and rays from Class Chondrichthyes that have skeletons composed of cartilage. All vertebrate skeletons are cartilaginous during the fetal stage of development. After birth, the cartilage hardens, or ossifies.

The skeleton of a vertebrate can be divided into two parts: the **axial skeleton** and the **appendicular skeleton** consisting of the following elements:

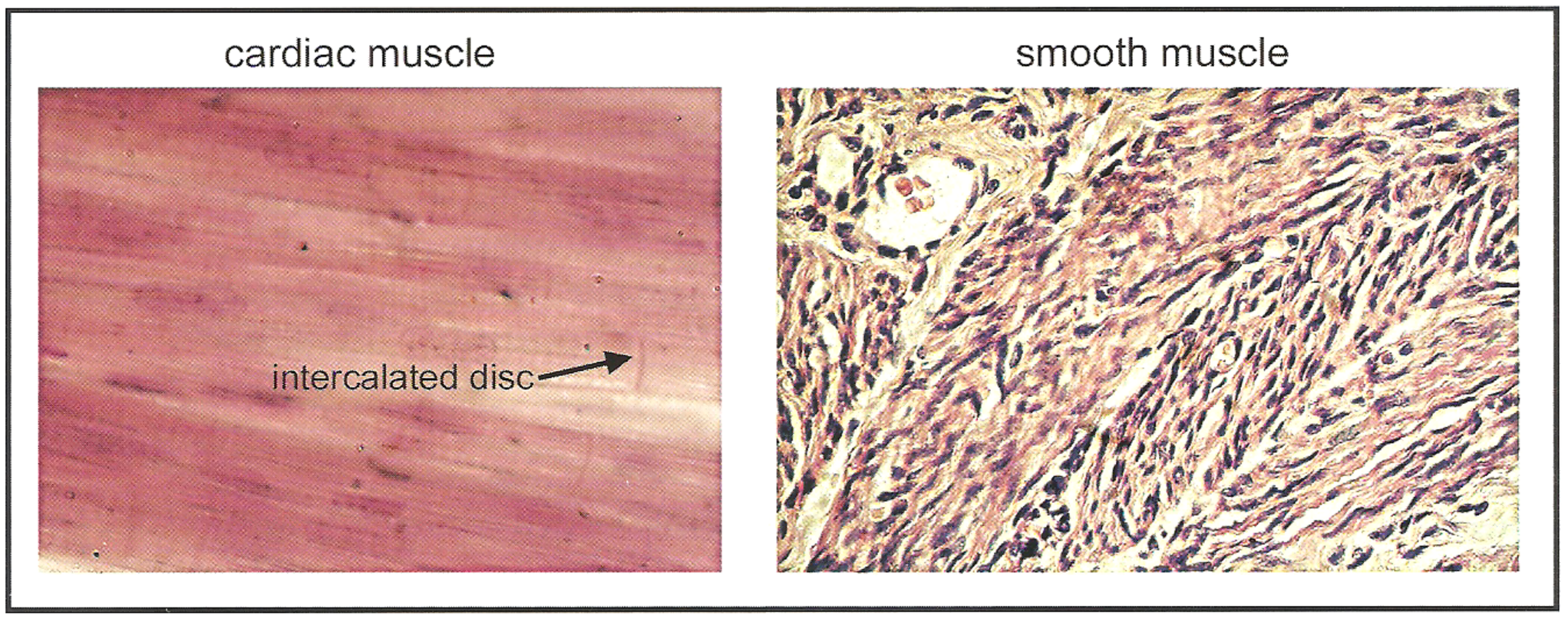
Axial skeleton	Appendicular skeleton
skull	pectoral girdle & associated fins
vertebral column	pelvic girdle & associated fins
ribs	
medial fins	

The Muscular System – figures 8

When skinning your perch, make an incision in the skin, following the dissection instructions as you go. With your forceps, lift the skin and carefully peel it away from the body by cutting underneath it with your scalpel. Follow the pattern of incisions shown in figure 9. This guide addresses only the most superficial muscles in the lateral view in figure 14.

Muscles are divided into three types: smooth muscle, skeletal muscle and cardiac muscle. Smooth muscle is the involuntary muscle responsible for visceral activities such as digestion. Skeletal muscle and cardiac muscle both have a striated appearance. They can be differentiated by the intercalated discs present only in the cardiac muscle. As the name implies, cardiac muscle is the involuntary muscle located in the heart. Skeletal muscle is voluntary and is located throughout the body. Notice the contrast in appearance between the striated cardiac muscle tissue and the smooth muscle tissue (figure 8).

figure 8 - Comparison of cardiac and smooth muscle tissue



The movement of a muscle is its **action**. There are many different types of actions associated with muscles. Four of the common actions are listed below:

- **Flexion** – Bending a joint so that the angle of that joint decreases. Example: bending your elbow or knee.
- **Extension** – Extending a joint so that the angle of the joint increases. Example: straightening out your arm or leg.
- **Adduction** – Moving the distal part of the bone toward the median axis of the body. (*Ad* = to) Example: lowering your horizontally raised arms down to the sides of your body.
- **Abduction** – Moving the distal part of the bone away from the median axis of the body. (*Ab* = from) Example: raising your arms from the sides of your body to a raised horizontal position.

Most muscles are paired and produce actions that are **antagonistic**. That is, they produce opposing effects. For example, on the human body the biceps and triceps are considered antagonists.

A muscle is typically composed of three parts: the **origin**, the **belly**, and the **insertion**. The origin is the end of the muscle connected to a fixed, typically rigid part of the skeleton. The belly is the middle part of the muscle. The insertion is the end of the muscle that is connected to a movable portion of the skeleton. The muscle contraction across diarthrotic joints is what causes movement. The insertion of the muscle moves closer to the origin of the muscle. The muscle is connected to the skeleton by a **tendon**, a tough connective tissue. An **aponeurosis**, another type of connective tissue, connects the muscles to its point of attachment on the cartilaginous skeleton. Muscle fibers are held together by **fascia**, a type of fibrous connective tissue.

On the perch (and most fishes), the bulk of the muscles consists of the **epaxial** and **hypaxial myotomes**. **Myotomes** are simply individual segments of muscle tissue. Each myotome is separated by a **myoseptum**. Like other fish, the myotomes of the perch are arranged in a "W" or zigzag pattern that allows for the powerful back and forth motion of the tail that provides forward thrust. The epaxial portion is located dorsal to the transverse septum and the hypaxial portion is located ventral to the transverse septum. The **transverse septum**, also called the horizontal septum, corresponds internally with the **lateral line**, which is located closer to the external surface of the body. While swimming, the perch's myotomes expand and contract to provide movement.

The Body Cavity and its Membranes

The body cavity, called the **coelom**, is divided into two regions: the anterior **pericardial cavity** and the posterior **peritoneal cavity**. The pericardial cavity houses the heart while the peritoneal cavity houses the liver, stomach, intestine, swim bladder and remaining visceral organs.

There are several membranes lining the body wall and various organs. They support the internal organs within the coelom. You will not be able to see these membranes on your specimen. The body wall is lined by a layer of epithelial tissue called the **parietal peritoneum**. The tissue covering the internal organs is the **visceral peritoneum**. A double layer of peritoneum is referred to as **mesentery**. The mesentery is found dorsal and ventral to the internal organs. It secures them in place within the coelom and contains multiple blood vessels for oxygen supply. The membranes covering the heart are the inner **visceral pericardium** directly lining the heart and the outer **parietal pericardium**.

The Dissection: – figures 9-13

Materials

*Perch	*Dissecting tray	*Protective gloves	*Scalpel	*T-pins
*Probe	*Apron	*Forceps	*Scissors	

1. *Obtain a perch, dissection tray, gloves and other items listed above.*
2. *Always wear gloves when handling the specimen.*
3. *Before proceeding to the dissection, observe the structures of the external anatomy. Use figure 7 to assist in identification of structures.*
4. *To begin the dissection, remove the gill operculum using your scissors as shown in figure 10.*

figure 9 - Dissection cuts

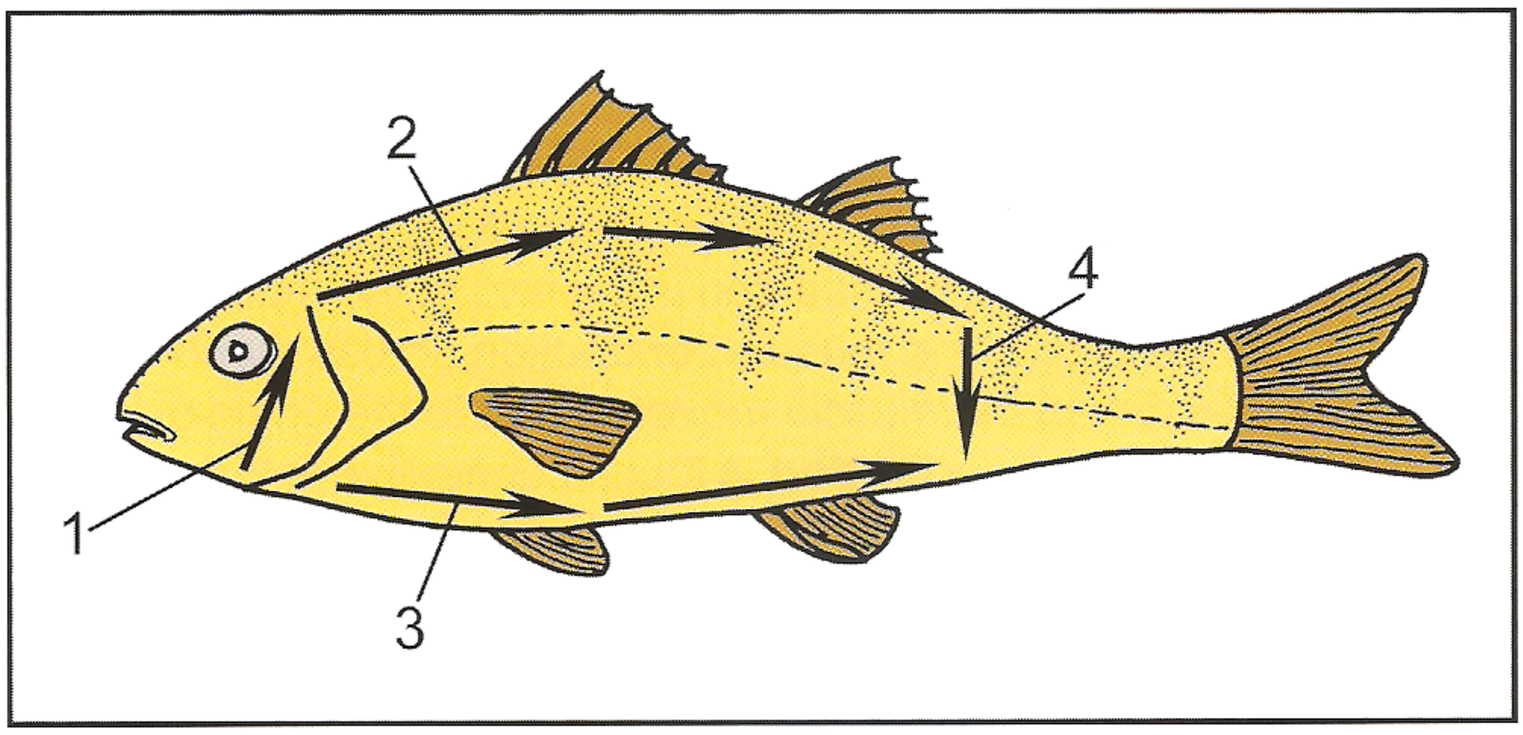


figure 10 - Cutting off the gill operculum

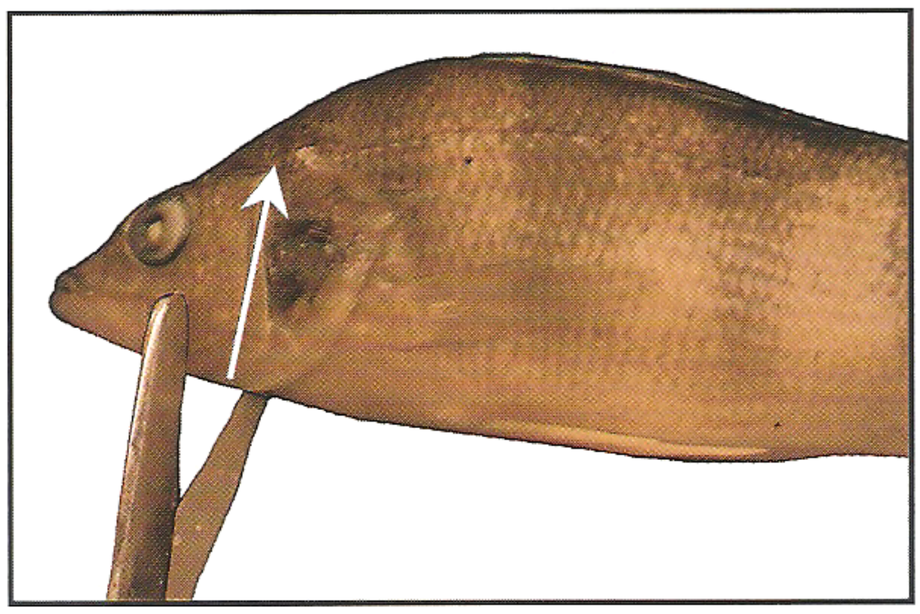


figure 11 - Peeling away the skin

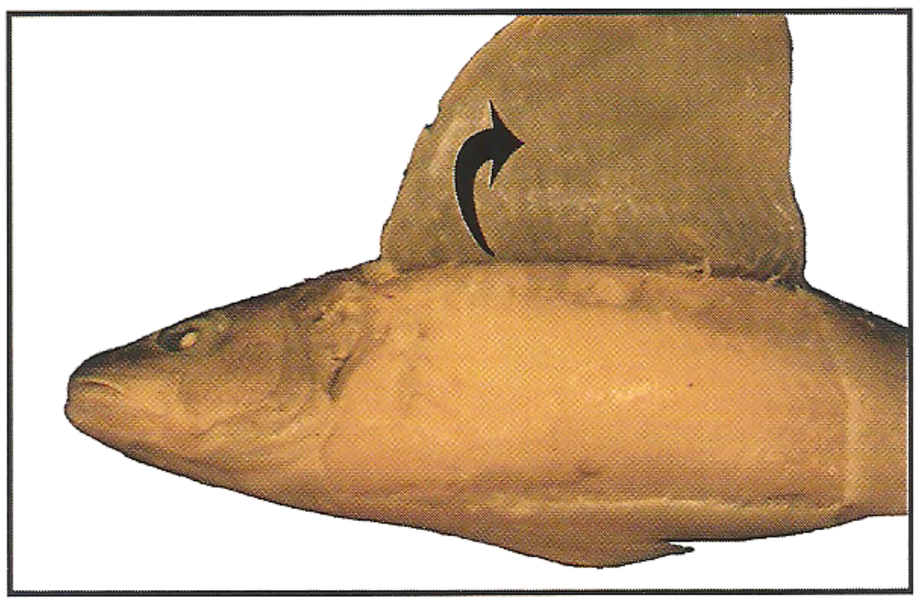
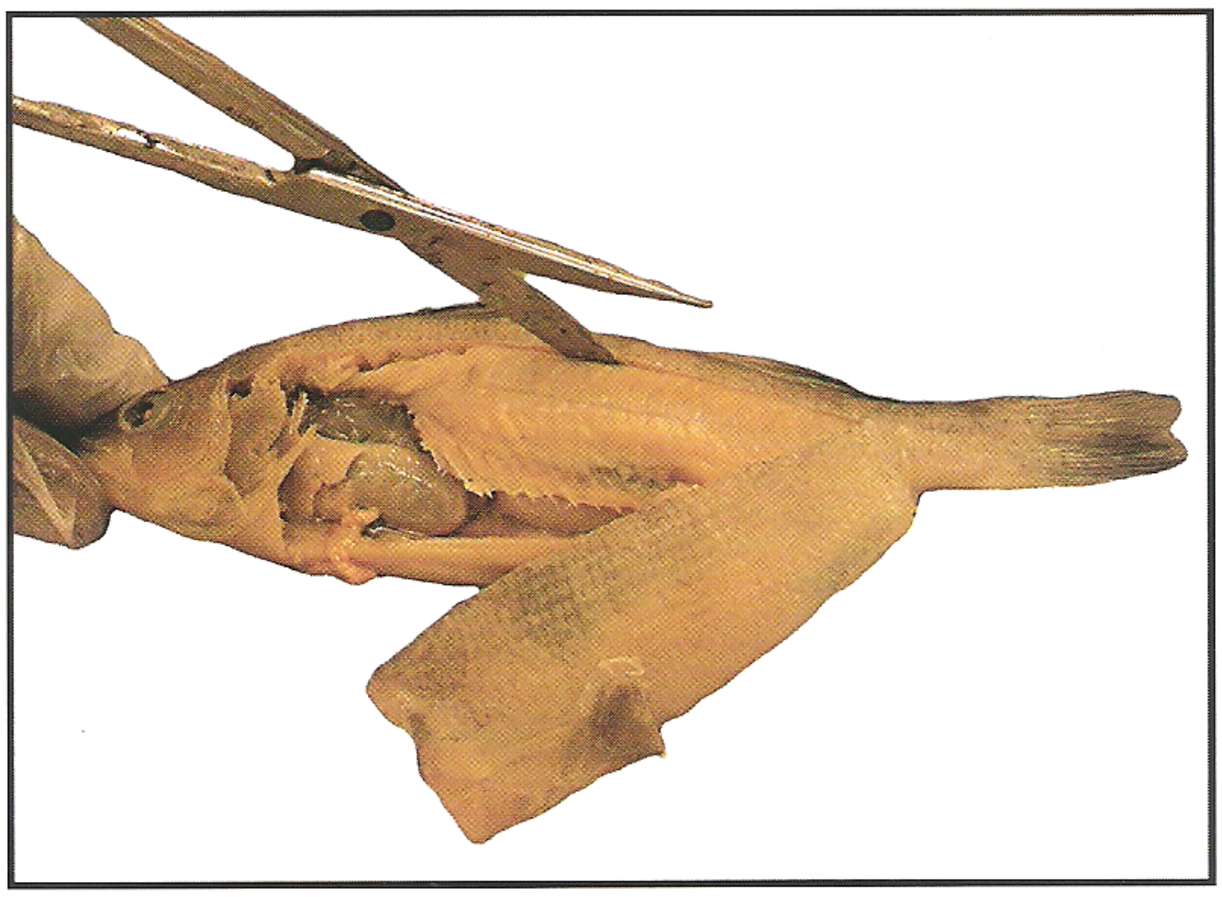


figure 12 - Cutting away the muscle and bones



5. Cut into your perch according to figure 9. The cuts are numbered in order. First, use your scalpel to make your incisions. Score the skin and then cut 0.5 inch (or 1 cm) down.

6. It is helpful to first remove the skin and then remove the muscles and bones (figure 11).

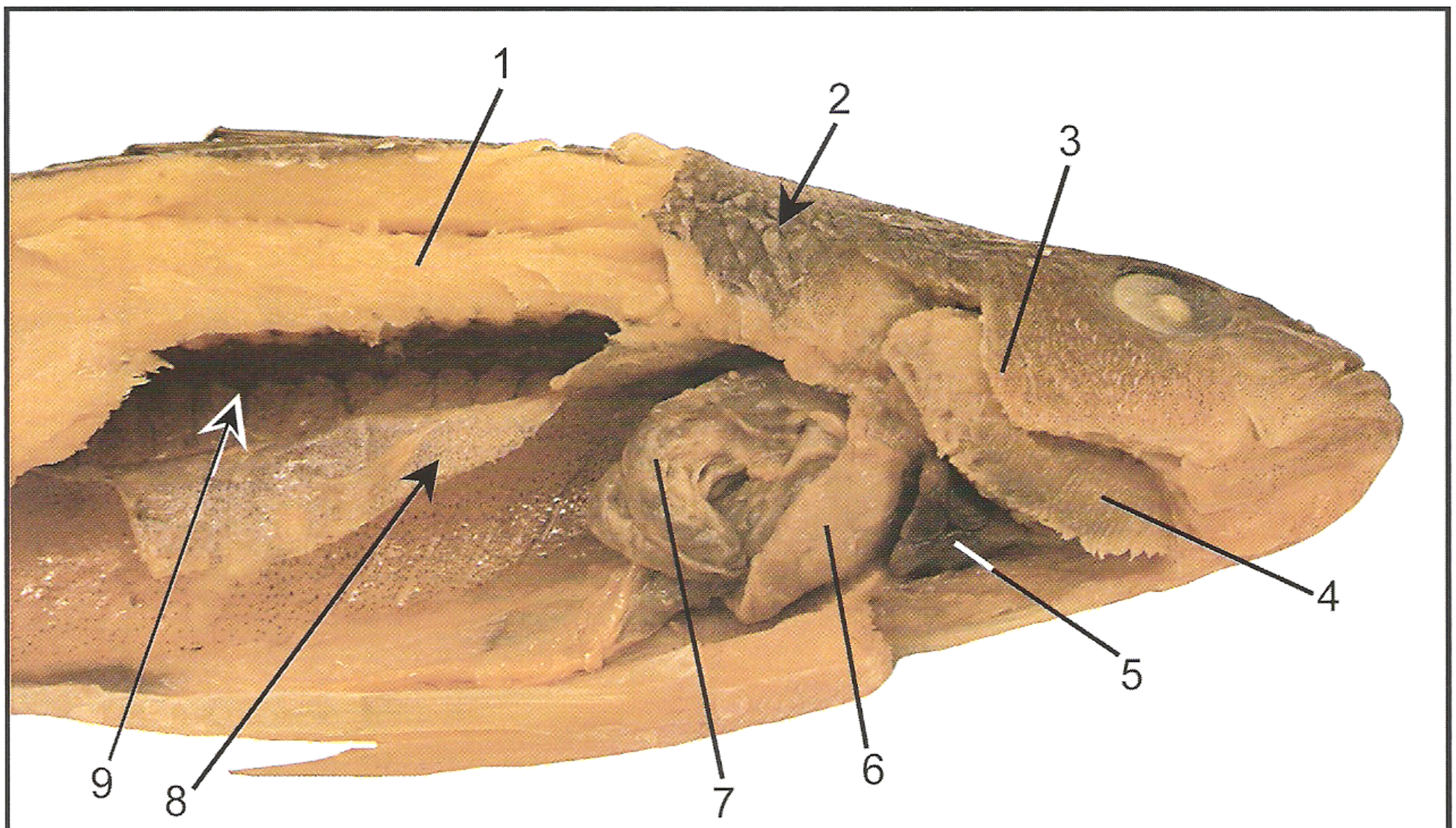
7. You will need to remove the muscles in layers. Use your scissors as in figure 12. When you get down to the ribs, remove them using your forceps and scissors. Try not to damage the internal organs.

8. As you enter the body cavity, take note of a thin membrane. This is the swim bladder. You will learn more about the swim bladder in the latter part of this guide.

9. In order to see the heart, make sure to cut under the head and towards the jaws. Cut your specimen to reveal the structures as shown in figure 13.

10. Once you have entered the body cavity, proceed to identify the internal organs as listed in this guide.

figure 13 - The swim bladder and internal organs



1-epaxial muscles; 2-ctenoid scales (dermal scales); 3-gill operculum; 4-gill filaments; 5-heart; 6-liver; 7-stomach; 8-membrane of the swim bladder; 9-kidney

The Body Cavity and its Membranes

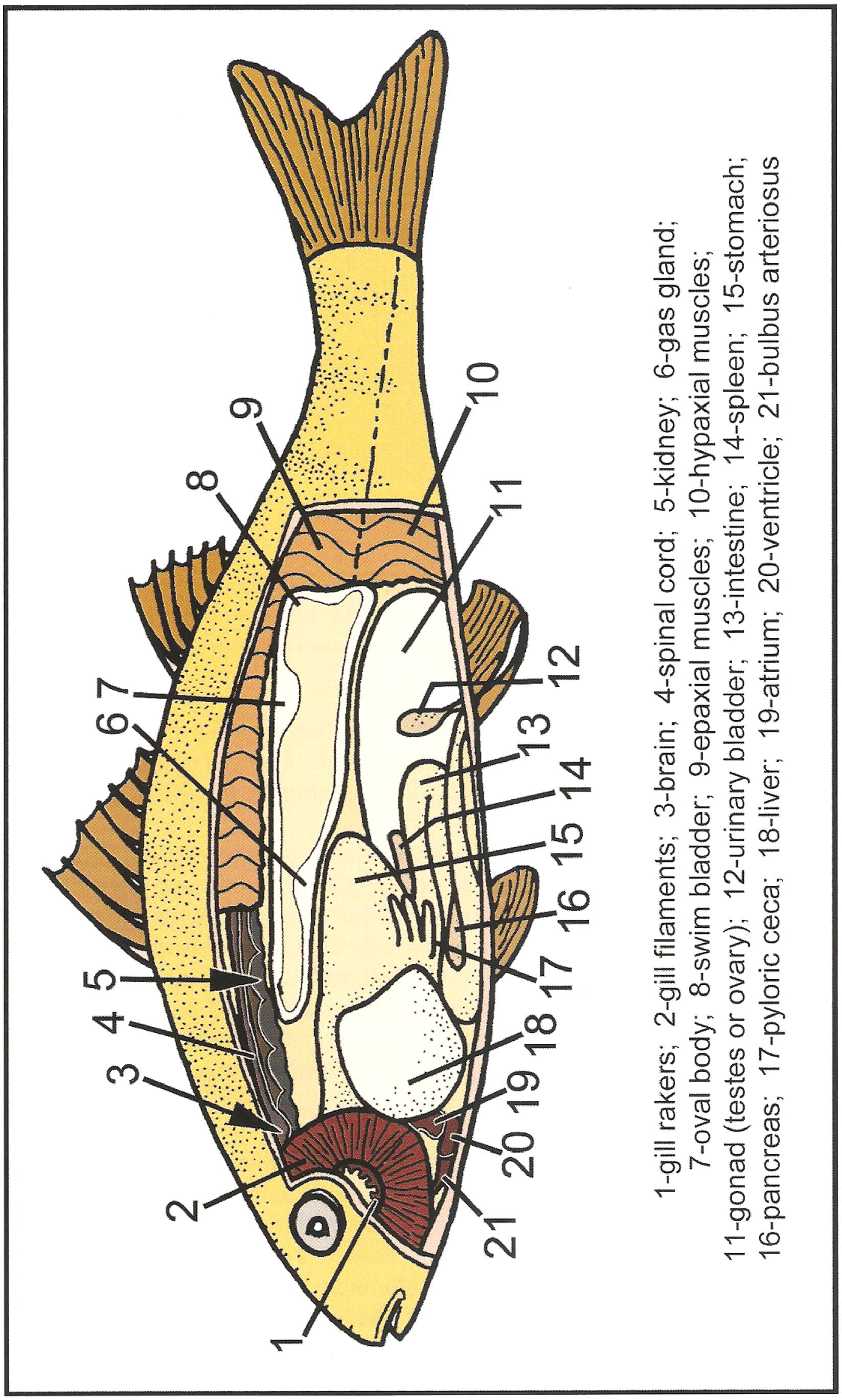
The body cavity, called the **coelom**, is divided into two regions: the anterior **pericardial cavity** and the posterior **peritoneal (coelomic) cavity**. The pericardial cavity houses the heart while the peritoneal cavity houses the liver, stomach, intestine, swim bladder and remaining visceral organs.

There are several membranes lining the body wall and various organs. They support the internal organs within the coelom. You will not be able to see these membranes on your specimen. The body wall is lined by a layer of epithelial tissue called the **parietal peritoneum**. The tissue covering the internal organs is the **visceral peritoneum**. A double layer of peritoneum is referred to as **mesentery**. The mesentery is found dorsal and ventral to the internal organs. It secures them in place within the coelom and contains a multiple blood vessels for oxygen supply. The membranes covering the heart are the inner **visceral pericardium** directly lining the heart and the outer **parietal pericardium**.

The Digestive System

The digestive system consists of the **alimentary canal**, which runs from the mouth to the **anus**. This type of system is considered a **complete digestive system**, since there is an entryway and a separate exit way. The general function of the digestive system is to process food into energy. Food enters the mouth and moves through the **pharynx**, through the **esophagus**, and into the **stomach**. Within the stomach, the food is mixed with acidic gastric juices and is further broken down. From there it passes through the **pyloric cecae** and into the **small intestine**. From there, digested material passes through the **large intestine** and out to the external environment through the **anus**. The digestive glands associated with the digestive process are the **liver**, the **gall bladder**, and the **pancreas**.

figure 14 - The internal organs of the body cavity



Internal features - The following list corresponds to the numbers in figure 14:

1. **Gill rakers** – The gill rakers are located on the **gill arch**. They help protect the fragile gill filaments and filter food particles passing through the pharynx to the gills.
2. **Gill filaments** – The gill filaments have a feathered texture to increase the surface area for oxygen absorption. Oxygen is transported through the gills into the body by a series of small capillaries.
3. **Brain** – The brain is responsible for motor coordination, translating sensory information, and autonomic functions such as heart rate and respiration.
4. **Spinal cord** – The spinal cord is the impulse highway that connects the brain with the rest of the nervous system.
5. **Kidney** – The kidney looks like a dark region that runs along either side of the spinal cord along the body. It is responsible for the removal of nitrogenous waste and eventually leads to the urinary bladder.
6. **Gas gland** – The gas gland is a small structure within the upper wall of the swim bladder. It contains a network of capillaries called the **rete mirable**. Together the gas gland and rete mirable secrete gases such as oxygen into the swim bladder to help maintain neutral buoyancy when the fish dives into deeper water.
7. **Oval body** – The oval body is a small structure that contains numerous capillaries within the lower wall of the swim bladder. It reabsorbs gases from the swim bladder to help maintain neutral buoyancy when the fish ascends into shallower water. *Note: You will probably not be able to see the gas gland or the oval body.*
8. **Swim bladder** – The swim bladder is a gaseous pocket within the body that maintains neutral buoyancy with the help of the gas gland and the oval body. This hydrostatic organ takes in or expels gases to counter the effects of gravity and allow the fish to hover in the water. Not all fish have a swim bladder. Typically, bottom dwelling fish, such as the flounder, lack a swim bladder. *The swim bladder will appear as a membrane you will see as you open the body cavity.*
9. **Epaxial muscles** – The expaxial muscles are located above the median axis of the body. This group of muscles functions in locomotion.
10. **Hypaxial muscles** – The hypaxial muscles are located below the median axis of the body. This group of muscles functions primarily in the support of the internal organs.
11. **Gonad** – "Gonad" is the generic name for the reproductive structure present. Depending on the gender of your fish, you will see either testes or the ovary. The testes are paired and appear cream colored and smooth in texture. An ovary will be more orange in color and granular in texture. Usually the ovary will contain eggs. If your ovary is packed full of eggs, the internal organs may be pushed against the body wall and will be more difficult to identify.
12. **Urinary bladder** – The urinary bladder holds nitrogenous waste received through the mesonephric duct from the kidneys until it is released into the external environment.
13. **Intestine** – The small and large intestine extend from the stomach to the anus. The pyloric cecae extend out from the first portion of the small intestine called the duodenum. It absorbs nutrients from food. *You may notice a slick, yellow substance around the intestine. This is fat tissue and can be carefully removed with your forceps.*
14. **Spleen** – The dark, slender spleen extends between the stomach and the intestine. It is part of the **retriculoendothelial system**, which is the system of macrophage cells. Macrophage cells engulf and digest foreign cells and dead cells in a process called

phagocytosis. The spleen's cells recycle old red blood cells and platelets by removing the iron and other useful components. These cells also process and remove bacteria. The spleen also serves an immune function by initiating responses by specialized cells called T-cells and B-cells. It is the site of the largest concentration of lymphatic tissue in the body.

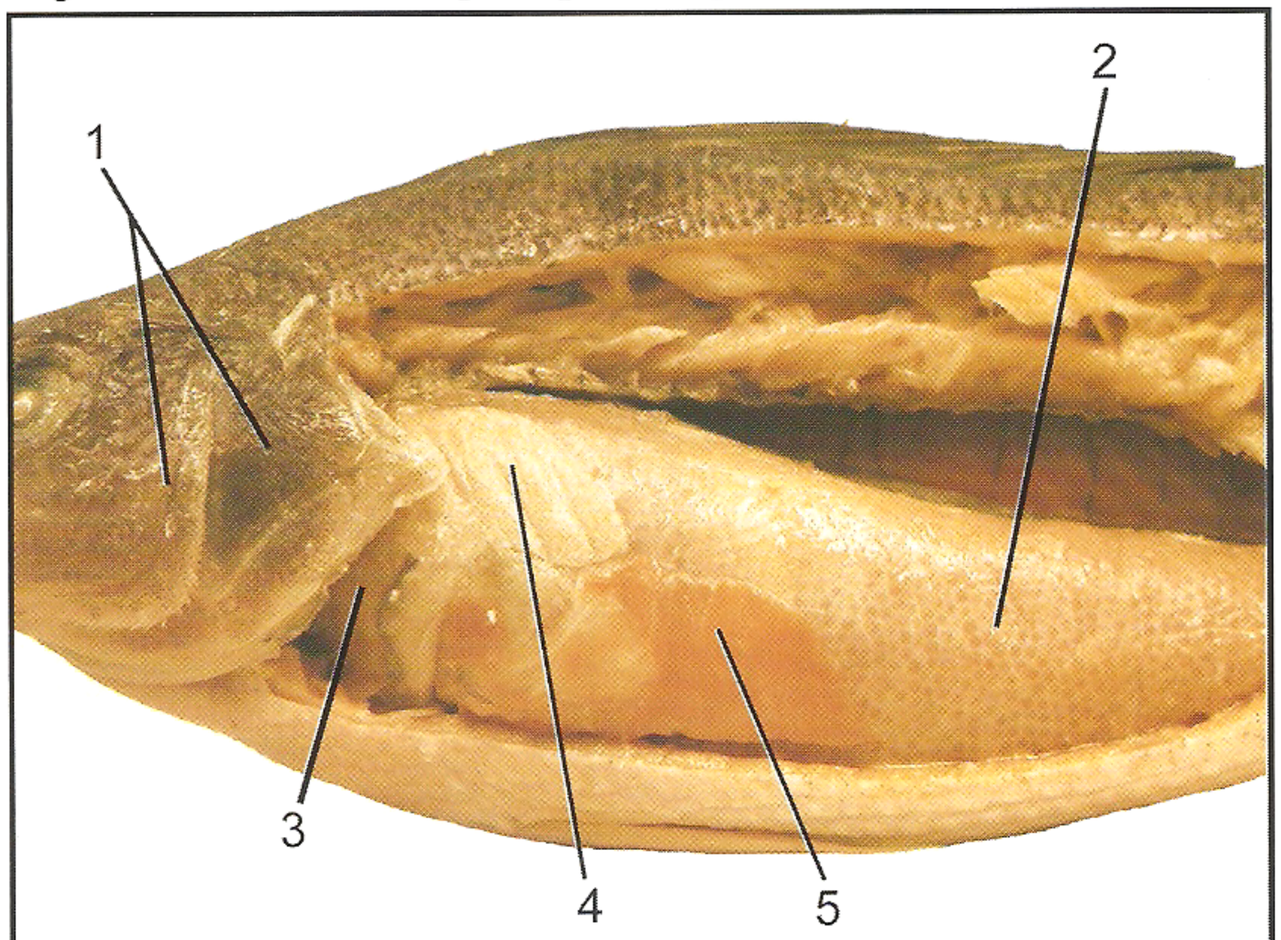
15. **Stomach** – The stomach stores food and absorbs nutrients. It consists of two regions, the cardiac region, closest to the esophagus, and the pyloric region, closest to the duodenum (the first portion of the small intestine). The passage of food from the stomach to the duodenum is regulated by the **pyloric valve**. *You may want to cut open the stomach to see the contents inside.*
16. **Pancreas** – The pancreas is the major gland of the digestive system in vertebrates. It secretes pancreatic (digestive) juices into the intestine. Pancreatic juice is a combination of water, electrolytes, and enzymes. The pancreas also produces hormones that are important in the regulation of sugar levels and the metabolism of fats and carbohydrates. *You may not be able to find this structure, due to its small size and indistinct appearance.*
17. **Pyloric ceca** – The pyloric cecae (*singular=ceca; plural=cecae*) are three finger-like projections extending between the stomach and the intestine. They increase the surface area for more efficient absorption of nutrients. *On some specimens the pyloric cecae is more prominent then on others. You may or may not be able to find them.*
18. **Liver** – The liver on your perch will appear light cream due to the bleaching of the preservative process. The vertebrate liver is the most prominent organ of the body cavity and has many functions. It metabolizes carbohydrates and fats and produces bile and bile salts that emulsify fats in the duodenum (the first portion of the small intestine). Bile is an alkaline solution of bile salts, bile pigments, cholesterol, and other components secreted by the liver. In the duodenum, bile functions in the emulsification, digestion, and absorption of fats. The alkaline nature of bile helps to neutralize the acids in the stomach. The liver contains epithelial cells called **hepatocytes** that contain enzymes that detoxify poisons. The **gall bladder** is located under the right lobe of the liver. It stores and concentrates bile secreted by the liver and delivers it to the duodenum through a series of tubules and ducts.
19. **Atrium** – The atrium is the thin walled portion of the heart. It is connected to the a large chamber, the **sinus venosus**, which you will learn more about in the circulatory system section of this guide. Blood moves through the heart in a series of chambers: the sinus venosus, the atrium, the ventricle, and the bulbus arteriosus.
20. **Ventricle** – The ventricle is the thick walled portion of the heart. It lies between the atrium and the bulbus arteriosus.
21. **Bulbus arteriosus** – The bulbus arteriosus is the most anterior chamber leading to the heart.

Individual Variation – figures 15 - 17

Like many complex vertebrates, perch have a lot of individual variation. For example, the liver on one individual may be reduced, while on another individual it is the prominent organ of the peritoneal cavity. To compensate for this wide disparity make sure to see some of your classmate's specimens.

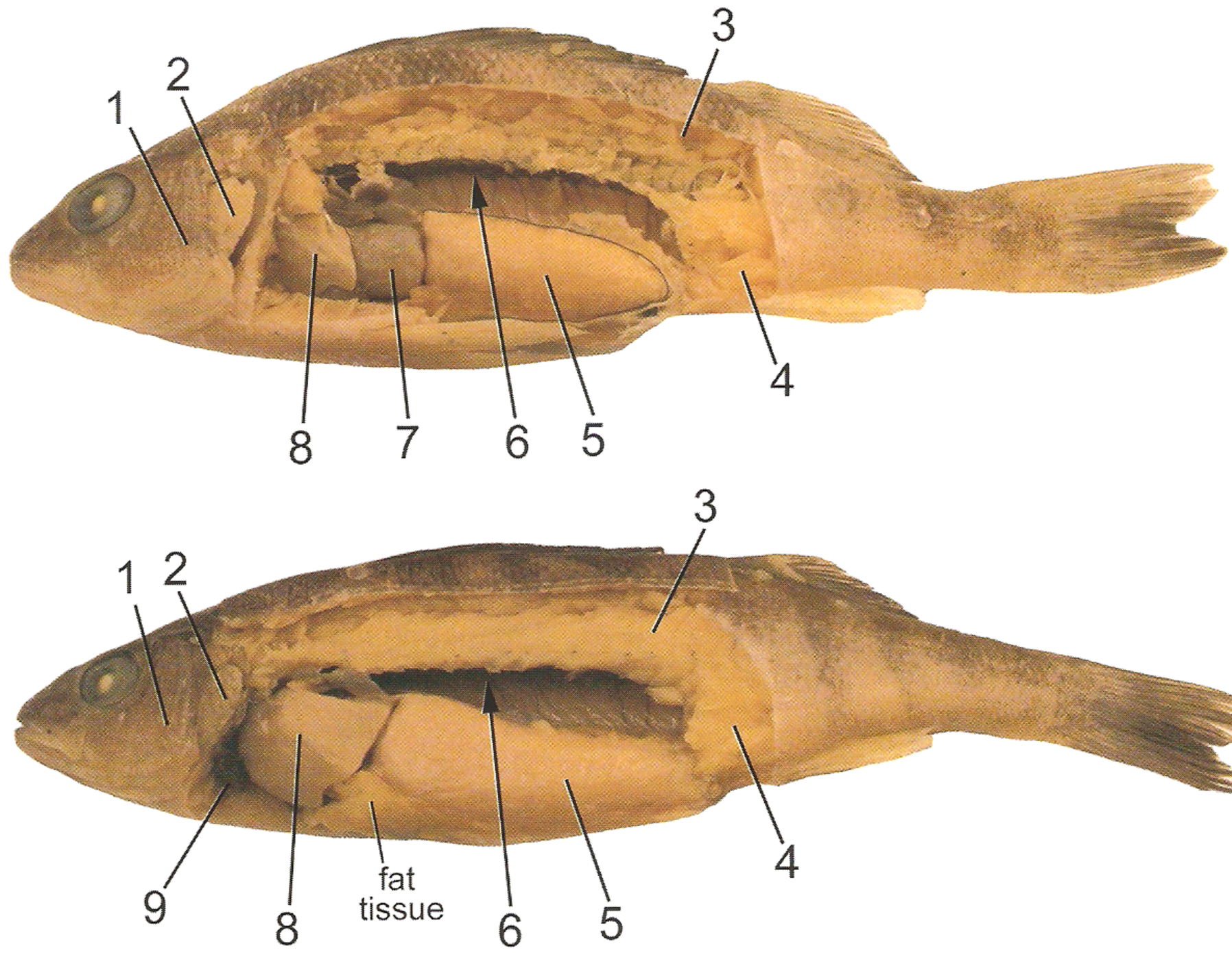
In addition to the naturally occurring individual variation, perch will differ in the size of their gonads. As part of the reproductive cycle, the gonads will grow during the breeding season. They are the largest in the winter months and especially just before spawning. If you have a gravid female, the organs will be crushed and it may be tricky to differentiate them (figure 15). If this is the case, make sure to view another specimen.

figure 15 - Female in pre-spawning state



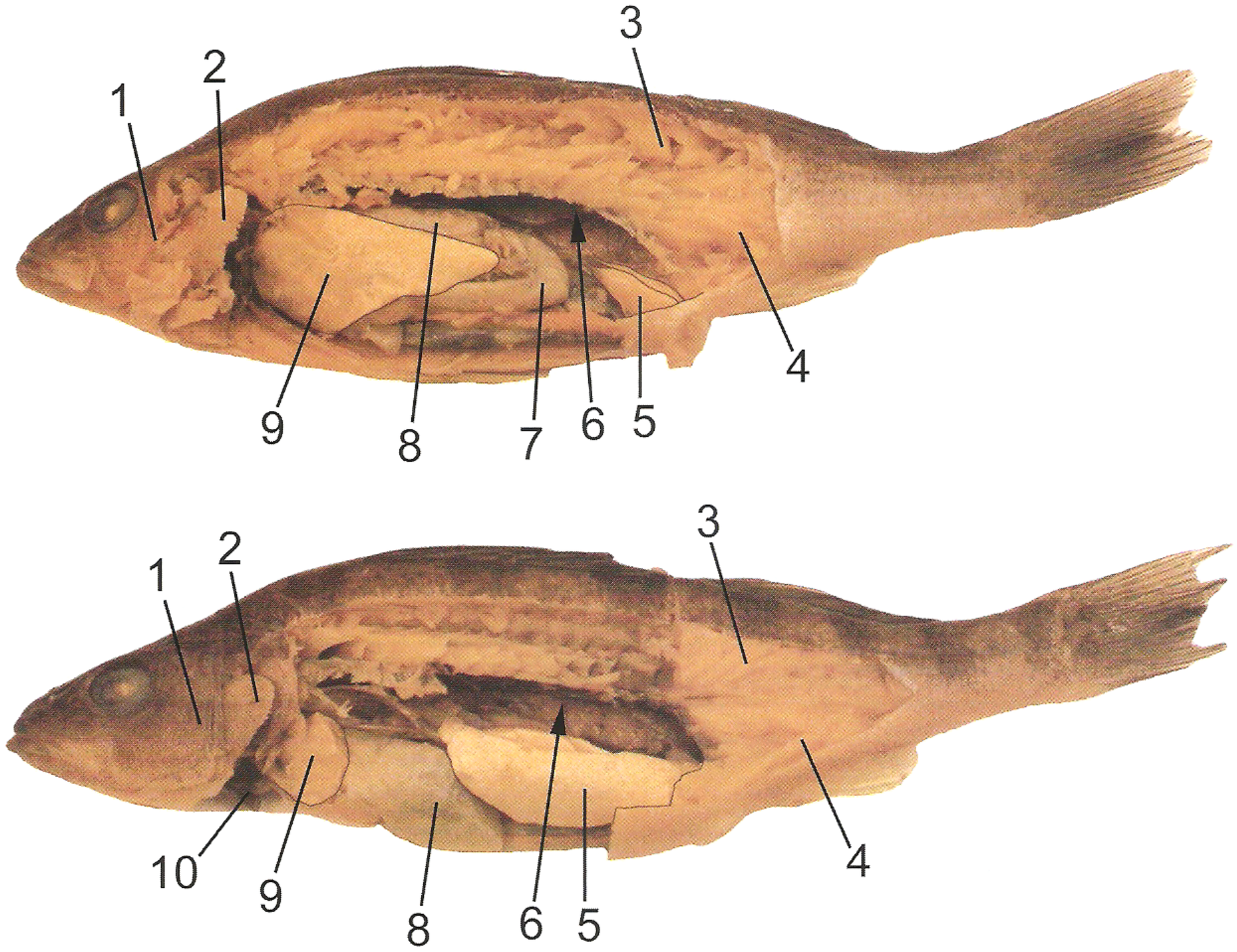
1-gill operculum; 2-ovary filled with eggs;
3-liver; 4-stomach; 5-fat tissue

figure 16 - Female individual variation



1-gill operculum; 2-gills; 3-epaxial muscles; 4-hypaxial muscles; 5-ovary (with eggs inside);
6-spinal cord & kidney; 7-stomach; 8-liver; 9-heart

figure 17 - Male individual variation



1-gill operculum; 2-gills; 3-epaxial muscles; 4-hypaxial muscles; 5-testes;
6-spinal cord and kidney; 7-intestine; 8-stomach; 9-liver; 10-heart

The Urogenital System

The urogenital system consists of the excretory system and the reproductive system, which differs between the male and female. The excretory system removes liquid nitrogenous waste from the body. The reproductive system produces young.

Note: If your specimen is sexually immature you will not see many of the structures listed. If this is the case, try to see a specimen from one of your classmates. Make sure to observe structures of both genders.

The Excretory System

The most prominent organs of the excretory system are the kidneys, which filter hydrophilic substances such as ions, water, urea and other nitrogenous wastes. They run along the vertebral column above the swim bladder. Eventually they empty through the mesonephric ducts (also called the Wolffian ducts) into the urinary bladder. Waste is excreted to the external environment through the excretory pore. On the female, a single excretory pore called the urogenital pore serves both the reproductive and excretory systems. On the male, the urinary pore functions for the excretory system, while the separate genital pore provides the opening for the reproductive system.

The Reproductive System

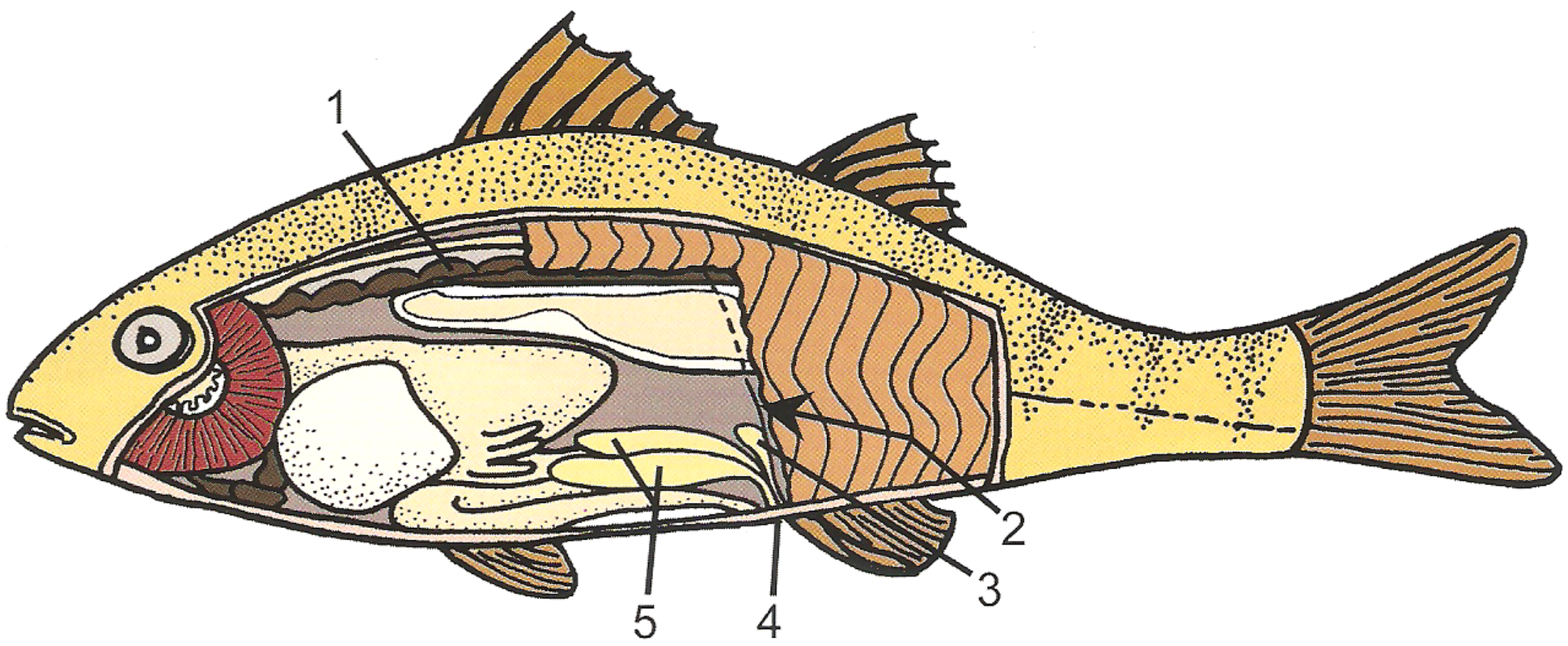
Like many aquatic animals, the majority of fish (including the perch) is **oviparous** (egg-laying) and undergoes **external fertilization**. In terms of physical morphology, perch are **dioecious**, since the male differs from the female. Even though most fish are oviparous, some species may be **ovoviviparous** (produce eggs with yolks to nourish the embryos, but bear live young), or **viviparous** (bear live young; in the uterus the embryos are nourished by the placenta).

The Perch Life Cycle

Perch characteristically live ~7 years. The males reach sexual maturity at 2-3 years old and females at 3-4 years old. When they are ready to reproduce, the females move into shallow water where there are plenty of weeds to protect the young. Males follow the females in preparation for the spawning. Typically, spawning is induced according to water temperature. For the perch, this is 45° F (7°C), which usually occurs in the spring. The female releases thousands of eggs, which one or more males fertilize. After fertilization, the male(s) and female separate. Perch, like most fish, do not exhibit any kind of parental care.

The developing embryos hatch within two weeks. The young larvae are small and feed on zooplankton, but still may be nourished by the yolk sac from the egg. As they grow, they become pelagic (move to open water). Once they achieve a length of approximately 1 inch (25 mm) long, they return to the shallow, weedy regions of the lake.

figure 18 - Male urogenital structures



Male: 1-kidney; 2-mesonephric duct; 3-urinary bladder;
4-excretory pores: anus, genital pore, and urinary pore; 5-paired testes

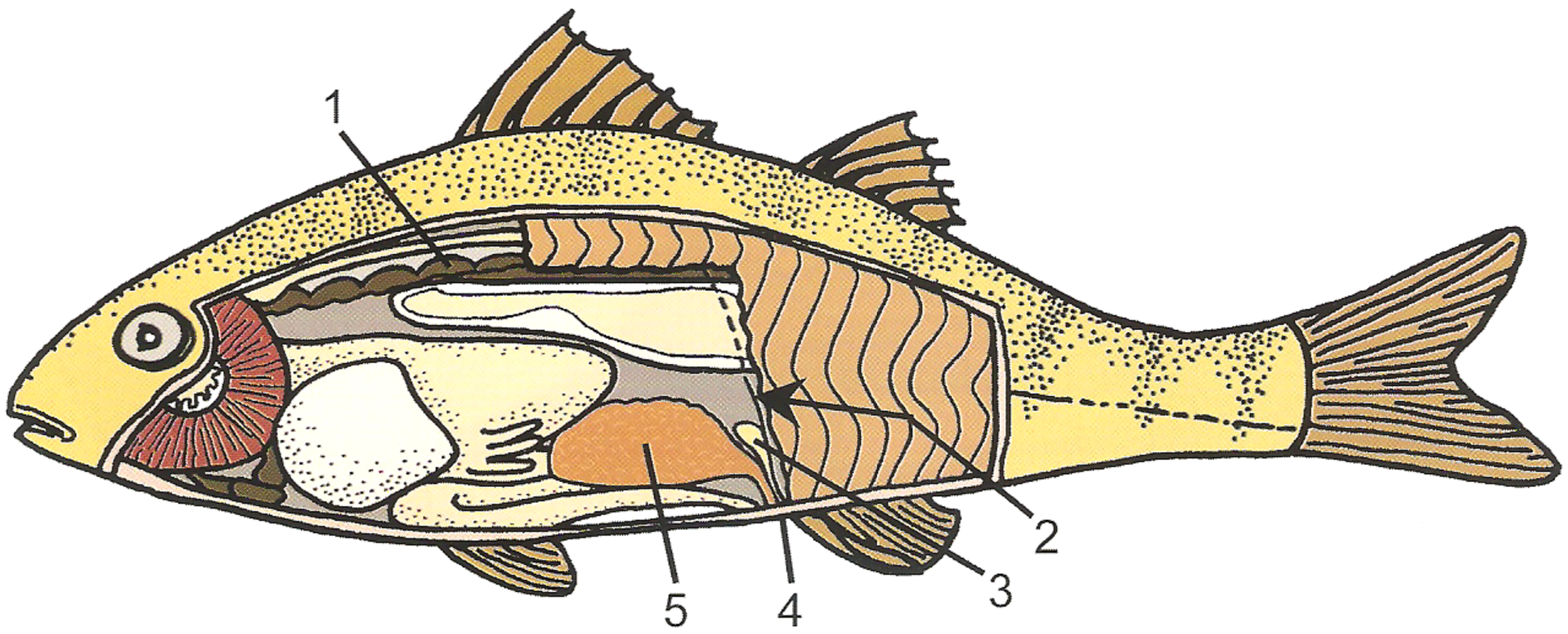
Male Urogenital Structures

The following list of structures and functions corresponds to figure 18.

1. **Kidney** – The kidneys are diffused organs that run along either side of the vertebral column and are positioned above the swim bladder. They are responsible for the excretion of hydrophilic substances such as ions, water, and other nitrogenous wastes. Despite having a different appearance than other vertebrate kidneys, fish kidneys function in a similar manner.

2. **Mesonephric duct** – The mesonephric ducts, also sometimes called the Wolffian ducts, extend from the kidneys to the urinary bladder.
3. **Urinary bladder** – Waste is stored in the urinary bladder until it is released into the external environment through the urinary pore.
4. **Excretory pores**:
    a. **Anus** – The anus is the excretory pore for the digestive system. Waste received from the intestine is released to the external environment through this pore. This is the most anterior pore.
    b. **Genital pore** – The genital pore is the excretory pore for the reproductive system. Sperm is received from the sperm ducts and is released over the female's eggs during fertilization. This pore lies between the anus and the urinary pore.
    c. **Urinary pore** – The urinary pore is the excretory pore for the excretory (urinary) system. Liquid waste is received from the urinary bladder to be released into the external environment.
5. **Paired testes** – The male's reproductive organs are the testes, which are paired. The testes *(testis=singular, testes=plural)* are the site of the production of sperm and androgen hormones. Two channels, called the sperm ducts (also called the vas deferens), extend from the testes and join together to release sperm out the genital pore.

figure 19 - Female urogenital structures



1-kidney; 2-mesonephric duct; 3-urinary bladder;
4-excretory pores: anus and urogenital pore; 5-ovary

Female Urogenital Structures

The following list of structures and functions corresponds to figure 19.

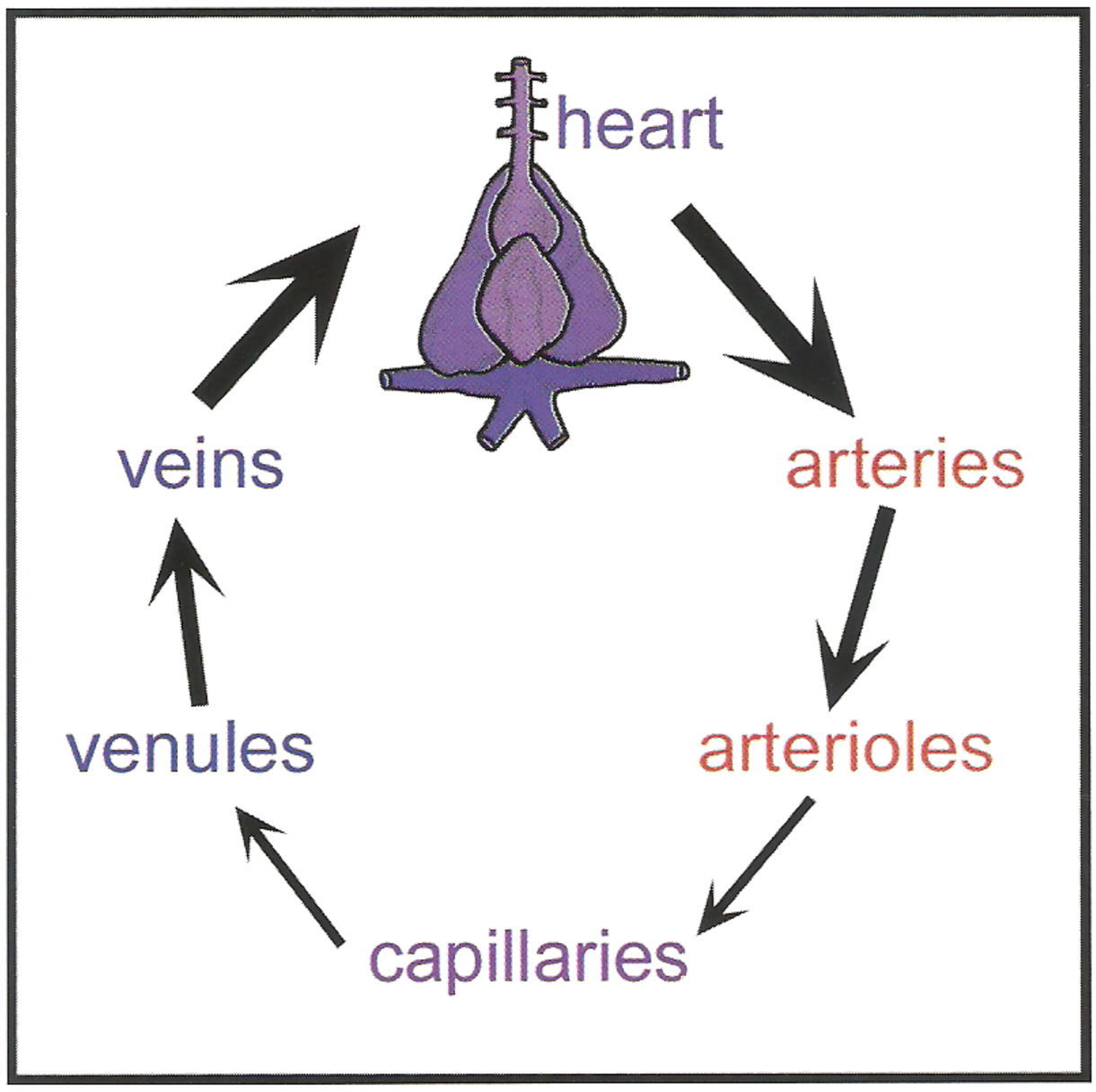
1. **Kidney** – The kidneys are diffused organs that run along either side of the vertebral column and are positioned above the swim bladder. They are responsible for the excretion of hydrophilic substances such as ions, water, and other nitrogenous wastes. Despite having a different appearance than other vertebrate kidneys, fish kidneys function in a similar manner.
2. **Mesonephric duct** – The mesonephric ducts, also sometimes called the Wolffian ducts, extend from the kidneys to the urinary bladder.

3. **Urinary bladder** – Waste is stored in the urinary bladder until it is released into the external environment through the urinary pore.
4. **Excretory pores**:
    a. **Anus** – The anus is the excretory pore for the digestive system. Waste received from the intestine is released to the external environment through this pore. This is the most anterior pore.
    b. **Urogenital pore** – The urogenital pore is part of the reproductive and excretory (urinary) systems. It releases both eggs (during spawning) and liquid waste to the external environment. The urinary bladder comes together with the oviduct (a tube that extends out from the ovary) to form a cavity called the urogenital sinus, which eventually empties through the urogenital pore.
5. **Ovary** – The single ovary may or may not be filled with eggs (figure 15), depending on what time of the breeding season the fish was harvested. The ovary is the site of oogenesis (creation of eggs) and production of sex hormones. While spawning, eggs released from the ovary pass through the oviduct, to the urogenital sinus, and out into the water through the urogenital pore.

Respiration – figure 21 (next page)

A perch "breathes" by extracting the oxygen present in the water in which it lives. Water is taken in by the mouth and passes out through the **gills**. As it passes over the gills, it moves through the **gill filaments** and through the smaller **gill lamellae** (*lamella=singular; lamellae=plural)*, which contain **capillary beds** that extract the oxygen. The gill lamellae increase the surface area available for the removal of oxygen. The **efferent and afferent branchial arteries** transport blood to and from the gills. The gills are somewhat fragile and are protected by the **gill operculum**. The **gill rakers** further protect the gills by straining out food particles that are passing through the pharynx.

figure 20 - General circulation scheme



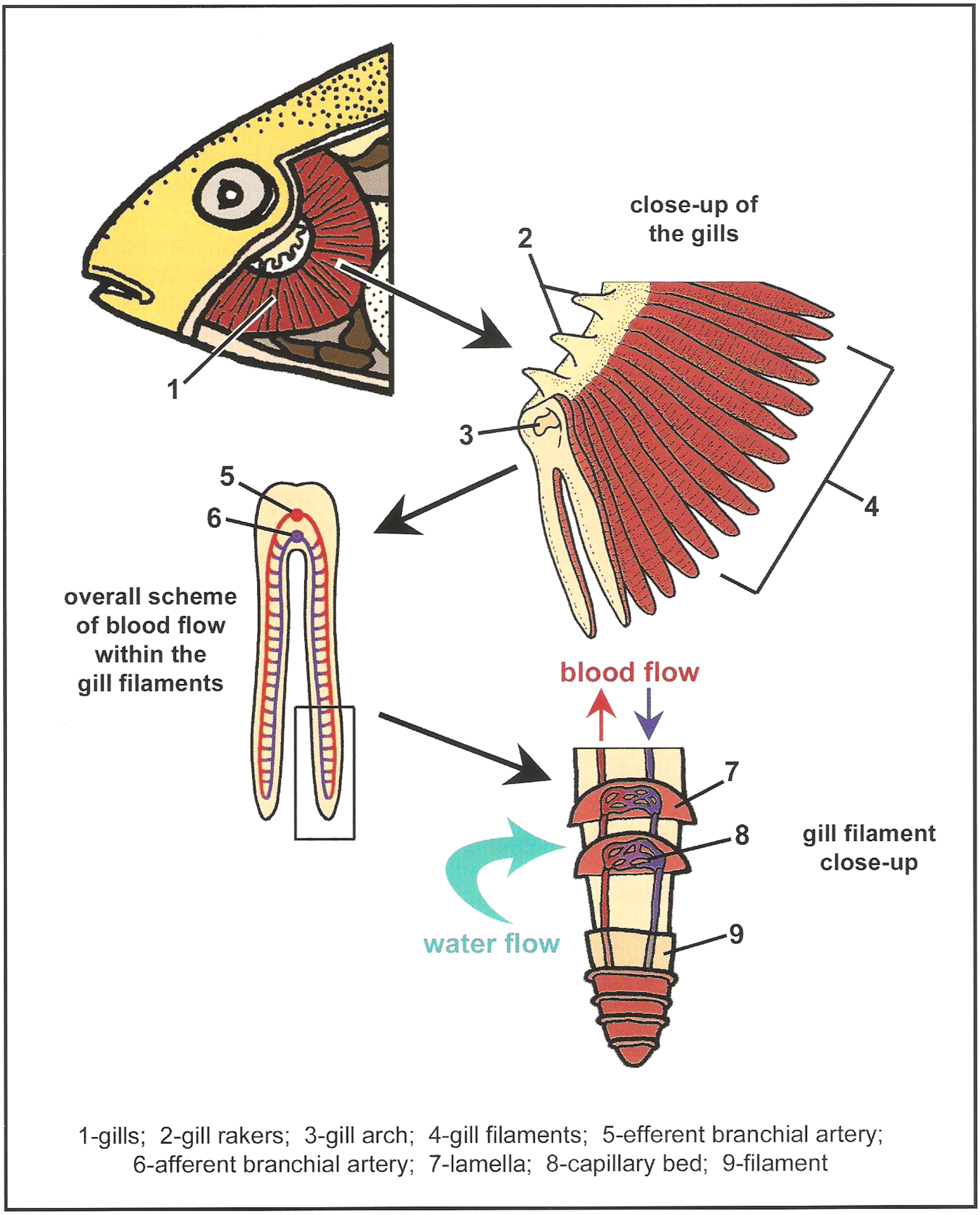
The Circulatory System

figures 20-23

Note: The arteries and veins on the perch can be difficult to see. You may choose to study the illustration rather than your specimen.

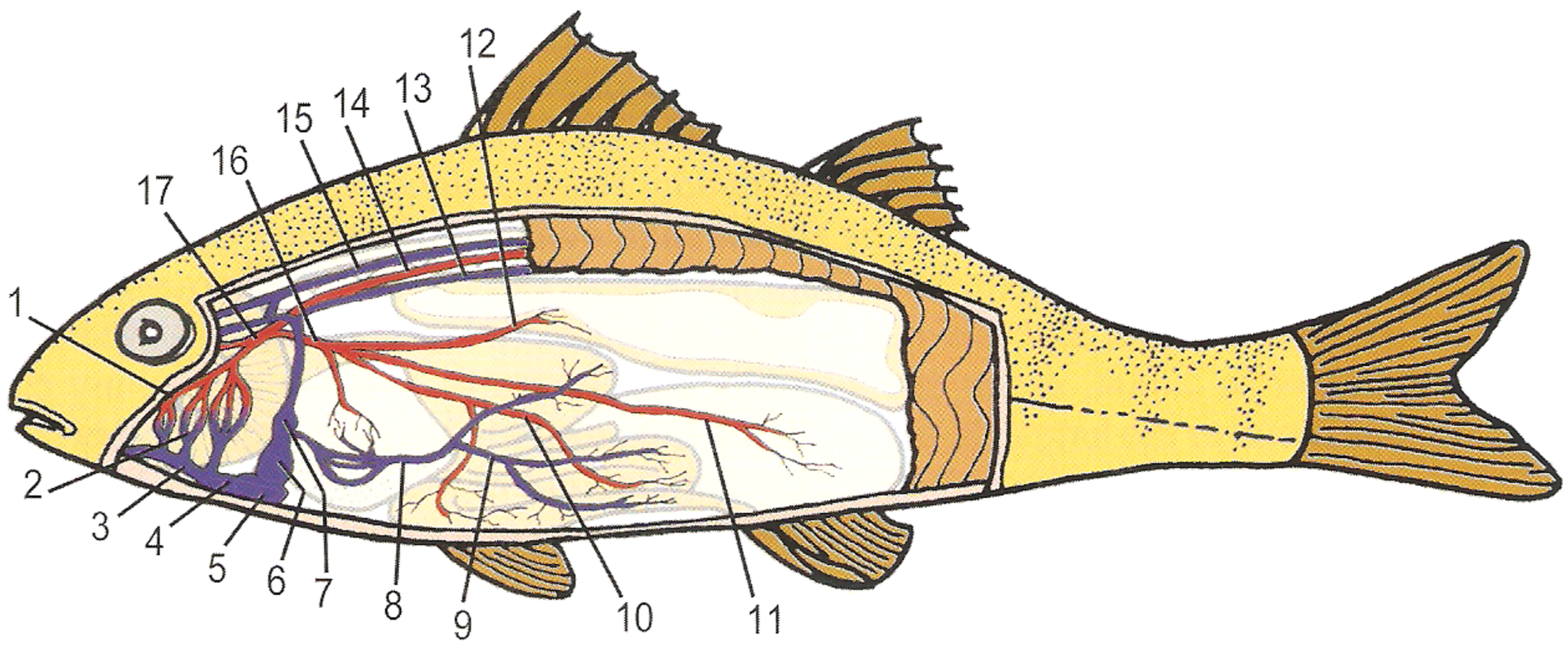
Blood flows through a series of vessels to transport oxygen and carbon dioxide throughout the body. In general, **arteries** and **arterioles** are thick-walled vessels that carry blood away from the heart. **Veins** and **venules** are thin-walled vessels that carry blood back towards the heart. The **capillaries** are the smallest vessels where the gases are exchanged with the cells of the body.

figure 21 - Structures of the gills



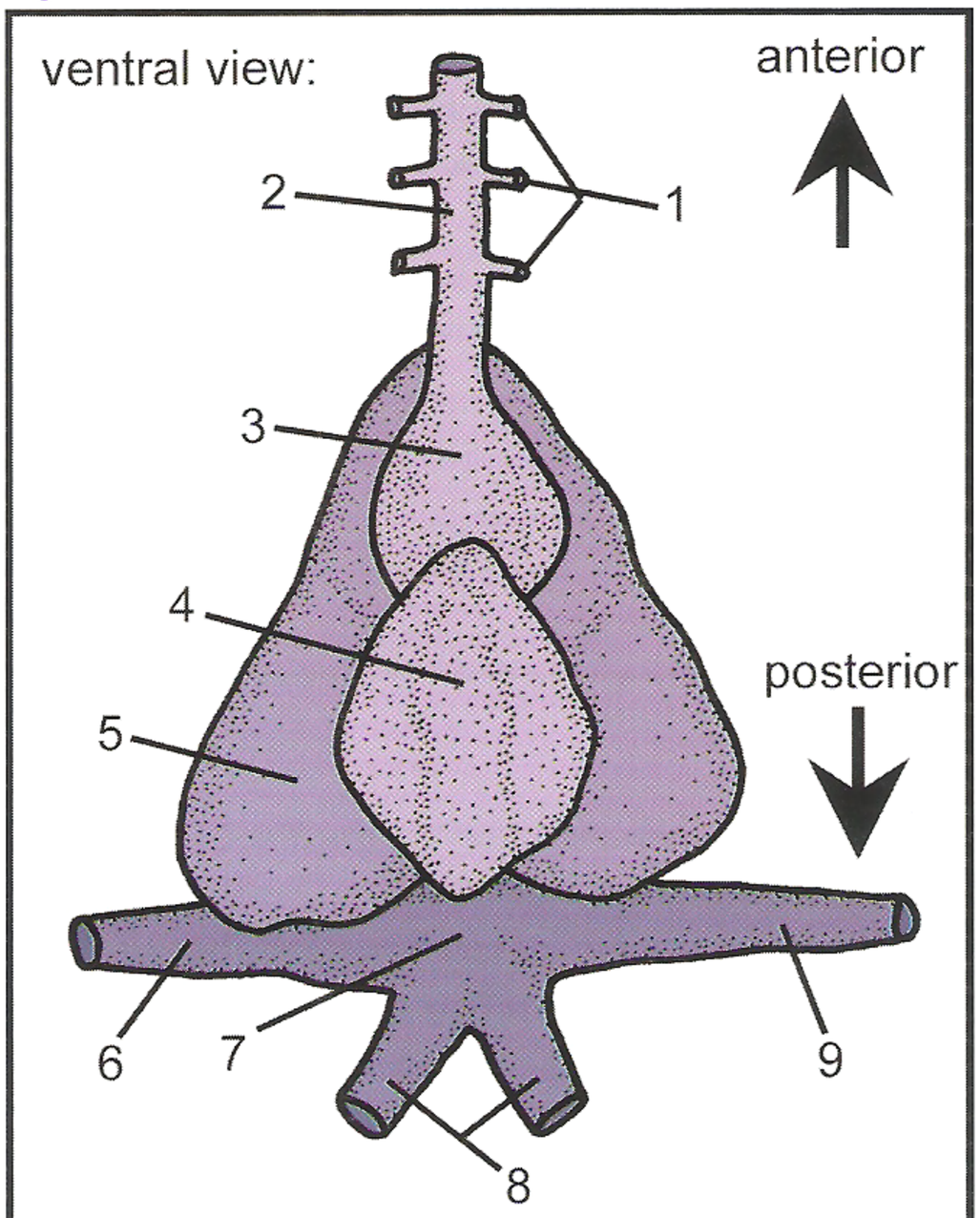
1-gills; 2-gill rakers; 3-gill arch; 4-gill filaments; 5-efferent branchial artery;
6-afferent branchial artery; 7-lamella; 8-capillary bed; 9-filament

figure 22 - Major veins and arteries



1-efferent branchial arteries; 2-afferent branchial arteries; 3-ventral aorta; 4-bulbus arteriosus; 5-ventricle; 6-atrium; 7-sinus venosus; 8-hepatic portal vein; 9-intestinal vein; 10-intestinal artery; 11-gonadal artery; 12-pneumatic artery; 13-left posterior cardinal vein; 14-dorsal aorta; 15-right posterior cardinal vein; 16-celiac artery; 17-branched region of the dorsal aorta

figure 23 - Structures of the heart and related blood vessels



1-afferent branchial arteries; 2-ventral aorta; 3-conus arteriosus; 4-ventricle; 5-atrium; 6-right cardinal vein; 7-sinus venosus; 8-hepatic veins; 9-left cardinal vein

The Heart – figures 22-23

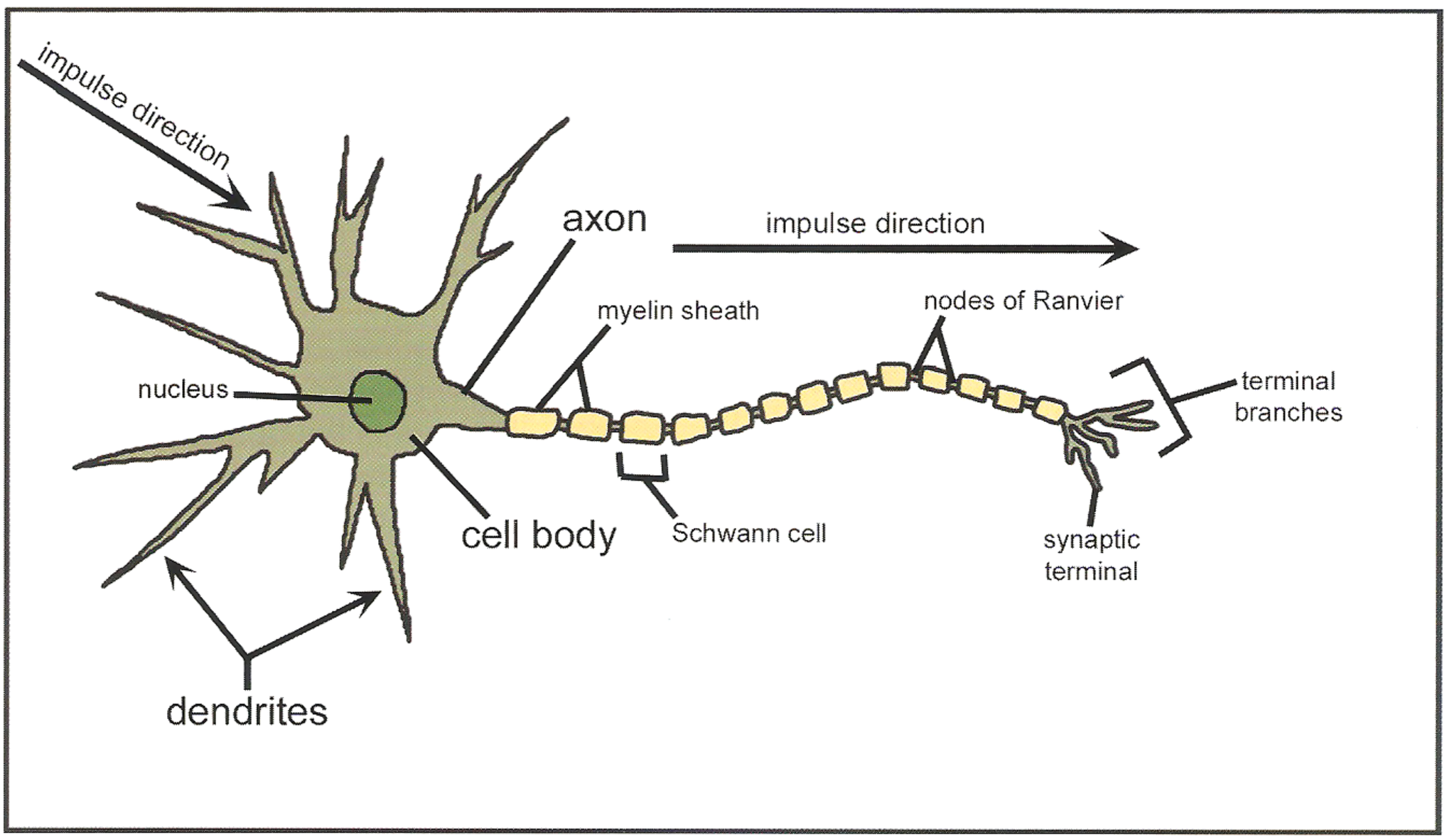
The heart is contained in the **pericardial cavity**. The rest of the body's organs are contained in the **abdominal cavity**. These two cavities are separated by the **transverse septum**. Technically, the heart consists of two chambers: the **ventricle** and the **atrium**. The ventricle is the muscular ventral portion of the heart. The atrium is the dorsal larger portion of the heart. Two other chambers are closely associated with the heart: the **conus arteriosus** (sometimes called the bulbus arteriosus) and the **sinus venosus**.

Blood flows from the **conus arteriosus** to the **ventral aorta**, through the **afferent branchial arteries** to be oxygenated in the **gills**. Once oxygenated, the blood travels from the **efferent branchial arteries** to the **dorsal aorta**. The dorsal aorta and subsequent vessels supply blood to all the organs of the body. Once delivered throughout the body, the blood returns to the heart via the **hepatic and cardinal veins** and empties into the **sinus**

venosus. Blood is then pumped into the **atrium** and into the **ventricle**. The pumping action of the ventricle is the driving force in circulation. Each contraction of the ventricle, called the **systolic period** of the heartbeat, forces blood into the **bulbus arteriosus**, which increases the pressure in that chamber. During the **diastolic period** of the heartbeat, in which the ventricle relaxes, this pressure is maintained in the bulbus arteriosus. Within the heart are a series of valves that prevent the backflow of blood. These valves, along with the constant pressure in the bulbus arteriosus, allow for smooth and even circulation throughout the body.

Fishes have a circulatory system that differs from other vertebrates. Mammals and other terrestrial vertebrates have a double circuit system of circulation, in which there are two separate circuits: the systemic circuit, which supplies blood to the body; and the pulmonary circuit, which supplies blood to the lungs. In all the fishes, including the perch, the circulatory system consists of a **single circuit**. The blood that is pumped out of the heart travels through the vessels in the gills and the vessels of the visceral organs in one large circuit.

figure 24 - The vertebrate neuron

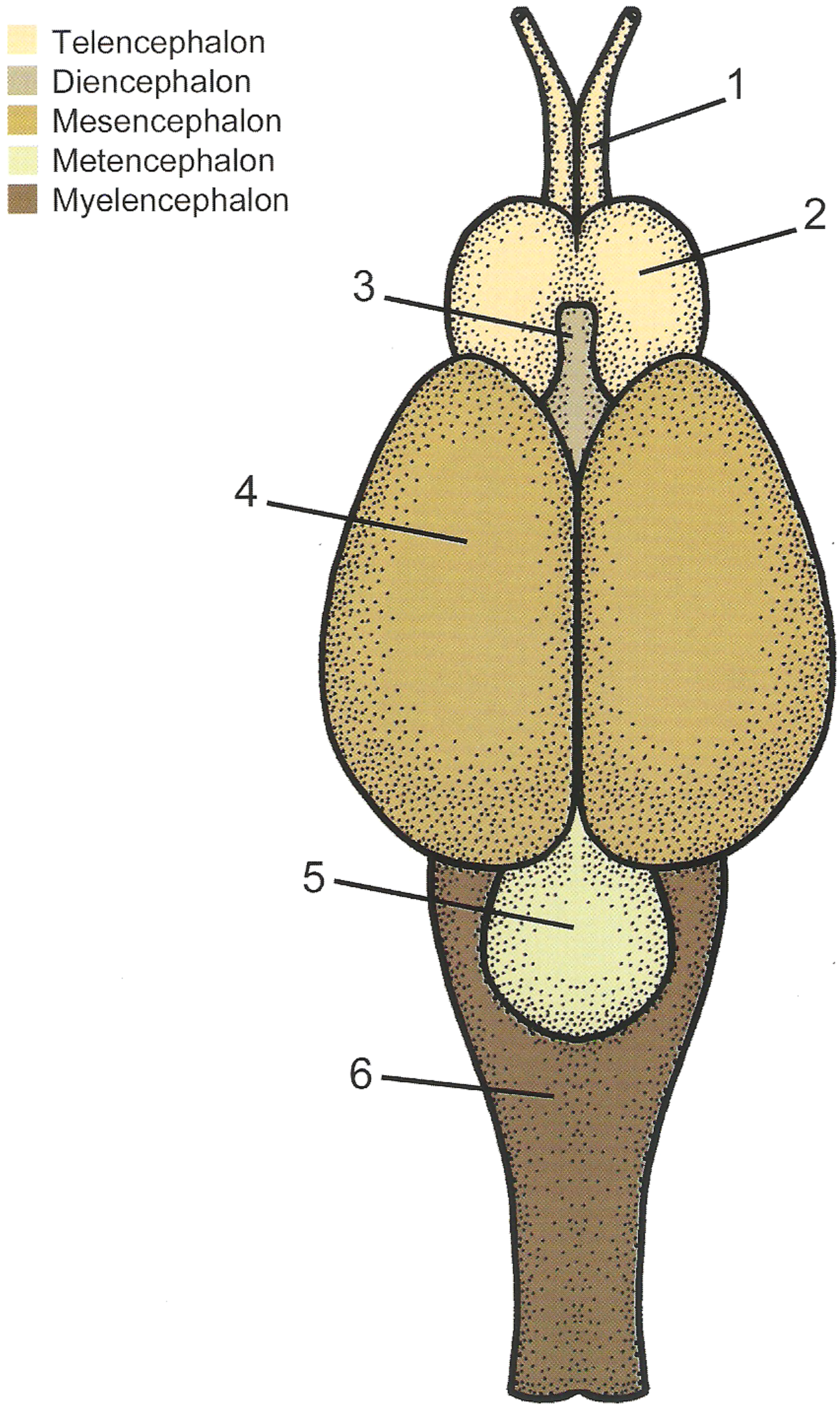


The Nervous System - figures 24-26

Many of the nerves of the perch can be difficult to find. Nerves are a bundle of neurons bound together by connective tissue. They will appear as thin, white cords. The perch brain may be difficult to access, since you will need to enter the cranial cavity through the skull. If you decide to look at your perch brain, it is best to approach it from the dorsal side. When removing the skull, shave away the skull with your scalpel (or a razor blade) in layers. You may decide to study the illustration provided.

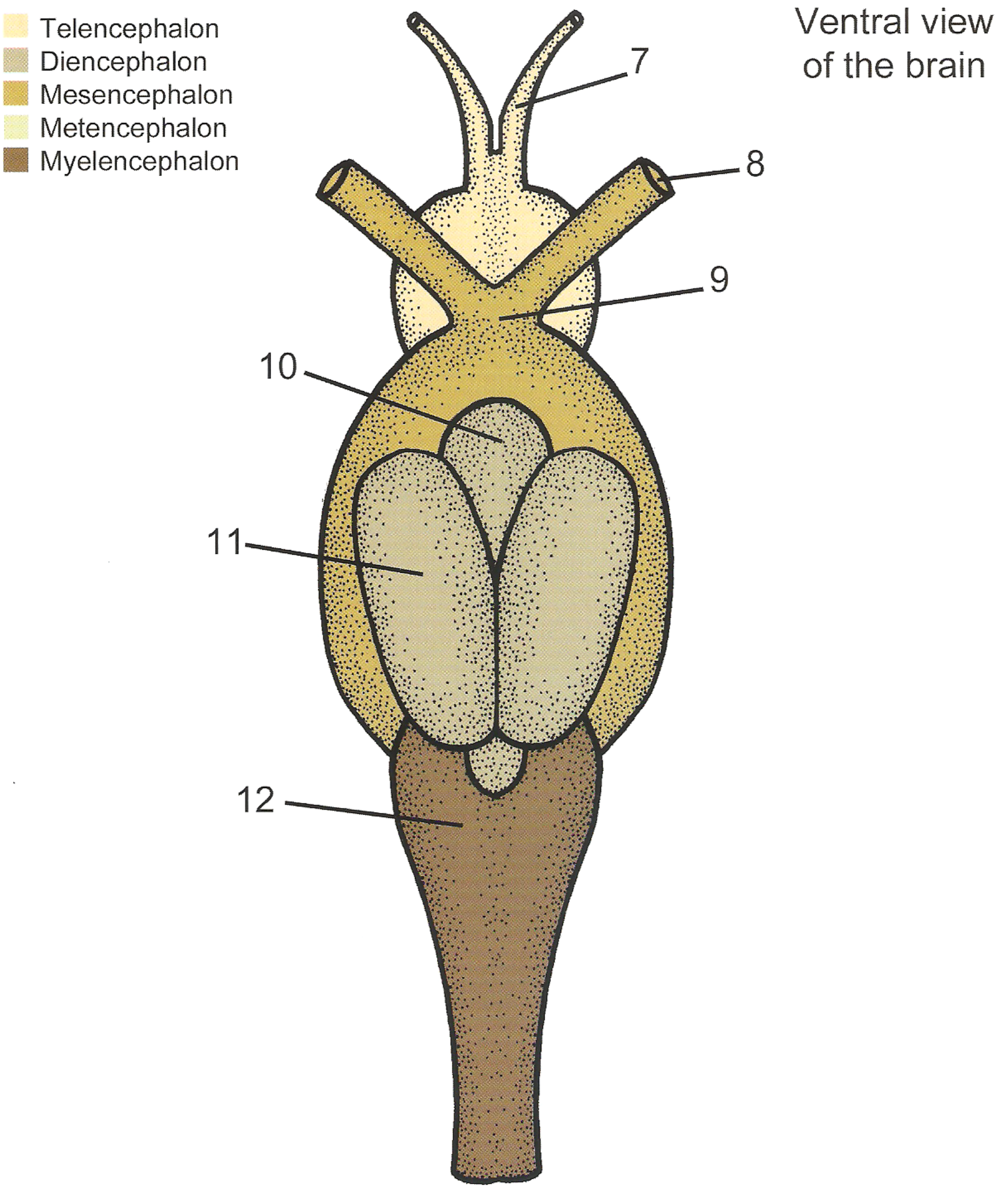
The nervous system in fishes and other higher vertebrates consists of the **central nervous system (CNS)** and the **peripheral nervous system (PNS)**. The central nervous system consists of the brain and the nerves along the spinal column (the spinal cord). The peripheral nervous system connects the central nervous system to the organs and other regions of the body.

figure 25 - Dorsal structures of the brain



1-olfactory tract; 2-cerebrum; 3-pineal body; 4-optic lobe;
5-cerebellum; 6-medulla oblongata

figure 26 - Ventral structures of the brain



7-olfactory tract; 8-optic nerve; 9-optic chiasma; 10-pituitary gland;
11-inferior lobe; 12-medulla oblongata

In general, the nervous system is responsible for distributing sensory and motor impulses. A nerve impulse is an electrical signal transmitted along **neurons**. A neuron consists of a **cell body** with a **nucleus**, branching extensions called **dendrites**, and a single extension called an **axon**. Dendrites transmit nerve impulses toward the cell body and the axon carries them away from the cell body to the synaptic terminal. The axon in the vertebrate peripheral nervous system is supported by a series of cells called **Schwann cells** that are protected by the **myelin sheath**. The myelin sheath functions as insulation to the cells. The spaces between the **Schawann cells** are referred to as the **nodes of Ranvier**. The axon ends in hundreds to thousands of **terminal branches**. At the terminal, the impulse connects with another nerve or an **effector** such as a muscle fiber. This junction is called a **synapse**. An effector is a cell or organ that responds to the nervous system in response to a stimulus. The stimulus is perceived through a **receptor**. Eyes, ears, and nose are considered organ receptors. Neurons are found throughout the body's nervous tissue and in the brain and spinal cord.

Regions of the Brain

The perch brain consists of five major regions:

Telencephalon – The telencephalon contains the olfactory tracts, the olfactory lobes, and the cerebrum. The olfactory structures function to translate chemical odors into information. In general, the cerebrum is responsible for motor coordination and deciphering sensory input.

Diencephalon – The diencephalon contains the pineal gland (also called the epiphysis), the thalamus, the hypothalamus, and the pituitary gland. The pituitary gland is technically not part of the central nervous system, but is highly associated with it. The pituitary gland is an endocrine gland that triggers other endocrine glands through hormone signaling. The diencephalon also controls the visceral activities in the body.

Mesencephalon – The mesencephalon contains the optic lobes, which are important for deciphering visual input.

Metencephalon – The metencephalon contains the cerebellum. The cerebellum is responsible for balance and equilibrium, motor coordination, and muscle tone.

Myelencephalon – The myelencephalon contains the medulla oblongata. This region is responsible for autonomic functions such as respiration, blood circulation, heart rate, swallowing reflex, and other involuntary functions. In terms of evolution, this was one of the first and most vital structures to appear.

Anatomical terms:

Anterior – Refers to the head region.
Cranial – Refers to the head region in many animals, including quadrupeds.

Posterior – Refers to the tail region.
Caudal – Refers to the tail region in many animals, including quadrupeds.

Dorsal – Refers to the upper surface.
Superior – Refers to the upper surface in many animals, including quadrupeds.

Ventral – Refers to the under surface.
Inferior – Refers to the under surface in many animals, including quadrupeds.

Lateral – Refers to the side.
Medial – Refers to the midline.

Proximal – Refers to the attached end of a structure.
Distal – Refers to the free end of a structure.

Key terms
The definitions of the following terms are basic and are described only as they pertain to the information in this guide. For further explanations, refer to a biology dictionary or textbook.

Abduction – Moving an extremity or some other part of the body away from the ventral median axis of the body. Example: moving the arm out to one side. (*ab = from*)
Action – The movements produced by muscles.
Adduction – Moving an extremity or some other part of the body towards the ventral median axis of the body. Example: moving a raised arm back to a resting position. (*ad = to*)
Antagonism – Two or more systems in an opposing relationship.
Antagonistic action – The complementary action produced by paired muscles; one muscle that produces contraction, the other that produces the opposite action, relaxation.
Appendicular skeleton – In vertebrates, the bones of the extremities, pelvic girdle, and pectoral girdle.
Axial skeleton – In vertebrates, the skull and the vertebral column.
B-cells – A type of lymphocyte that is responsible for the humoral immune response. B-cells differentiate into antibody producing plasma cells when triggered by antigens.
Belly – The central part of a muscle.
Bile – An alkaline solution of bile salts, bile pigments, cholesterol, and other components secreted by the liver. Bile is stored in the gallbladder and delivered to the duodenum through the bile duct. In the duodenum, bile functions in the emulsification, digestion, and absorption of fats.
Bipedal – An animal with the ability to walk on two legs.
Blastopore – In embryology, the opening to the future gut of the embryo in the gastrula stage.
Carnivore – An animal that obtains its nutrients by eating other animals.
Cephalization – A gathering of ganglia, or nervous tissue and formation of a head in the anterior region.

Closed circulatory system – A system of circulation in which the blood is enclosed within vessels throughout the body cavity (the coelom).
Coelom – A body cavity that is completely lined with mesoderm tissue.
Complete digestive system – A system of digestion in which food moves through the animal through an entryway (usually the mouth) and an exit-way (usually the anus).
Copulation – The sexual union of two individuals.
Deuterostome development – In embryological development, the blastopore develops into the anus; exhibits radial and indeterminate cleavage.
Digitigrade – The specialized gait of an animal in which only the digits (the fingers and toes) make contact with the ground. This is often seen in animals capable of rapid movement.
Diurnal – Most active during the day.
Endocrine gland – A ductless gland that generally produces hormones distributed in the bloodstream.
Euchordates – An informal group of animals that include the animals with a cranium.
Exocrine gland – Any gland that produces secretions and uses a duct for distribution.
Fascia – A sheet of connective tissue. Example: the layer of adipose tissue (a type of loose connective tissue) that lies under the dermis.
Ganglion *(ganglion=singular; ganglia=plural)* – A bundle of nerve cell bodies and the centers for the coordination of nerve impulses in vertebrates.
Gestation – In a viviparous animal, the time period between fertilization and birth.
Gonad – An animal's reproductive organ.
Gravid – Pregnant or heavy with eggs.
Hydrophilic – Having an affinity for water.
Hydrostatic pressure – The pressure created from a volume of fluid.
Insertion – The end of a muscle that is connected to a movable part of the skeleton.
Integument – A protective body covering in animals. In mammals, the integument consists of the epidermis, dermis, and various glands.
Lactation – In mammals, the time period when the mother nourishes it's young by producing milk in the mammary glands.
Lymphocytes – A type of white blood cell that plays a role in immune responses. There are two principle types of lymphocytes, B-cells and T-cells.
Macrophage cell – A leukocyte (white blood cell) responsible for engulfing and destroying foreign material and cell debris. It is considered part of the immune response in the reticuloendothelial system.
Marsupial – A pouched mammal considered more primitive than placental mammals. The pouch holds the immature young after birth and protects while they develop and mature. Within the pouch, they are nourished by the mammary glands. Examples: kangaroo, opossum, koala bear. Most marsupials are from Australia.
Metamerism – The segmentation of the body.
Monotreme – A mammal that lays eggs. After the young hatch, they move to a pouch where they are protected and nourished in a similar manner as the marsupials. The mammary glands of monotremes are primitive and lack nipples. The milk is transferred through specialized ducts.
Neutral bouyancy – The specific lightness achieved in the water without rising to the surface or sinking; maintaining a hovering stance.
Nocturnal – Most active at night.
Omnivore – An organism that eats both plants and animals.

Origin – The end of the muscle connected to a fixed, typically rigid part of the skeleton.
Oviparous – Laying or spawning eggs that develop and hatch externally. Fertilization may occur internally (e.g. birds) or externally (e.g. fish).
Ovoviviparous – Giving birth to live young, but retaining the eggs within the uterus. The developing embryo is nourished by the yolk of the egg.
Ovulation – The period of time during which an ovum (egg) is released from the ovary through a follicle. It is received by the fallopian tube / oviduct.
Papilla – (*singular=papilla; plural=papillae*) Any projection from the surface of an animal tissue or organ.
Pericardial sinus – A cavity that houses the heart and related structures.
Phagocytosis – The process by which a cell engulfs solid particles.
Placental mammals – The largest group of mammals that nourish the embryo within the mother by means of a placenta.
Plantigrade – The gait of an animal in which the entire sole of the foot makes contact with the ground.
Portal system – A portal system is a type of circulation that originates in the capillaries of one organ and ends in the capillaries of another organ.
Protochordate – The name given to a group of chordates (see section on "Phylum Chordata" for the four features of chordates on page 1 of this guide) that lack a cranium (skull). Protochordates include cephalochordates such as the lancelet, *Amphioxus*, and urochordates such as the sea squirt.
Retriculoendothelial system – The system of macrophage cells, which is responsible for engulfing and destroying foreign material and cell debris.
Sexual dimorphism – Showing visible differences between males and females.
Spawning – The process of producing and laying eggs.
Spermatogenesis – The development of sperm from undifferentiated germ cells.
Striated muscles – A type of muscle that is striped in appearance. Striated muscles are found in voluntary skeletal muscle and involuntary cardiac muscle.
T-cells – A type of lymphocyte that is responsible for the cell-mediated immune response and interacts directly with foreign invaders such as viruses or bacteria.
Triploblastic development – Forming three germ layers: endoderm, mesoderm, and ectoderm. Various tissue types can arise from these three germ layers.
Vestigial structure – An organ or structure having no known function, but showing hints to an ancestral past. This structure may be completely functional in related groups of animals.
Viviparous – Giving birth to live young. Fertilization is internal and the embryo is nourished internally by the placenta.
Zooplankton – A general term used for a group of animal-like microscopic organisms which include protists, small crustaceans, insect larvae, and other aquatic larvae.