Abstract. This program facilitates a study of the anatomy of the perch. Each individual system can be viewed and discussed separately, giving the instructor the flexibility to choose only those portions that are needed.


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The Anatomy of the Perch

Narration

Most people feel certain they know what is and is not a fish. For example, these goldfish are certainly fish, as are these guppies. They both live in water and have fins and scales. And most people recognize this sea horse as a fish and know that this eel is a fish and not a snake. But it isn’t always quite so easy to identify an animal as a fish or not. Animals as different as starfish and crabs have been mistaken for fish. Some people even mistake marine mammals like whales and dolphins for fish.

What are the traits all fish have in common? All fish are vertebrates with backbones made of cartilage or bone; all fish have a cartilaginous or bony covering, the cranium, around the brain; all fish live in the water and have gills that are used throughout life; and all fish have fins that lack the five digits found on the limbs of other vertebrates.

Fish have been evolving for 500 million years. Some of the earliest forms, the **Ostracoderms**, were highly armored creatures without jaws.

Modern fish live in almost every type of water available. They live in running rivers and streams, still ponds and lakes, brackish sounds and inlets, and the saltwater of the world’s oceans.

Fish can be divided into several large groupings. A major division is those fish without jaws, the **Agnathans**, such as lampreys and hagfish, and another major division includes those with jaws, the **Gnathostomes**. The Gnathostomes can be further divided into the **Chondrichthyes** or sharks and rays, which have cartilaginous skeletons, and the **Osteichthyes** or bony fish, which have bony skeletons. The more evolutionarily advanced bony fish are the **Teleosts**.

The subject of this program, the yellow perch (**Perca flavescens**), is a teleost and a member of the order **Perciformes**, the perchlike fish. Even though the teleosts are extremely diverse, the yellow perch is an excellent representative for the anatomy of a typical bony fish.

THE EXTERNAL ANATOMY

At this time we need to review some positional terms. **Cranial** is toward the head. When speaking specifically about the head, **rostral** is toward the nose. **Caudal** is toward the tail. **Dorsal** is toward the back. **Ventral** is toward the belly. **Distal** indicates a relative position away from the center of the body, while **medial** indicates a relative position toward the center of the body.

The body of the fish is divided into three regions for study: the **head**, the **trunk**, and the **tail**. The head extends from the tip of the...
snout to the caudal edge of the gill openings or **operculum**. The trunk extends from there to the ventral openings for the anus and urogenital organs. The tail extends caudally from these openings. The body of the perch is somewhat fusiform or torpedo-shaped, an indication that the perch is capable of rapid bursts of speed.

Several important structures can be seen on the head of the fish, most notably the **mouth**, the paired **nostrils**, and the paired **eyes**. The position of the mouth is often a key to the species’ style of feeding. The terminal mouth of the perch indicates it is a predator that pursues active prey. Membranous **lips** surround the mouth, which has **teeth** that are used to capture and hold prey during swallowing. The perch swallows its prey whole. The **nostrils** of fish do not connect with the pharynx as in land vertebrates. Instead the nostrils serve as passages for water as it moves over the olfactory epithelium. There are two external openings for each nostril. Water enters through the rostral opening, and exits through the caudal opening. Like all fish, perch have lidless eyes situated on opposite sides of the head. At the caudal end of the head on each side is a gill opening covered by an **operculum**. The operculum is an external bony shield that protects the gills and allows water to pass out of the oral cavity during swallowing and breathing.

Readily apparent on the trunk are two sets of paired fins, the **pectoral fins**, found on opposite sides of the trunk behind the operculum, and the **pelvic fins**, located ventral and caudal to the pectoral fins. These paired fins are important in directional movement. In addition to the paired fins, there are four unpaired fins: the **cranial and caudal dorsal fins**, the **anal fin**, and the **caudal fin**. The dorsal fins and the anal fin act as stabilizers, while the caudal fin provides propulsion. It is important to note also that the cranial and caudal dorsal fins differ in their support structures. The cranial dorsal fin contains several sharp **spines**, while the caudal dorsal fin contains several soft **rays**.

Cranial to the anal fin are the **anal** and **urogenital openings**. These mark the cranial boundary of the tail. The primary structure of the tail is the **homocercal** caudal fin, with the dorsal and ventral halves being shaped roughly the same.

A distinct **lateral line** can be seen running along the middle of each side from the operculum to the caudal fin. The lateral line is a specialized sense organ that detects vibrations, current directions, temperature, and possibly minute electrical charges in the water.

No discussion of external anatomy would be complete without considering the skin and its scales. The skin is composed of both an outer **epidermis** and a thick **dermis**. The epidermis contains many mucous glands that produce the fish’s protective covering of mucus. Besides making fish slippery and possibly providing some lubrication, mucus protects the fish against bacteria, external irritants, and certain heavy
metal salts. The dermis contains connective tissue, nerves, blood vessels, and pigment glands, and is the site of production of scales. Most of the skin of the perch is covered with these flexible scales, arranged in orderly rows and slightly overlapping each other. Scales provide a tough protective barrier for the skin. Perch have ctenoid scales. A highly magnified view of a scale shows many minute spines or ctenii along the exposed caudal edge. Also evident are growth rings, which result from the seasonal deposition of new material along the margins of the scale. Scales grow continuously throughout the life of the fish and are not regenerated if lost.

THE SKELETAL SYSTEM

The skeleton of the perch and all other bony fish is composed of bone and cartilage. The perch skeleton can be divided into two primary divisions, the axial skeleton, composed of the skull, vertebral column, and the unpaired fins, and the appendicular skeleton, composed of the pectoral and pelvic girdles and their appendages.

The axial skeleton begins with the skull, which is composed of numerous small bones. Some of the more prominent bones of the skull are the premaxilla, the maxilla, the dentary, the frontal, and the operculum.

The vertebral column extends posteriorly from the skull and is composed of numerous supporting structures called vertebrae. Each vertebra has a large cylindrical body, the centrum. Vertebrae in the trunk region have a dorsal neural arch through which the spinal cord passes. In addition, each has a single dorsal neural spine. Some trunk vertebrae articulate with the ribs. There are two types of ribs in the perch, ventral ribs, which protect the visceral organs, and dorsal ribs, which articulate with the ventral ribs and separate the large dorsal and ventral muscle groups. The caudal vertebrae have both a neural arch and a ventral hemal arch through which the caudal artery passes. Ventral to the hemal arch is a hemal spine.

The cranial dorsal fin is supported by stiff spines. The base of each spine lies within the musculature and is supported by a thin, bony structure. There are 12–14 spines in the cranial dorsal fin of the yellow perch. The caudal dorsal fin is supported by soft rays and is actually a continuation of the cranial dorsal fin. There are usually two sharp spines followed by 12 soft rays in the yellow perch.

The ventral anal fin of the perch contains two sharp spines followed by seven to eight soft rays. The support structures are the same, except that the basal portion of the first two or three spines are fused into a single large bone. This bone fuses with the last pair or two of ribs.

The caudal fin has no sharp spines, only soft rays. The caudal fin rays are modified caudal vertebrae.
The appendicular skeleton is composed of the pectoral girdle and its fins, and the pelvic girdle and its fins. The pectoral girdle is composed of several bones that support the pectoral fin. Most obvious of these are the scapula, the coracoid, and the radials. The pectoral fins are supported by soft rays based on the radials. The pelvic girdle is composed of paired pelvic plates which support the soft rays of the pelvic fins.

THE MUSCULAR SYSTEM

Fish have a relatively simple muscular system. With the exception of certain muscles that control the jaws and individual fins, most of the musculature consists of large, segmented, V-shaped muscle groups called myotomes. The perch must be skinned in order to see the myotomes. Individual myotomes are separated from each other by a sheet of connective tissue, the myoseptum. The myotomes are also separated into dorsal and ventral groups by a transverse septum.

THE RESPIRATORY SYSTEM

To study the respiratory system of the perch, we must remove the bony operculum from one side and expose the gills. There are four gills within each gill chamber. Each gill has many gill filaments, highly vascularized fingerlike structures that provide additional surface area for the exchange of gases. Each gill also has a gill arch, a bony structure that provides support for the gill filaments. Also apparent are the gill rakers, hard spiny projections that protect the gill filaments and prevent large objects from passing through the gills.

THE INTERNAL ANATOMY

The internal organs of the perch are revealed by removing the body wall from one side of the specimen. This is done by making a shallow, longitudinal incision along the ventral surface extending from a point just dorsal to the anus to a point cranial to the caudal margin of the operculum. The operculum must be removed, and incisions made upward from the ends of this ventral incision to the lateral line. This segment of the body wall may now be opened by lifting the flap of tissue and pinning it out of the way.

Opening the body wall in this manner provides access to the large coelom which is divided into two main parts, a large peritoneal cavity, and a smaller pericardial cavity. The peritoneal cavity contains the visceral organs, while the pericardial cavity contains the heart.
THE DIGESTIVE SYSTEM

With the viscera exposed, the digestive system can be studied. The large liver is found at the cranial end of the abdominal cavity. The liver has many functions: it produces bile which aids in the digestion of fats; it filters and breaks down toxins in the blood; it produces, stores, and releases glycogen; and it stores nutrients.

Moving aside the liver makes other organs visible. The esophagus is a short, straight tube located at the most cranial end of the abdomen. It connects the pharynx to the stomach. The esophagus can expand to allow large prey to be swallowed and transported whole to the stomach.

At the caudal end of the esophagus is the stomach, a muscular structure where food is mixed with digestive fluids and broken down.

The small intestine extends caudally from the stomach. The contents of the stomach are further digested and absorbed in the small intestine. The length of the small intestine varies in species of fish with different diets. Herbivorous fish have very long intestines, strict carnivores have relatively short intestines, while omnivores have intestines of varying lengths related to their specific food habits.

Attached to the most cranial end of the small intestine are three short sacs, the pyloric caeca. The caeca are believed to function in both digestion and absorption.

Caudally the small intestine empties into the large intestine, a straight tube that carries undigested waste products to the anus, where they pass to the exterior.

We will now discuss other organs that, although not a part of the digestive system, are also located in this area. The spleen is located along the caudal surface of the stomach. The spleen is a highly vascular organ that filters blood, produces white blood cells, and plays an active role in immunity.

Immediately dorsal to the peritoneal cavity is the saclike swim bladder which normally contains a mixture of gases. The swim bladder provides buoyancy and allows the fish to remain at a specific depth.

THE CIRCULATORY SYSTEM

Located within the pericardial cavity is the two-chambered heart. As in all fish, the perch has a single, thin-walled atrium and a single, thick-walled ventricle. Two other chamberlike structures are evident, a saclike sinus venosus and a muscular tube, the bulbous arteriosus. Blood comes to the heart from the sinus venosus. From the sinus venosus, it passes into the atrium. There is no valve between the atrium and sinus venosus to keep blood from flowing backward. Blood enters the
ventricle from the atrium. A bicuspid valve between the atrium and ventricle prevents blood from flowing back into the atrium as the ventricle contracts. Blood passes through another valve as it leaves the ventricle and passes into the bulbous arteriosus. Note: More primitive fishes such as sharks, rays, hagfish, and lampreys have a conus arteriosus instead of the bulbous arteriosus. The conus arteriosus is heavily muscularized and is able to contract with substantial force. The bulbous arteriosus is actually an expansion of the ventral aorta and is less muscular, thus it cannot contract forcibly. From the bulbous arteriosus, blood flows into the short, muscular ventral aorta. From the ventral aorta, blood flows to the gills. It enters the gills through the afferent branchial arteries, passes through the capillaries in the gill filaments, and leaves the gills through the efferent branchial arteries. From the efferent arteries, blood enters the dorsal aorta. Numerous arteries branch from the dorsal aorta to supply blood to the various regions of the body.

Microscopic capillaries lie between the arteries and veins. The diameter of the capillaries is so small that blood cells often must pass through them in single file. The walls of capillaries are very thin, allowing gases and nutrients to pass out of the blood to the individual cells, and waste products to pass from the cells into the blood.

Blood returns to the heart through the systemic veins and the hepatic portal system. The hepatic portal system consists of veins from the stomach, intestine, and other organs that pass blood into the capillary beds of the liver where it is filtered and toxins are removed. It then passes into the hepatic veins and directly into the sinus venosus.

THE EXCRETORY SYSTEM

The main excretory organs of the perch are a pair of elongated, slender kidneys. The kidneys filter nitrogenous wastes from the blood and are located dorsal to the swim bladder. Wastes pass from the kidneys through the Wolffian ducts and into the urinary bladder. From the bladder, wastes pass to the outside through the urinary pore in males, and through the common urogenital pore in females.

THE REPRODUCTIVE SYSTEM

The primary reproductive organs of the male are the paired testes, located caudal to the stomach and ventral to the air bladder. The testes produce sperm and male sex hormones. Sperm pass through the vasa deferentia to the genital sinus, and then to the exterior through the genital pore.
The female has a single large **ovary** located in the same position as the male testes. The ovary is a saclike structure that produces and releases eggs into the **oviduct**. The eggs then pass to the exterior through the **urogenital sinus** and **urogenital pore**. Fertilization occurs exterior to the body after the eggs are released by the female.

**THE NERVOUS SYSTEM**

As in all chordates, the nervous system of the perch consists of two main divisions, the **central nervous system**, composed of the brain and spinal cord, and the **peripheral nervous system**, composed of those nerves outside the brain and spinal cord. We will restrict our study in this program to the central nervous system.

The **brain** of the perch is enclosed in the bony cranium. It is further protected by a gelatinous mass, and by a thin pigmented membrane.

Removal of the brain from the perch reveals that it is composed of five divisions. In this dorsal view, the most rostral portion of the brain is the **telencephalon**, composed of the **olfactory lobes**, and the **cerebral hemispheres**. The olfactory lobes are the site where the olfactory nerves enter the brain. The cerebral hemispheres correlate to the cerebral hemispheres of higher vertebrates.

The **diencephalon** is the next region. It is composed of the **thalamus**, **hypothalamus**, **pineal body**, and **pituitary gland**. The pituitary is located on the ventral side of the brain and is an important endocrine gland that secretes a number of hormones and controls the production and release of numerous others.

The **mesencephalon** is composed of the **optic lobes**. The size of the optic lobes is an indication of the important role vision plays in the perch. A ventral view of the brain reveals the paired **optic nerves** that carry nervous impulses from the eyes to the optic lobes.

The **metencephalon** is composed of the **cerebellum**, which is responsible for the coordination of muscular activity and equilibrium.

The most caudal division is the **myelencephalon**, composed of the **medulla oblongata**, an elongated region of the brain. The medulla is responsible for heart rate, the constriction and dilation of blood vessels, and the control of many reflexes and other vital functions.

The yellow perch is but a single species of fish. As such it cannot be expected to be typical of all the types of fish alive today. And it cannot be expected to be typical of the majority of the 20,000 known species of bony fish alive today. However, careful study of this organism demonstrates important features of bony fishes and illustrates a relatively simple vertebrate. Comparison of the anatomy of the perch with more complex vertebrates like amphibians, reptiles, birds, and mammals helps us understand the basic relatedness of all vertebrates.
GLOSSARY

**Afferent branchial artery.** One of the arteries that carries blood from the ventral aorta to the gills.

**Anal fin.** The unpaired fin located immediately caudal to the anal and urogenital openings.

**Anus.** The caudal opening of the digestive tract.

**Appendicular skeleton.** That portion of the skeleton comprised of the pectoral and pelvic girdles and their associated fins.

**Atrium.** The chamber of the heart in the perch that receives blood from the sinus venosus.

**Axial skeleton.** That portion of the skeleton comprised of the skull, vertebral column, and ribs.

**Bicuspid valve.** A two-parted valve located between the atrium and the ventricle that prevents the backflow of blood.

**Bulbous arteriosus.** The muscular, expanded portion of the ventral aorta immediately adjacent to the ventricle.

**Capillary.** One of the many thin-walled blood vessels that connects an artery and a vein. The capillaries are the sites for exchange of oxygen, carbon dioxide, wastes, nutrients, and chemical messengers between the circulatory system and the body cells.

**Caudal.** An anatomical term meaning toward the tail.

**Caudal fin.** The tail fin.

**Central nervous system.** That portion of the nervous system comprised of the brain and spinal cord.

**Centrum.** The thick, round, central portion of a vertebra. The centrum surrounds the remnants of the notochord.

**Cerebellum.** The portion of the brain associated with the coordination of muscular activity and equilibrium.

**Cranial.** An anatomical term meaning toward the head.

**Ctenoid scale.** A thin, overlapping dermal scale found on many advanced fishes. The exposed margin of the ctenoid scale has minute, toothlike spines known as cteni.

**Dermis.** The thick portion of the skin underlying the epidermis. It is comprised of muscle, connective tissue, arteries and veins, nerves, and mucus glands; it produces the scales.

**Diencephalon.** The portion of the brain comprised of the thalamus, hypothalamus, pineal body, and the pituitary gland.

**Distal.** An anatomical term meaning away from the midline.

**Dorsal.** An anatomical term meaning toward the back.

**Dorsal aorta.** The large, muscular artery that carries blood away from the efferent arteries of the gills. The dorsal aorta branches into numerous smaller arteries, which then supply blood to the various regions of the body.
Dorsal fin. The large unpaired fin located on the dorsal surface of the perch. The dorsal fin has two divisions—a cranial dorsal fin supported by sharp spines, and a caudal dorsal fin supported by soft rays.

Efferent branchial artery. One of the arteries that carry blood away from the gills to the dorsal aorta.

Epidermis. The thin, outer layer of the skin.

Esophagus. The short, muscular tube connecting the pharynx with the stomach; part of the digestive system.

Gill arch. One of the hard, bony structures that support the gills.

Gill filament. A highly vascularized structure located on the gill arch. Each gill arch contains hundreds of filaments, each with thousands of capillaries. The gill filaments are the site of the exchange of gases between the perch and the environment.

Gill raker. A hard, toothlike projection from the gill arch that prevents large particles of food and other materials from passing into the gill lamellae from the pharynx.

Gill. The respiratory organ of the perch.

Hepatic portal system. The system of veins and capillary beds that receives blood from various organs and carries it to the liver. In the liver, the blood is filtered and toxins are removed before it is returned to the heart.

Homocercal. A caudal fin with symmetrical upper and lower lobes.

Hypothalamus. A ventral portion of the brain located beneath the thalamus. The hypothalamus helps to regulate the autonomic nervous system.

Kidney. One of the paired excretory organs of the perch. The kidneys filter nitrogenous wastes from the blood.

Large intestine. The short, expanded section of the digestive tract where wastes are concentrated.

Lateral line. The tubelike organ immediately beneath the skin containing sensory receptors for the detection of currents. The lateral line helps the fish maintain its position in water currents or in a school, and possibly serves as a receptor for electrical currents.

Liver. A large multifunctioned organ that produces bile; breaks down old red blood cells; breaks down and removes toxins; produces, stores and releases glycogen; and stores nutrients. The liver is an accessory organ of the digestive system.

Medial. An anatomical term meaning toward the midline.

Medulla oblongata. The most caudal portion of the brain.

Mesencephalon. The portion of the midbrain composed of the optic lobes.

Metencephalon. The portion of the hindbrain composed of the cerebellum.

Myelencephalon. The portion of the hindbrain composed of the medulla oblongata.
Myoseptum. The thin connective tissue separating the individual myotomes.

Myotome. One of the V-shaped voluntary muscle groups in the perch and other fishes.

Olfactory lobe. The portion of the brain where sensory impulses from the olfactory nerves are interpreted.

Optic lobe. The portion of the brain where sensory impulses from the optic nerves are received and interpreted.

Optic nerve. One of the large paired nerve trunks that carries sensory impulses from the eyes to the optic lobe of the brain.

Ovary. The female gonad. The ovary produces eggs and certain hormones.

Oviduct. A tubelike structure that carries eggs from the ovary to the urogenital opening.

Pectoral fin. One of the paired appendages associated with the pectoral girdle.

Pectoral girdle. The group of bones that support the paired pectoral fins.

Pelvic fin. One of the paired appendages associated with the pelvic girdle.

Pelvic girdle. The group of bones that support the paired pelvic fins.

Pericardial cavity. The mesodermally-lined portion of the coelom containing the heart.

Peripheral nervous system. That portion of the nervous system comprised of the spinal cord and those nerves outside the brain.

Peritoneal cavity. The mesodermally-lined portion of the coelom containing the visceral organs.

Pituitary gland. An endocrine gland located on the ventral surface of the brain. The pituitary gland produces a number of hormones and regulates the activities of numerous other glands.

Pyloric caecum. One of the three pouchlike structures located at the junction of the small intestine and the stomach. The pyloric caeca function in both digestion and absorption of nutrients.

Rostral. An anatomical term meaning toward the nose.

Sinus venosus. A saclike portion of the heart that receives blood from the veins and passes it into the atrium.

Small intestine. The long tubelike digestive organ where digestion is completed and nutrients are absorbed into the blood.

Spleen. A highly vascularized organ of the circulatory system that filters and stores blood, and produces white blood cells.

Stomach. The muscular chamber of the digestive tract where food is mixed with enzymes and acids, and where digestion begins.

Swim bladder. The large, gas-filled organ that allows the fish to regulate its buoyancy and thus its depth in the water.
Telencephalon. The anteriormost portion of the brain.

Testis. One of the pair of male gonads. The testes produce sperm and certain hormones.

Thalamus. That portion of the brain that serves as the relay center for the sensory tracts of the spinal cord.

Transverse septum. The line of connective tissue separating the myotomes into dorsal and ventral groups.

Urinary bladder. The thin, saclike organ that receives and stores urine from the kidneys, and excretes it to the outside.

Urinary pore. The opening of the excretory system in the male perch.

Urogenital pore. The common opening for the excretory and reproductive systems in the female perch.

Ventral. An anatomical term meaning toward the underside or belly.

Ventral aorta. The thick, muscular artery that carries blood from the bulbous arteriosus to the afferent arteries in the gills.

Ventricle. The thick, muscular chamber of the heart that pumps blood throughout the body.
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