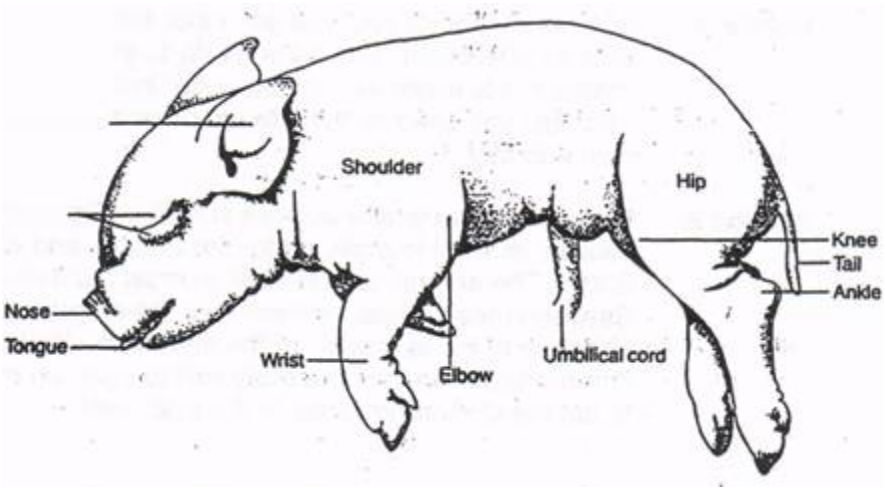
Fetal Pig Anatomy
Coloring Packet

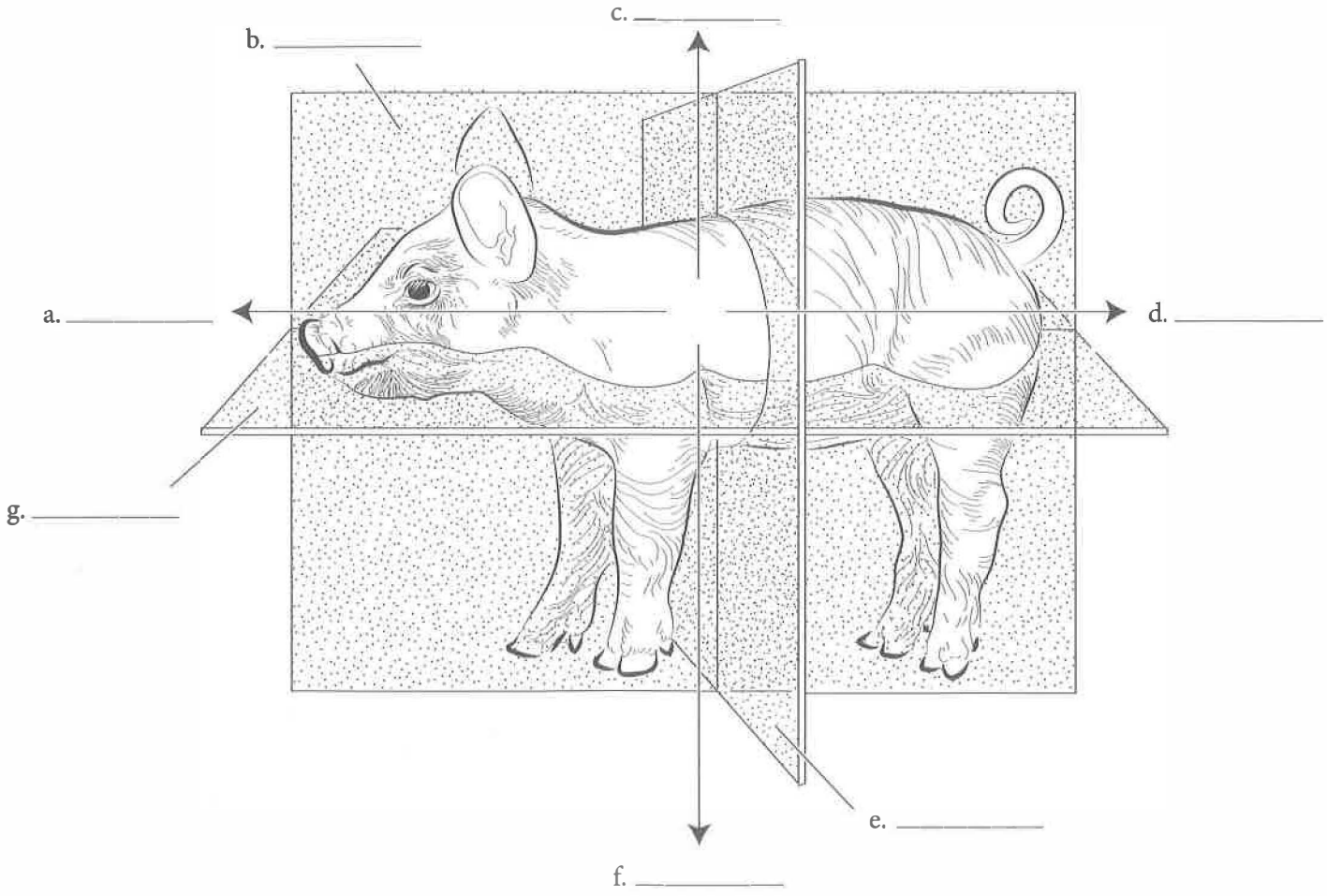


Dissection Exam
Make Up Credit

Mr. Powner
Biology

PLANES OF SECTION

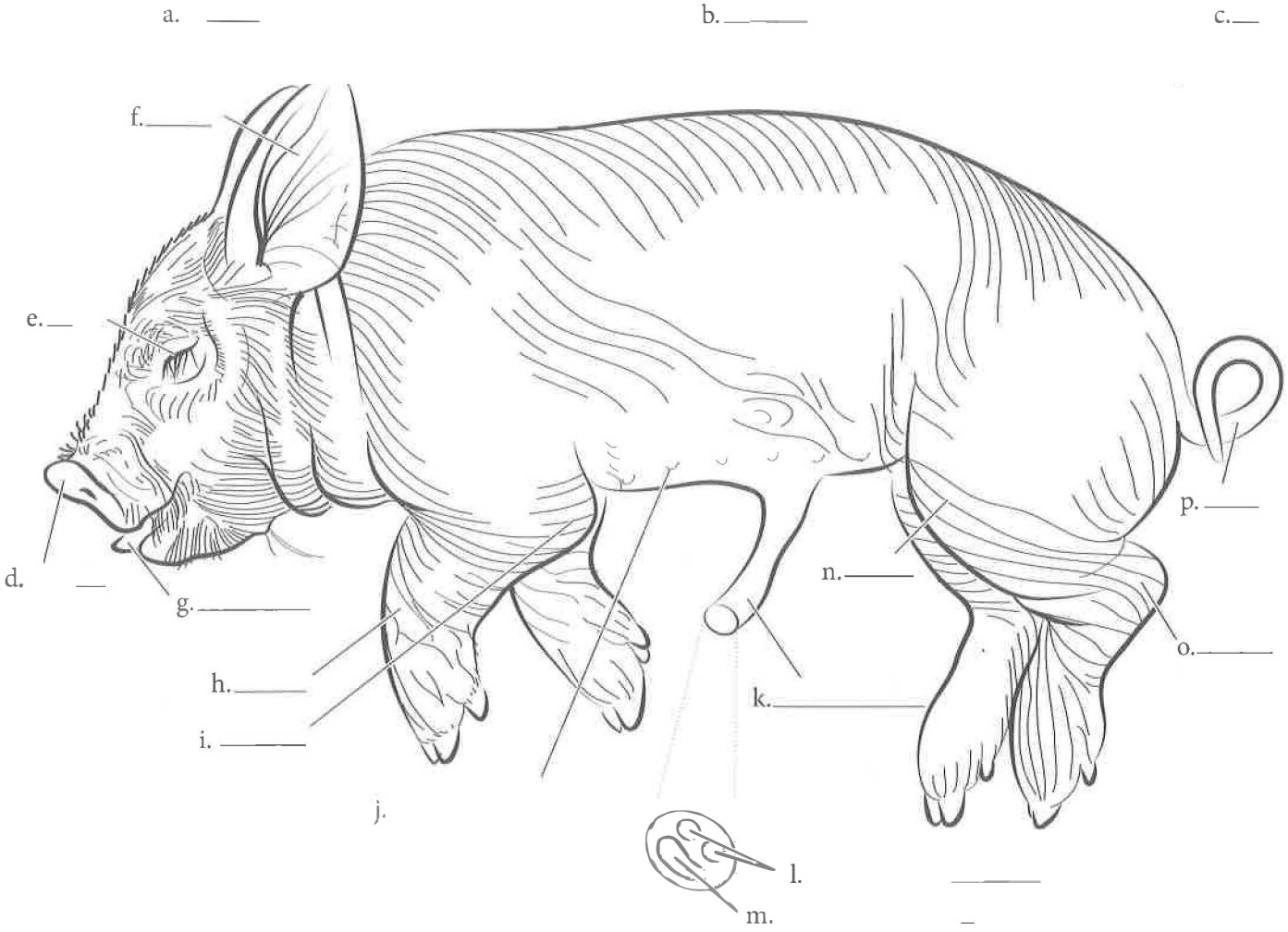
Planes of section are used in describing anatomical positions. These planes are perpendicular to one another, and provide a way to show a two-dimensional representation of a three-dimensional animal. If you were to figuratively slice completely through the pig from head to tail, cutting it into left and right portions, this would be a **sagittal** section. The midsagittal section would divide the pig into equal halves. A **frontal** or horizontal plane splits the animal into top and bottom portions, while a transverse or cross section cuts across the pig, creating front (**cranial**) and rear (**caudal**) portions.



The body of the pig may be divided into three major regions—the head, trunk, and tail. Many sensory organs are concentrated in the **head**, while the **trunk** provides protection for delicate internal organs and is a site of attachment for the appendages used in locomotion. Locate the organs found in the head region and identify their functions. The external **nares** are located in the snout and form the beginning of the air passages for the respiratory system. The mouth is the site of food ingestion and contains the tongue and teeth for tasting and chewing food. The ear and eye are responsible for the senses of hearing and sight.

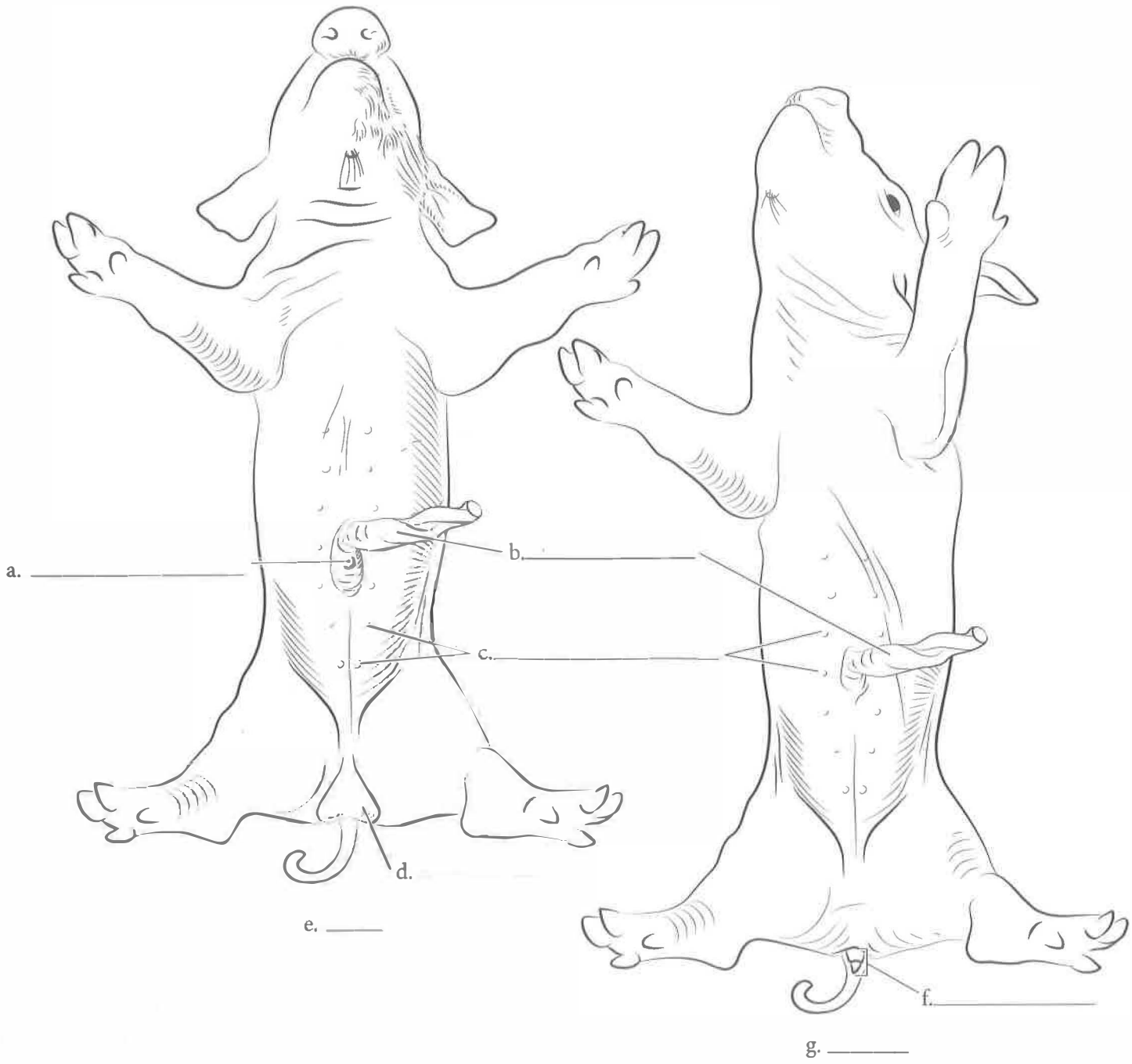
The appendages include two forelimbs and two hindlimbs. The **elbow** and **knee** of the pig are located close to the trunk, and the **wrist** and **ankle** are raised off the ground because the pig literally walks on its toes. Locate these joints in the diagram.

A cross section of the umbilical cord shows that it contains three blood vessels two **umbilical arteries** that carry deoxygenated and waste-laden blood into the placenta from the fetus, and a single large **umbilical vein** that carries oxygenated and nutritionally enriched blood from the placenta toward the fetal heart.



SEX DIFFERENCES

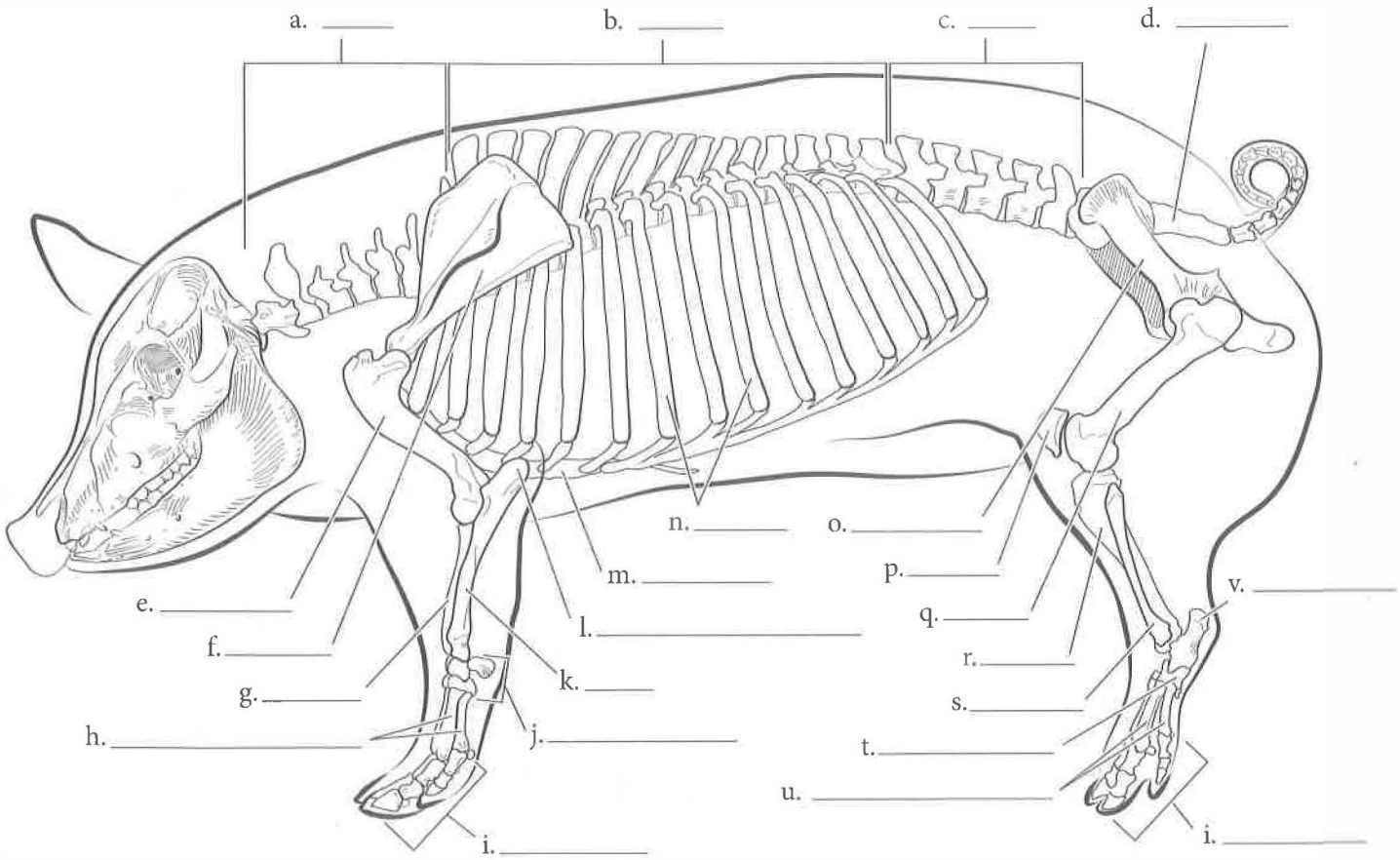
You can tell the sex of a fetal pig by observing several structures on the ventral surface. Both males and females have 5–7 pairs of teats, or **mammary papillae**, along the ventral surface of the trunk, but they will become functional mammary glands only in the adult female. In males, a urogenital opening is found on the abdomen, just caudal to the umbilical cord, and is the opening for the penis. The male's **scrotum** is a sac of skin beneath the anus and between the hind legs. The testes will descend into the scrotum from the abdominal location where they develop, and this usually occurs before the pig is born, so the scrotum may contain the testes in larger fetal pigs. The urogenital opening of females is found on a spike-like **urogenital papilla** located ventral to the anus and tail.

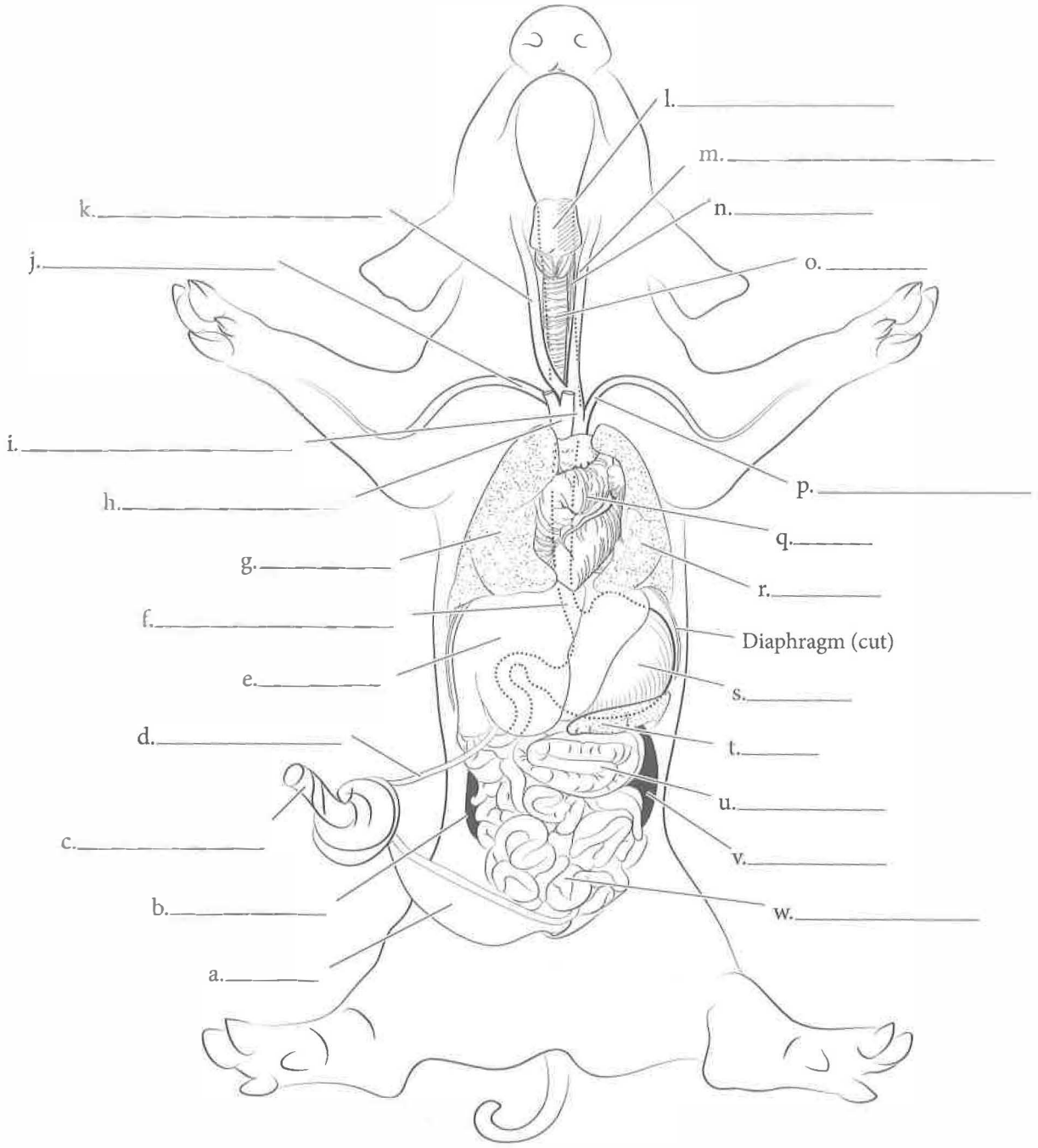


SKELETON, LATERAL

The vertebrae are part of the axial skeleton and can be divided into five regions. The **cervical** or neck region has seven, including the cranial two vertebrae which have special names—the atlas and axis; the **thoracic** or chest region may have anywhere from 13–17; the **lumbar** or abdominal region has five; the **sacrum** in the adult pig is composed of four vertebrae fused together and articulates with the bones of the pelvis; and the remaining caudal vertebrae are located in the tail. Each vertebra has a central canal for the passage of the spinal cord, with varying bony processes extending dorsally or laterally to provide attachment for muscles or articulation with other vertebrae or ribs. Thoracic vertebrae provide the attachment point for the **ribs**, some of which are connected by cartilage with the **sternum** or breastbone (true ribs), while others have cartilage that connects to an adjoining rib (false ribs).

The pectoral girdle supports the forelimbs and includes the **scapula** or shoulder blade; unlike humans, there is no clavicle in the pig. The pelvic girdle supports the hindlimbs and includes several bones which fuse to form the coxal bone in the pig, called the **os coxae**. The bones of the legs are analogous in most mammals, including the pig and humans. Find and color the forelimb bones—**humerus**, **ulna**, and **radius**, along with the wrist bones, the **carpals**, and the forefoot bones, the **metacarpals** and **phalanges**. Find and color the bones of the rear leg—**femur**, **tibia** and **fibula**, as well as the ankle bones, the **tarsals**, and the foot bones, the **metatarsals** and phalanges.

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Diaphragm (cut)
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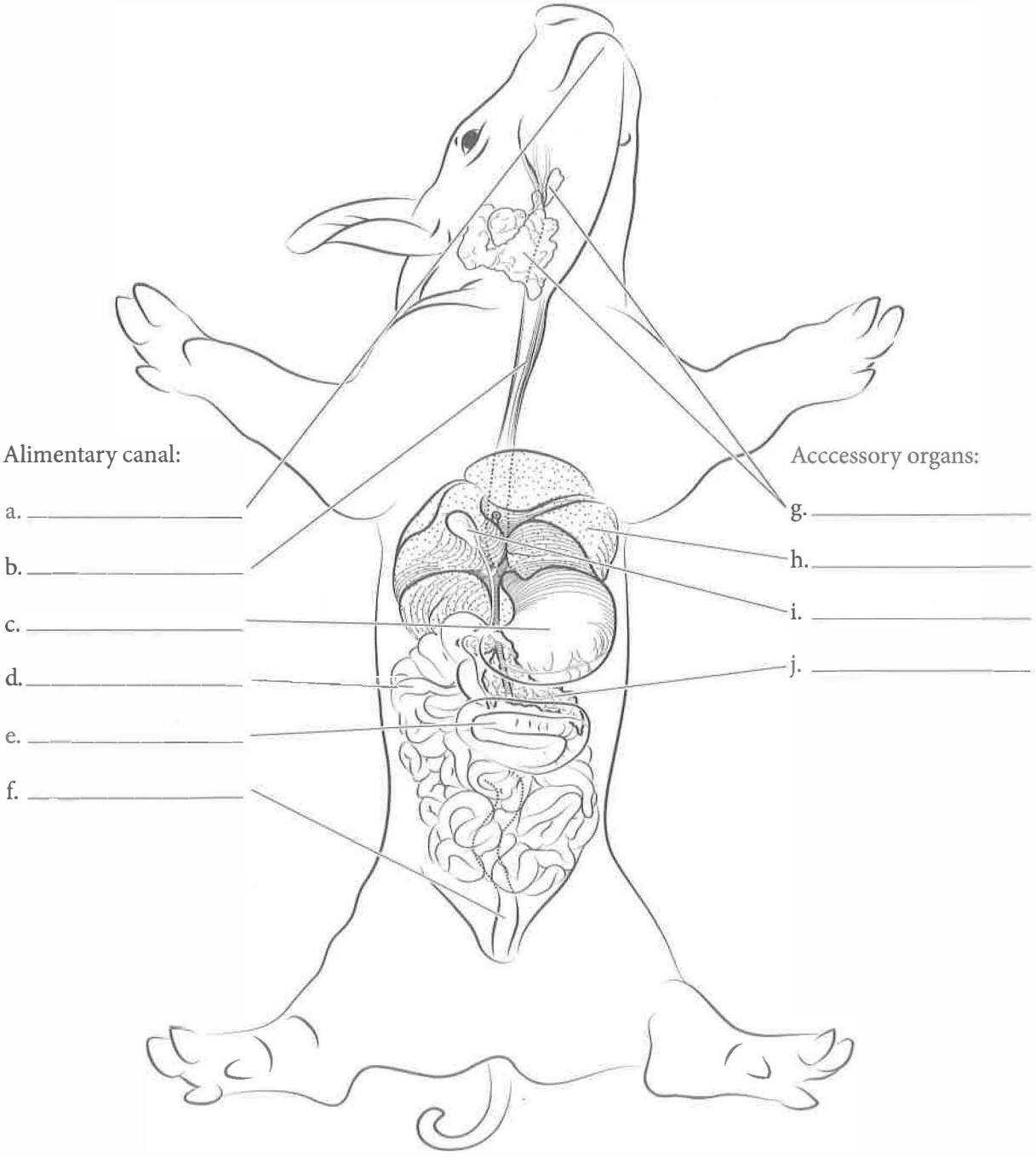
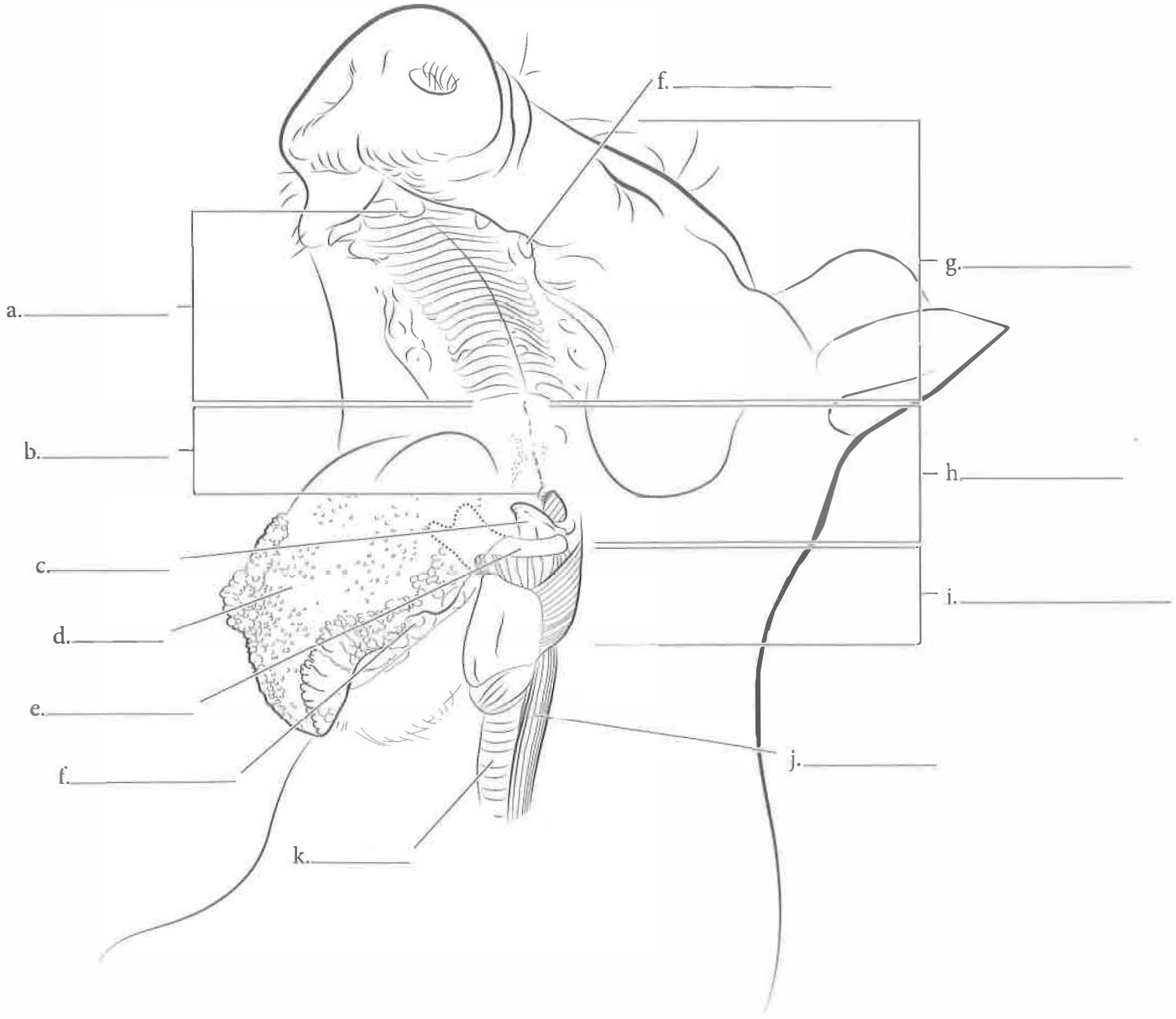
Like humans, pigs are omnivores, and their digestive system is more like humans than other mammals. This means that the digestive system is optimized for ingesting and digesting both animal flesh and herbaceous materials. The digestive system is essentially a long tube running from the **mouth** where food is ingested, through specialized digestive regions such as the stomach and intestines, to the anus where undigested waste materials are eliminated; in all, the pig's intestinal tract is about 15 times the length of its body! From the mouth, food travels through the **esophagus** into the **stomach**, which is very acidic and begins the digestion of proteins. In the **small intestine**, most digestion of protein, carbohydrate, and fat occurs, as well as the nearly all absorption of these nutrients; it may be divided into three regions—a short duodenum, long jejunum, and short ileum. In the large intestine or **colon**, water is absorbed, microorganisms may break down some undigested nutrients, and the wastes are compacted for elimination. The pig's colon is structured differently from the human: Although relatively longer than that in humans, the pig's colon is not much larger in diameter than the small intestine. In addition, the ascending colon is arranged in a highly coiled structure called the **spiral colon**, which leads to the transverse and descending colon. The final straight stretch of colon before the anus is the **rectum**. The digestive system also includes the associated organs that assist in processing the food, such as the **liver**, **gall bladder**, and **pancreas**.



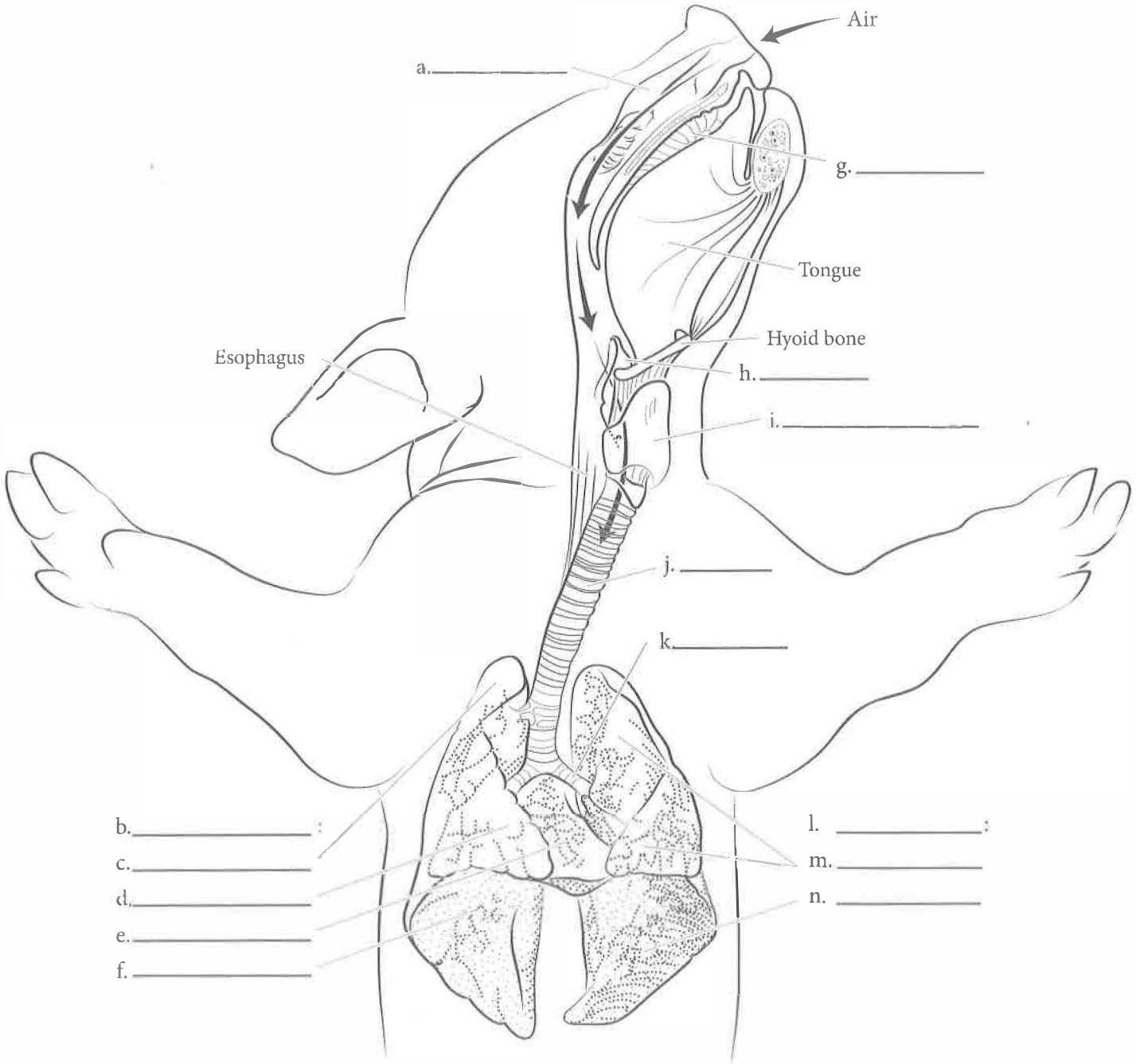
ORAL CAVITY AND PHARYNX

Opening the oral cavity widely allows one to view the structure of this important portal to the digestive system, and to understand how it interfaces with the respiratory system. Food enters the oral cavity through the mouth, is chewed and formed into a compact mass by the teeth and **tongue**, and leaves the oral cavity through the esophagus. The throat, or **pharynx**, is a common passageway with regions that serve both the digestive and respiratory systems. The roof of the oral cavity is formed by the bony **hard palate** which separates it from the nasal cavity; the **soft palate** continues caudally—it separates the **nasopharynx** dorsally from the **oropharynx** below. The **laryngopharynx** is dorsal to the larynx and leads to the esophagus which carries food to the stomach.

The cartilaginous **epiglottis** prevents swallowed food from entering the **glottis**—the opening to the **larynx**, which then opens into the **trachea** or windpipe. The **hyoid** is a bone at the base of the tongue that supports and interacts with the cartilage of the larynx. Besides the teeth, the major structure in the oral cavity is the tongue, a muscular organ with taste buds located on its surface. Notice the marginal papillae that form a fringe-like edge to the tongue in the fetal pig and assist the newborn in suckling. As the pig's diet gradually changes from milk to solid food, the marginal papillae will regress.



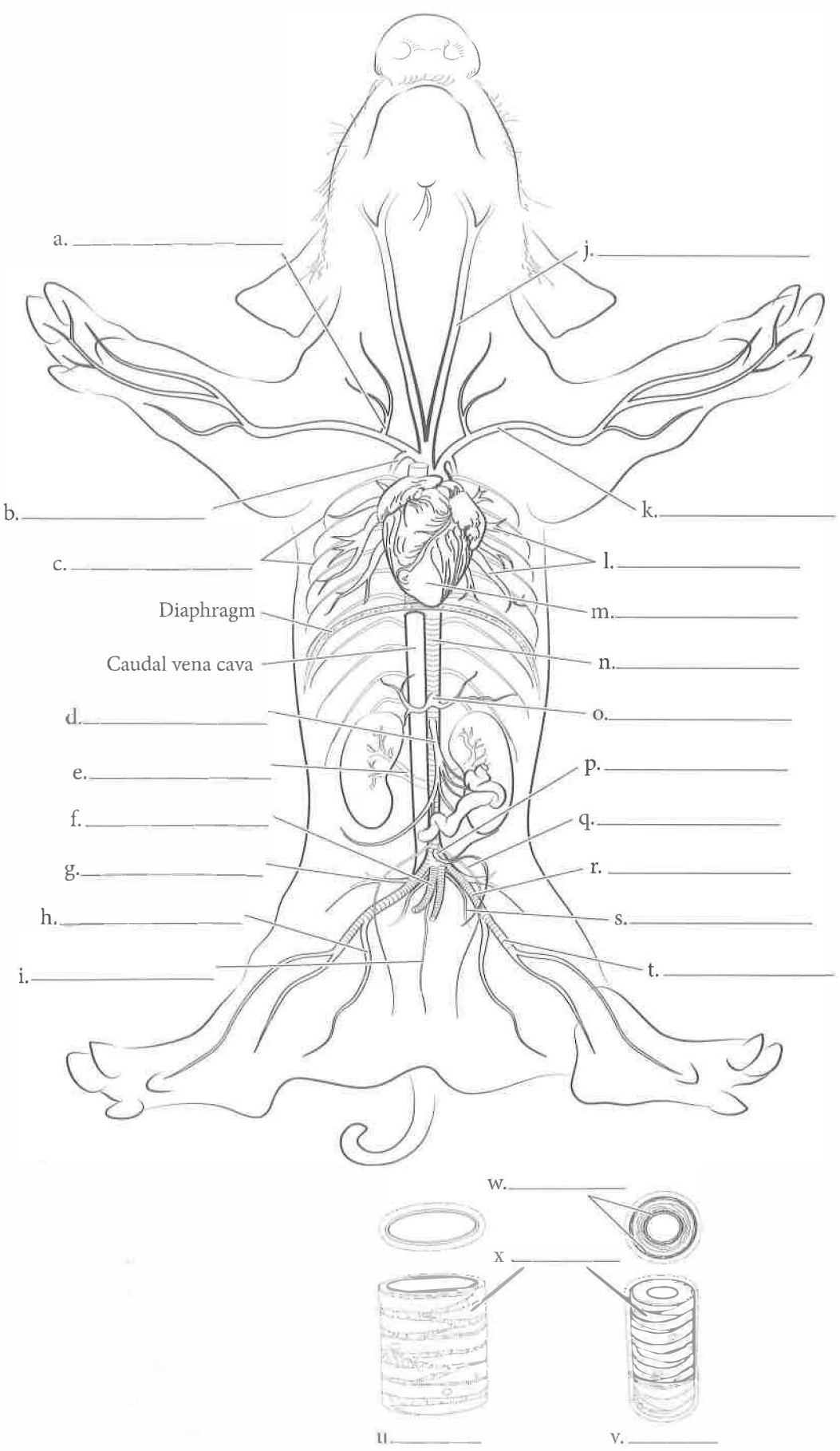
The respiratory system is responsible for bringing oxygen into the lungs where it diffuses into the bloodstream, and for carrying off carbon dioxide waste. The respiratory system begins at the snout, where air enters the nasal cavity through the external nares. After passing through the pharynx, which is shared with the digestive system, air enters the trachea through an opening called the glottis. The glottis is protected by a flap of tissue—the epiglottis—which prevents food and water from entering the respiratory passages. After passing through the larynx, which contains the vocal cords and is protected by the thyroid cartilage, air enters the trachea. The trachea is held open for air passage by cartilaginous rings, which are incomplete on the dorsal side. The trachea divides to form two bronchii for air to enter both of the paired lungs. As in humans, each lung is divided into lobes; in the pig, the right lung has four lobes instead of three, while the left has two lobes as in humans. The diaphragm is a bell-shaped muscle that completely separates the thoracic and abdominal cavities, by its attachment to the body wall in all directions. To function in breathing, the sheet-like diaphragm muscle contracts, moving it downward to enlarge the thoracic cavity. As the lungs expand with the thoracic cavity, air is drawn in. As the diaphragm relaxes and space for the lungs decreases, air is forced out.



The circulatory system transports nutrients, oxygen, carbon dioxide, hormones, and dissolved waste products to and from individual cells. The circulatory system itself includes a four-chambered heart along with networks of vessels to carry blood between the heart and tissues throughout the body. Pigs have a double circulation—a pulmonary circuit to the lungs and a systemic system to distribute the oxygenated blood to the rest of the body.

Arteries are thick-walled vessels because they have a substantial layer of smooth muscle and elastic fibers, which allows for expansion of vessels during heart contractions and modulation of blood pressure by constricting or dilating the arteries. Arterial distribution of blood occurs through the **pulmonary trunk** and **aort**—the great vessels that leave the heart. The pulmonary trunk divides into right and left **pulmonary arteries**; each further branches to provide blood to each of the lobes of the lung. The aorta divides as it arches to the left shortly after exiting the heart; the **ascending aorta** supplies blood to regions anterior to the heart, and the **descending aorta** serves tissues and organs posterior to the heart.

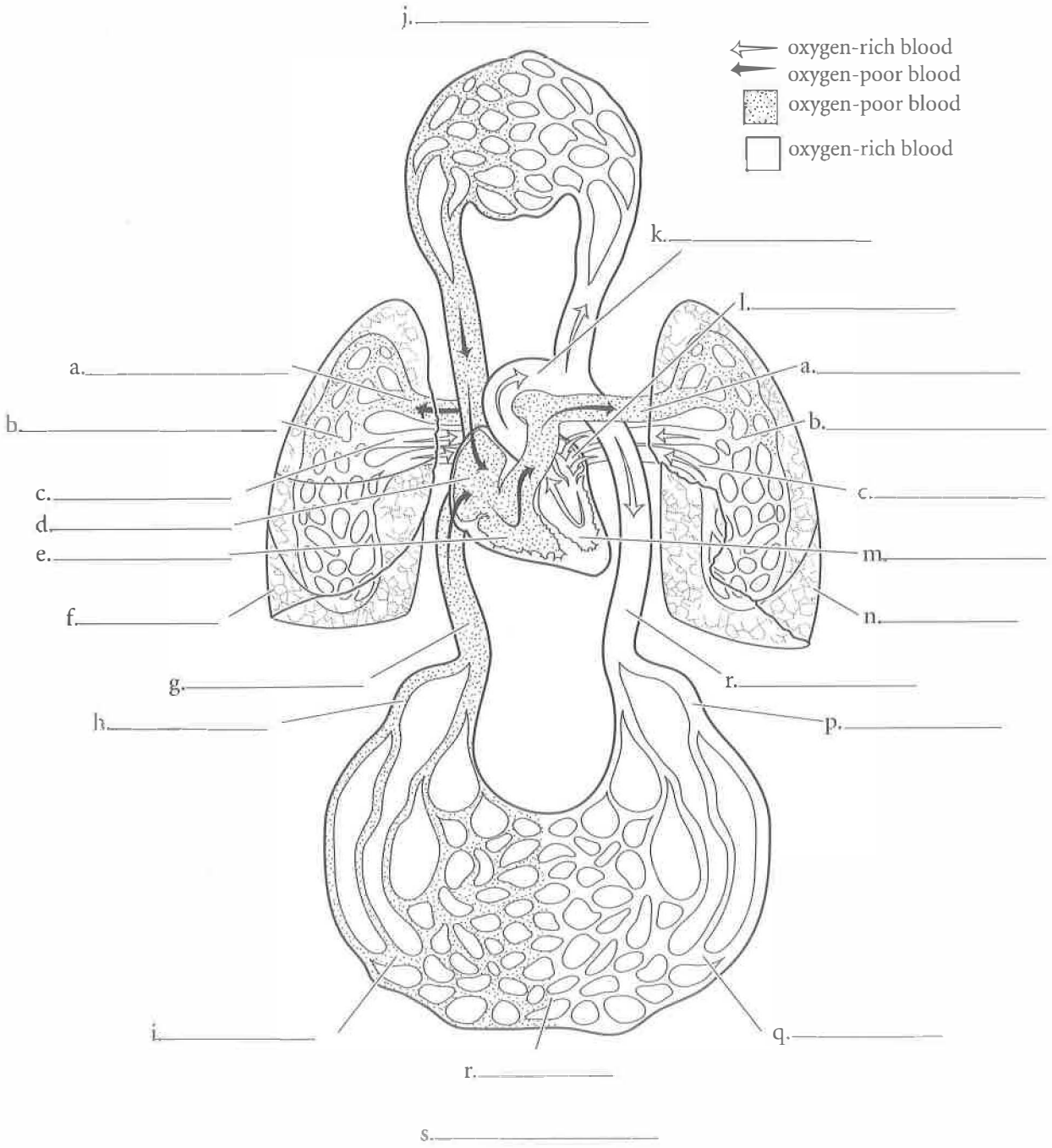
Names of arteries are usually related to the organs and tissues they supply or to their location in the body. Although it is occasionally difficult to discern that connection, learn each artery's name along with the parts of the body supplied by it as you color each vessel. Label the structures in the diagrams—following convention, color arteries red. The exception is to color the pulmonary arteries blue (because they carry deoxygenated blood away from the heart).



ADULT CIRCULATION

Like all mammals, pigs have a double circulation—a **pulmonary circulation** that carries blood between the heart and the lungs, and a systemic circulation between the heart and all other tissues of the body. In the pulmonary circulation, the right ventricle pumps blood to the lungs through the pulmonary trunk which divides to form left and right pulmonary arteries; pulmonary veins return oxygenated blood to the left **atrium** of the heart. In the systemic circulation, the left ventricle pumps blood through the aorta, from which exit major arteries serving all parts of the pig's body. The arteries divide into smaller vessels called **arterioles** and eventually feed capillaries. In the capillaries, oxygen and nutrients are supplied to the tissues, and waste products are removed. The blood then returns to the right atrium as capillaries feed into **venules**, combining to form veins which join to form the vena cava before they enter the heart. Just as the pulmonary circulation divides to the left and right lungs, the systemic circulation splits shortly after leaving the heart to supply both the anterior and posterior regions of the organism.

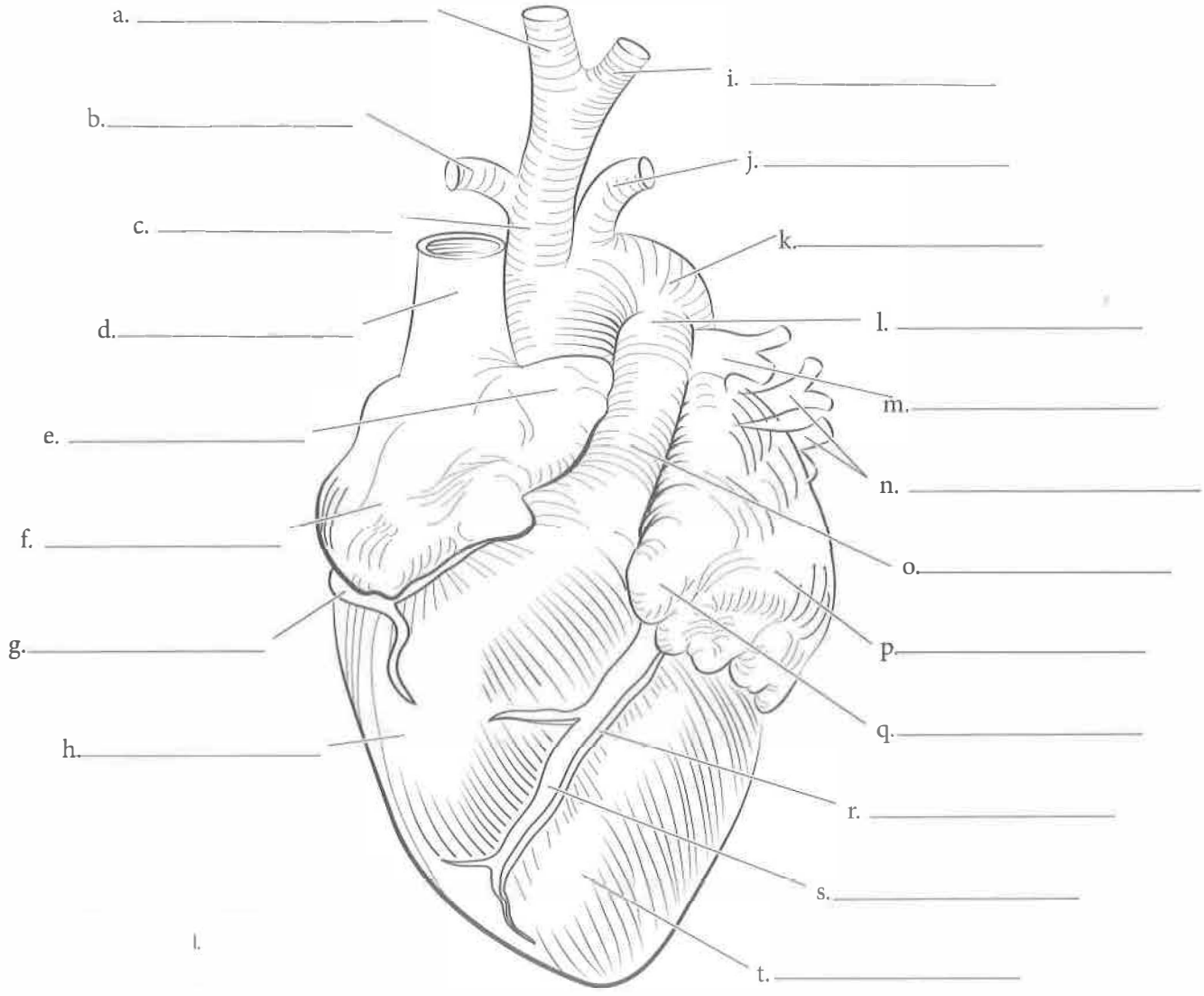
Follow the blood flow as you color the oxygenated areas red and the deoxygenated areas blue in the diagram. At each point, be sure you recognize whether the blood is oxygenated or deoxygenated, which circulation you are part of, and whether the vessel is an artery or vein. This is also a good time to recognize the advantages of a four-chambered heart which can keep both circulations going simultaneously, while keeping oxygenated and deoxygenated blood separate.



VENTRAL HEART

Seen from the ventral aspect, the left atrium and ventricle are on the right, the right atrium and ventricle are on the left. The apex or base points caudally; the great vessels emerge at the cranial end of the heart. **Coronary arteries** are obvious on the surface of the heart; they emerge from the base of the aorta too deep for the source to be visible externally. The large **left coronary vein** is also seen on this aspect. The pulmonary trunk is the most obvious great vessel; the aorta arises from the left ventricle behind the pulmonary trunk, divides to give rise to the brachocephalic and left subclavian arteries, and arches to the left. As the aorta passes over the pulmonary trunk in the fetus, the ductus arteriosus connects the two vessels to shunt more of the blood away from the non-functional lungs and into the aorta. From this aspect, the cranial vena cava is evident as it enters the right atrium; the caudal vena cava enters the same atrium on the dorsal, caudal side. This deoxygenated blood goes from the right atrium, into the right ventricle, and out the pulmonary trunk. Distal to the ductus arteriosus, the pulmonary trunk divides to form the left and right pulmonary arteries to supply the lungs. Blood returning from the lungs through the pulmonary veins enters the left atrium, on its way to the left ventricle and the aorta.

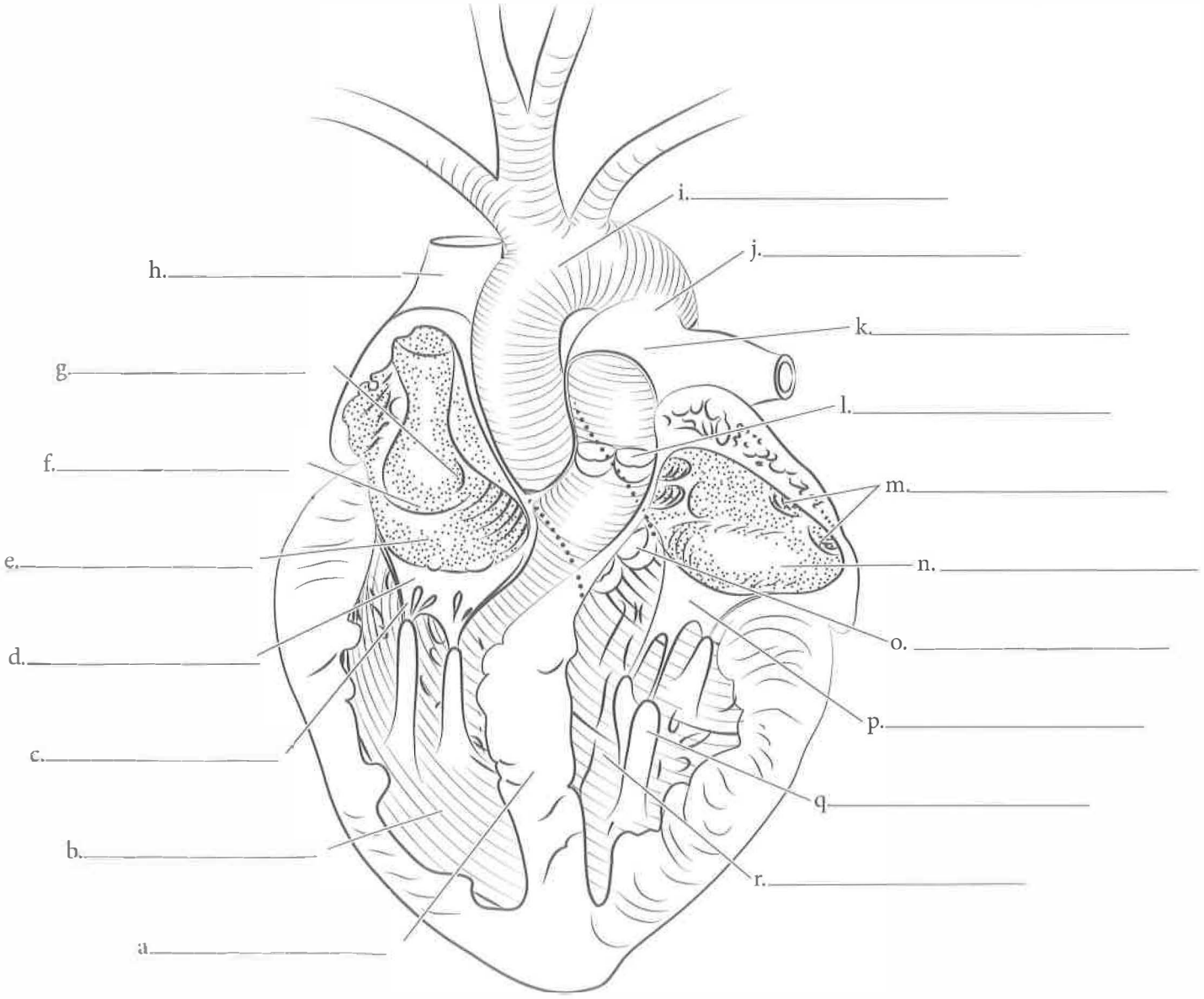
Label all vessels entering or emerging from the heart; color them appropriately according to the oxygenation status of the blood. To do this properly, you will need to know the role each plays in the systemic or pulmonary circulation, so it is a good time to test yourself on your ability to trace the path of blood through both circulations, and through the heart.



FRONTAL PLANE OF HEART

Looking at the inside of the heart from the ventral view, all four chambers of the heart are visible. Color the structures in the same order as the blood flows to each on its route through the heart. Two kinds of valves keep the blood from flowing backwards. The **atrioventricular valves** open when the ventricle relaxes, allowing blood to flow from the atrium into the ventricle. These valves are connected via the **chordae tendinae** to papillary muscles which are stimulated to contract along with the adjacent ventricular muscle; this action pulls the valve flaps closed, preventing blood from backing up into the atrium when the ventricle contracts. On the right side, this valve is called the **tricuspid**, on the left it is called the **bicuspid** or sometimes the mitral valve, especially in humans. The other heart valves are **semilunar valves**, placed between the ventricles and the pulmonary trunk or the aorta; these cup-like valves close as they fill with blood when it begins to back up as the ventricle relaxes.

Atrial walls are quite thin as they only need to create enough force to empty the atrium into the ventricle when the atrioventricular valve opens. The interatrial septum is perforated by the foramen ovale in the fetus, allowing placental blood entering the right atrium through the caudal vena cava to largely exit to the left atrium for distribution throughout the systemic circulation. Note the interventricular septum between the two ventricles, and the thick ventricular walls which can contract with enough force to push the blood out of the heart, through the arteries, capillaries, and veins, and back to the heart again. The left ventricular wall is much thicker than the right since more force is needed to get blood throughout the systemic circulation than the shorter passage through the lungs.

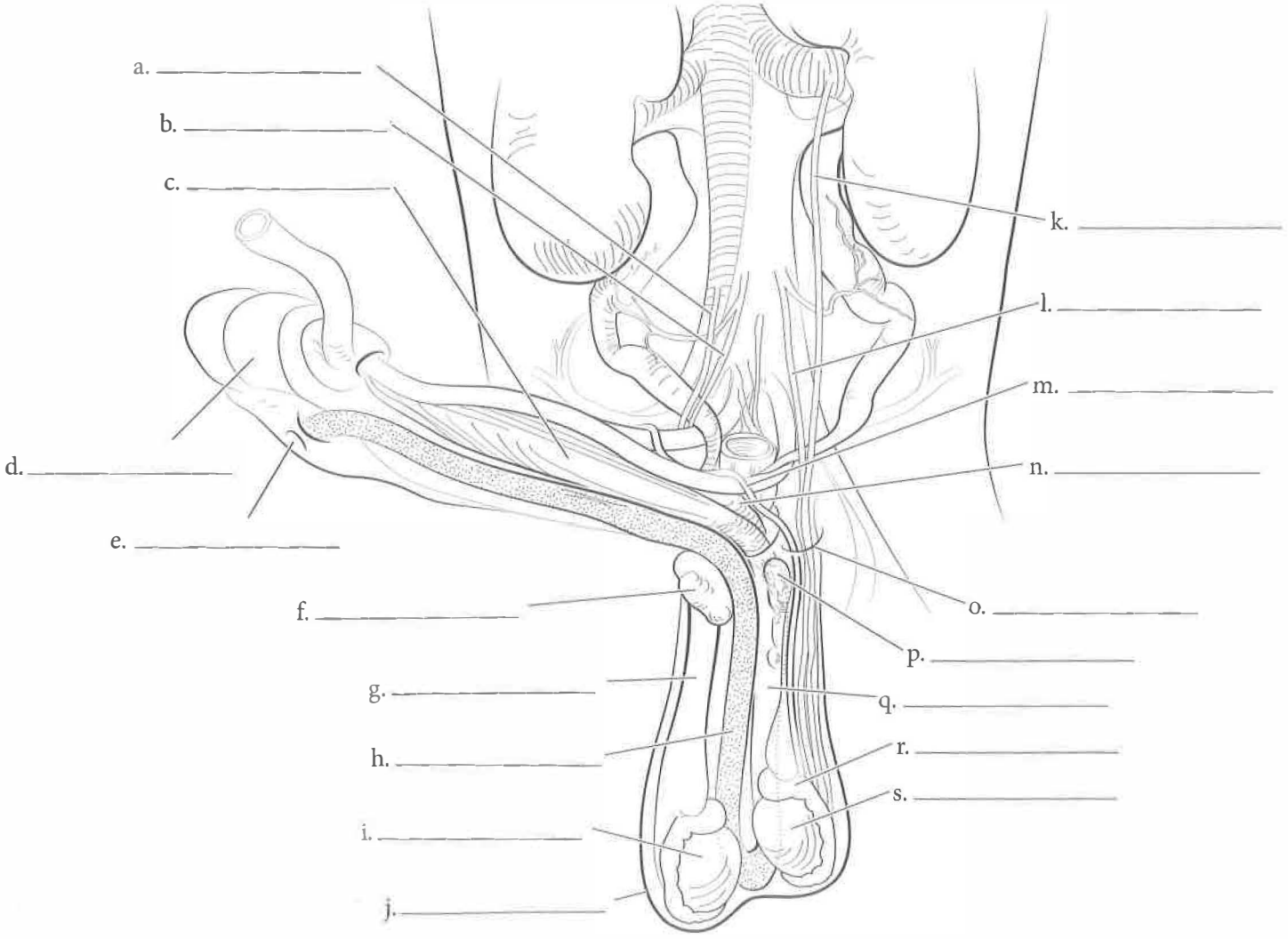


REPRODUCTIVE SYSTEM—MALE

The male **testes** develop dorsal to the coelomic cavity, near the kidneys, but migrate during development to lie in an external pouch, the scrotum, ventral to the anus, where the temperature is several degrees cooler than the animal's internal body temperature. In the early fetus, the testes have not yet descended, but in the larger fetal pigs usually studied, they have already migrated to the scrotum. The **testicular artery** and **vein** along with nerves pass into the scrotum through an opening in the body wall called the **inguinal canal**. After the animal reaches sexual maturity, sperm is formed in the testes and passes through or is stored in the **epididymis** which extends alongside the testes and continues into the **ductus deferens**. The ductus deferens from each testis then passes through the inguinal canal and enters the urethra prior to the point where it enters the penis.

In the pig, the penis is very long and lies in a sheath embedded in the ventral body wall, surrounded by erectile tissue. A retractor muscle pulls the penis back into its sheath after an erection. Accessory glands that are also found in the male reproductive tract include the **prostate**, **seminal vesicles**, and **bulbourethral glands**, all of which secrete part of the seminal fluid which carries and nourishes the sperm.

Begin by coloring the urinary system structures as you did before. Name and color the structures in the reproductive system beginning with the testes and continuing in the order in which the sperm pass through the structures. This sequence will help you in remembering the names and functions.



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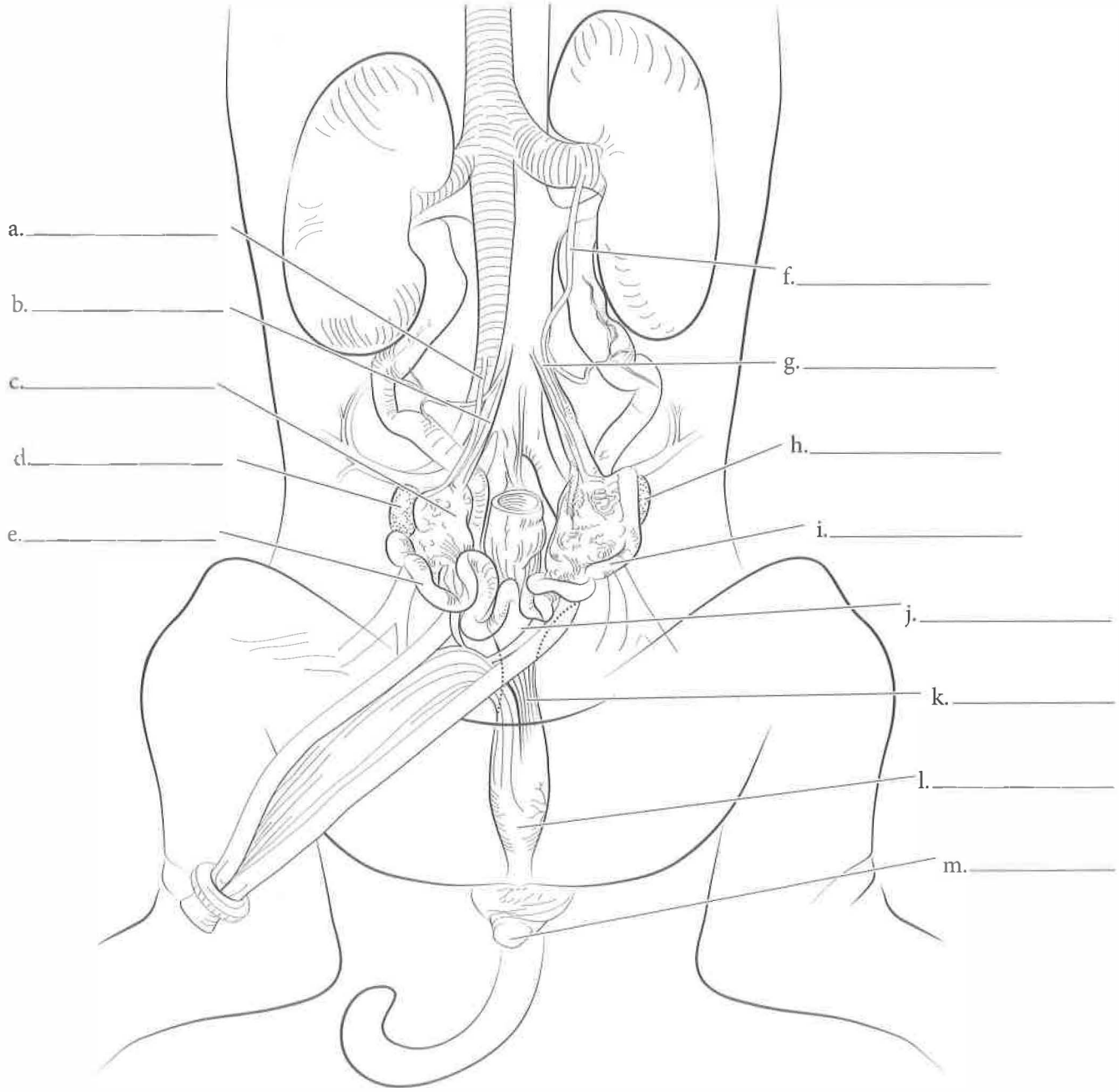
REPRODUCTIVE SYSTEM—FEMALE

The female reproductive tract includes two **ovaries** which produce eggs that pass through the **fallopian tubes** to the uterus. The fetal ovaries are small, oval organs lying near the dorsal wall of the abdomen, caudal to the kidneys. The mesosalpinx is part of the broad ligament of the uterus which encloses the fallopian tube. In the pig, there is a small **uterine body** with long, convoluted **uterine horns** which are the site of embryo implantation after the eggs are fertilized. In contrast, the human female has no uterine horns but a large uterine body where implantation occurs. The uterus of the pig leads into the vagina which unites with the urethra to form a **urogenital canal** leading to the body surface. In the human, the vagina and urethra open independently on the surface.

Begin by coloring the urinary system structures as you did before. Name and color the structures of the reproductive system beginning with the ovary and continuing in the order in which the egg or developing offspring pass through the structures. This sequence will help you in remembering both the names and functions of each.

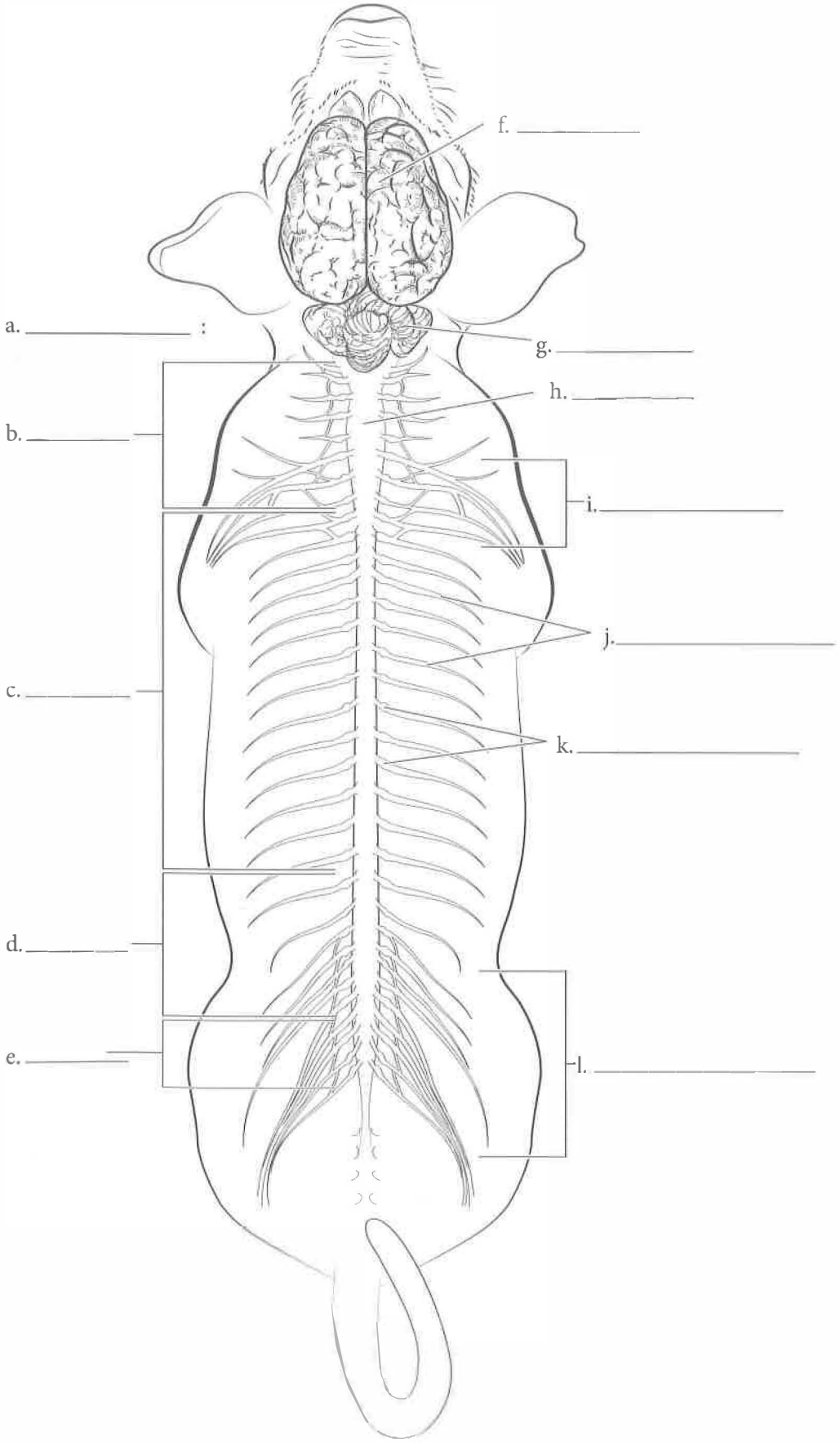


NERVOUS SYSTEM, DORSAL VIEW

The nervous system functions to sense and respond to the external environment, to sense and respond to changes in the internal environment, and to communicate messages between parts of the body. In order to accomplish this, the nervous system includes sense organs (eye, ear), other sensory tissues (taste buds, olfactory tissue, pressure sensors), both sensory and motor neurons to conduct impulses, and the central nervous system.

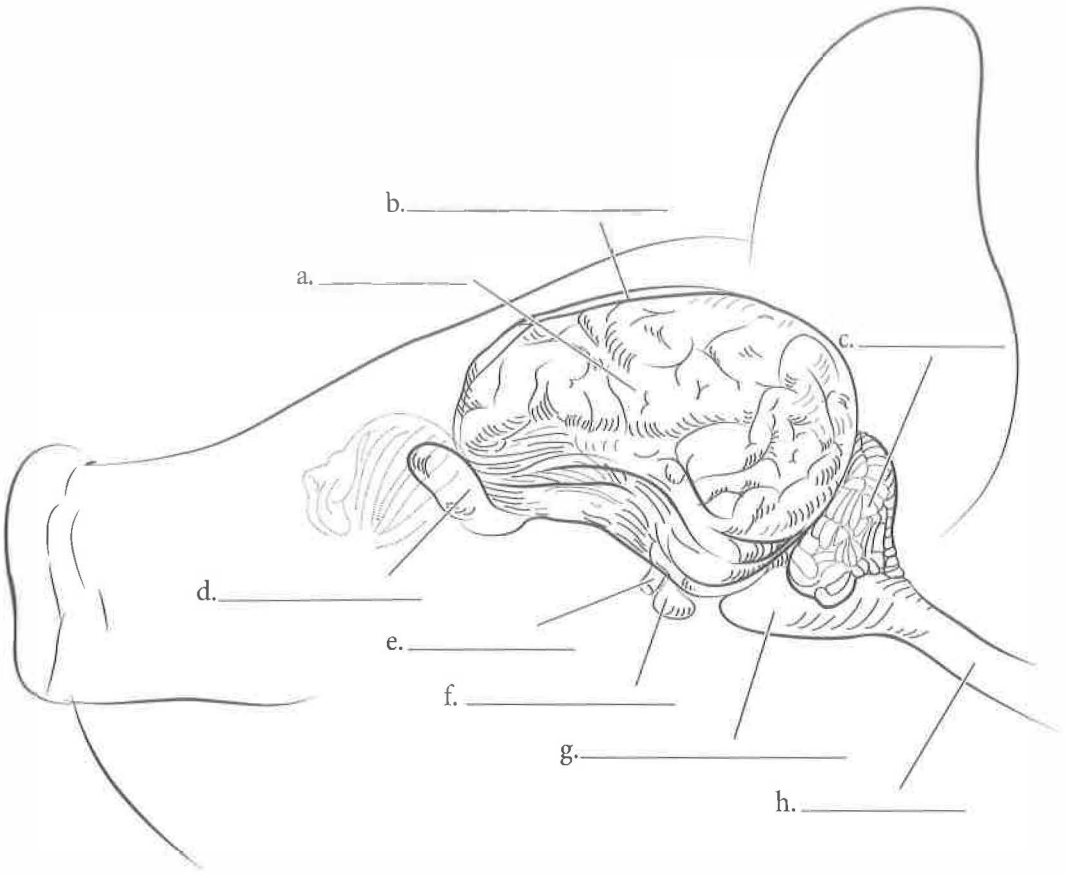
The central nervous system includes the **brain** and **spinal cord**, which function to integrate and coordinate activities throughout the body. The brain is located inside the cranium and is continuous with the spinal cord stretching along the dorsal midline of the body. **Cranial nerves** from the head region enter the brain directly, while communication with the rest of the body depends upon **spinal nerves** entering the spinal cord. These neurons located outside the central nervous system are called the peripheral nervous system and can be divided into sensory or motor neurons, depending upon whether they convey information toward or away from the central nervous system. Many nerves are mixed in nature—including both sensory and motor nerve fibers.

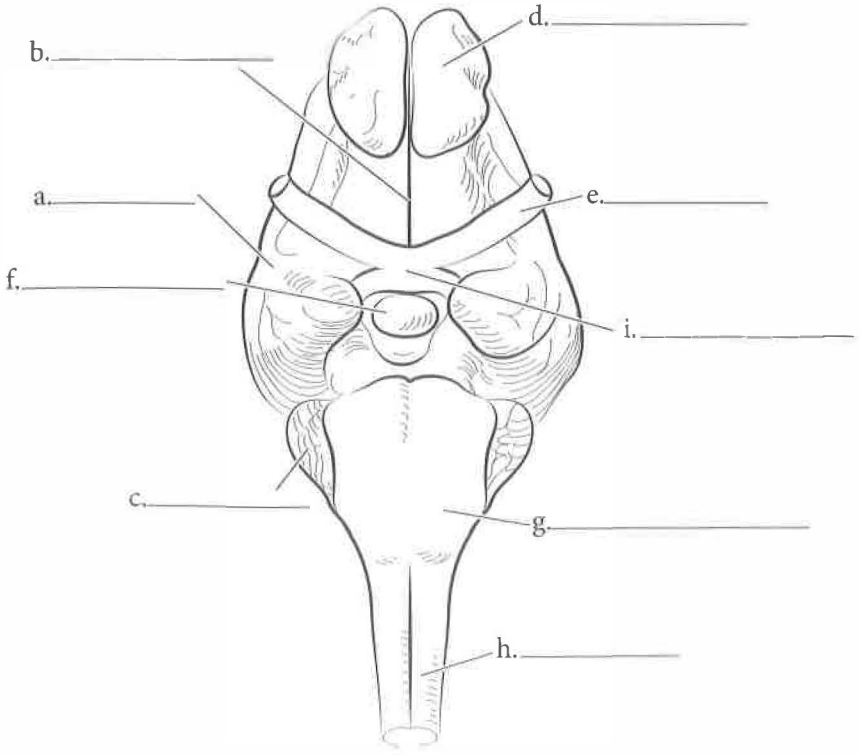
Motor neurons of the peripheral nervous system may be divided into somatic motor neurons controlling voluntary muscles and autonomic motor neurons which regulate smooth muscle, cardiac muscle, and glands. The autonomic neurons may be further divided into the sympathetic and parasympathetic systems, which often provide organs with compensatory signals. For example, sympathetic stimulation is responsible for dilating the pupil of the eye in low light, while parasympathetic stimulation will constrict the pupil when light levels are higher.



LATERAL BRAIN, VENTRAL BRAIN

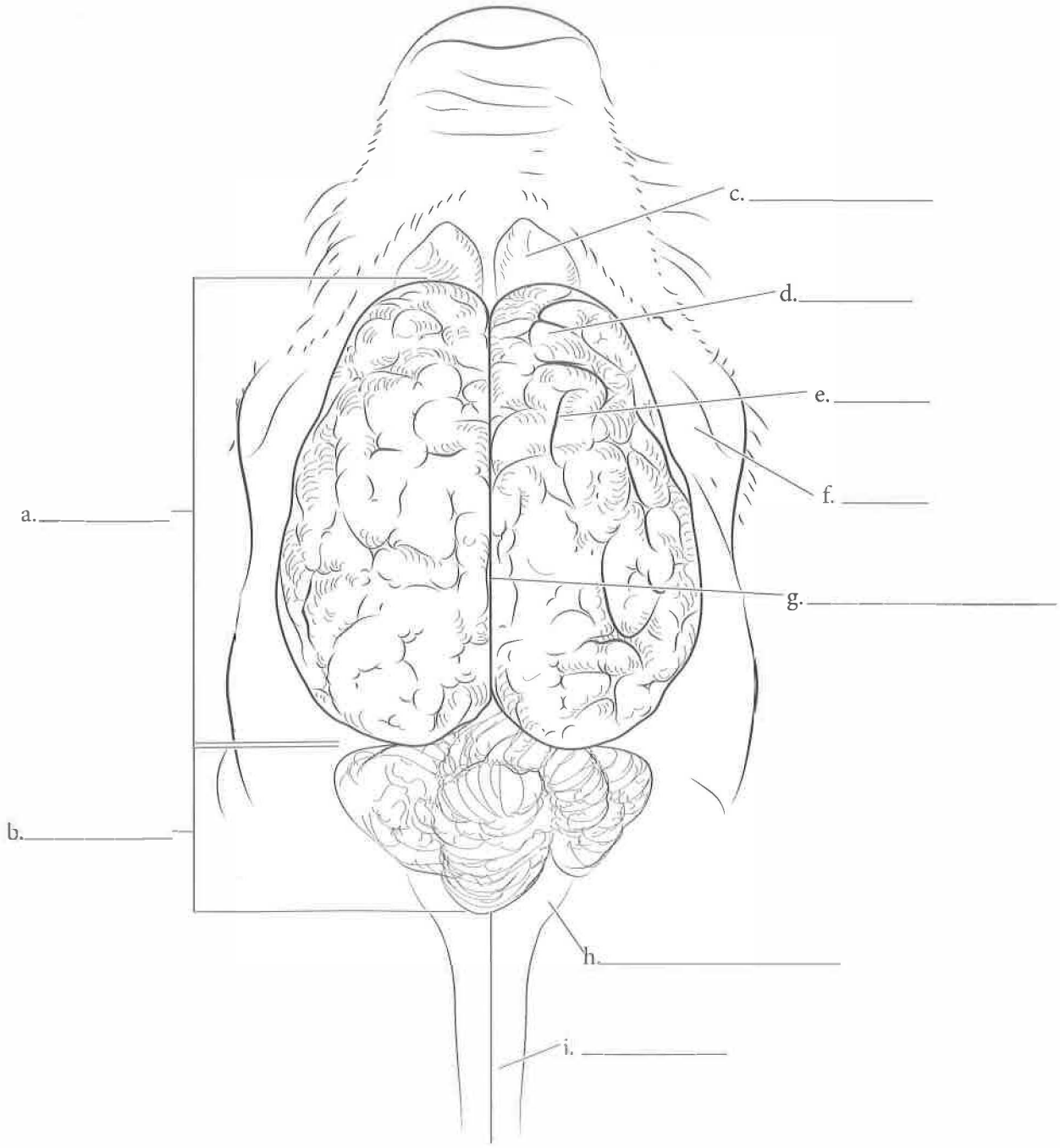
The brain is located inside the cranium, and derives from the enlarged anterior portion of the dorsal hollow nerve cord as in all vertebrates. Similar to other mammals, the **cerebrum** is the largest section (although not as large as in humans). Cranial nerves from the head region enter the brain directly, including the **optic nerve** shown entering the ventral side of the brain. Anteriorly, the olfactory bulb is close to its source of stimulation—the nasal conchae containing smell receptors. The **pituitary gland** on the ventral aspect of the brain secretes hormones which control the other endocrine glands and influence growth, metabolism, and maturation. Posterior to the cerebrum is the **cerebellum**, which functions largely in muscular coordination, and the **medulla oblongata**, which controls many involuntary activities such as heart beat, blood pressure, salivation, swallowing, and breathing.





DORSAL BRAIN

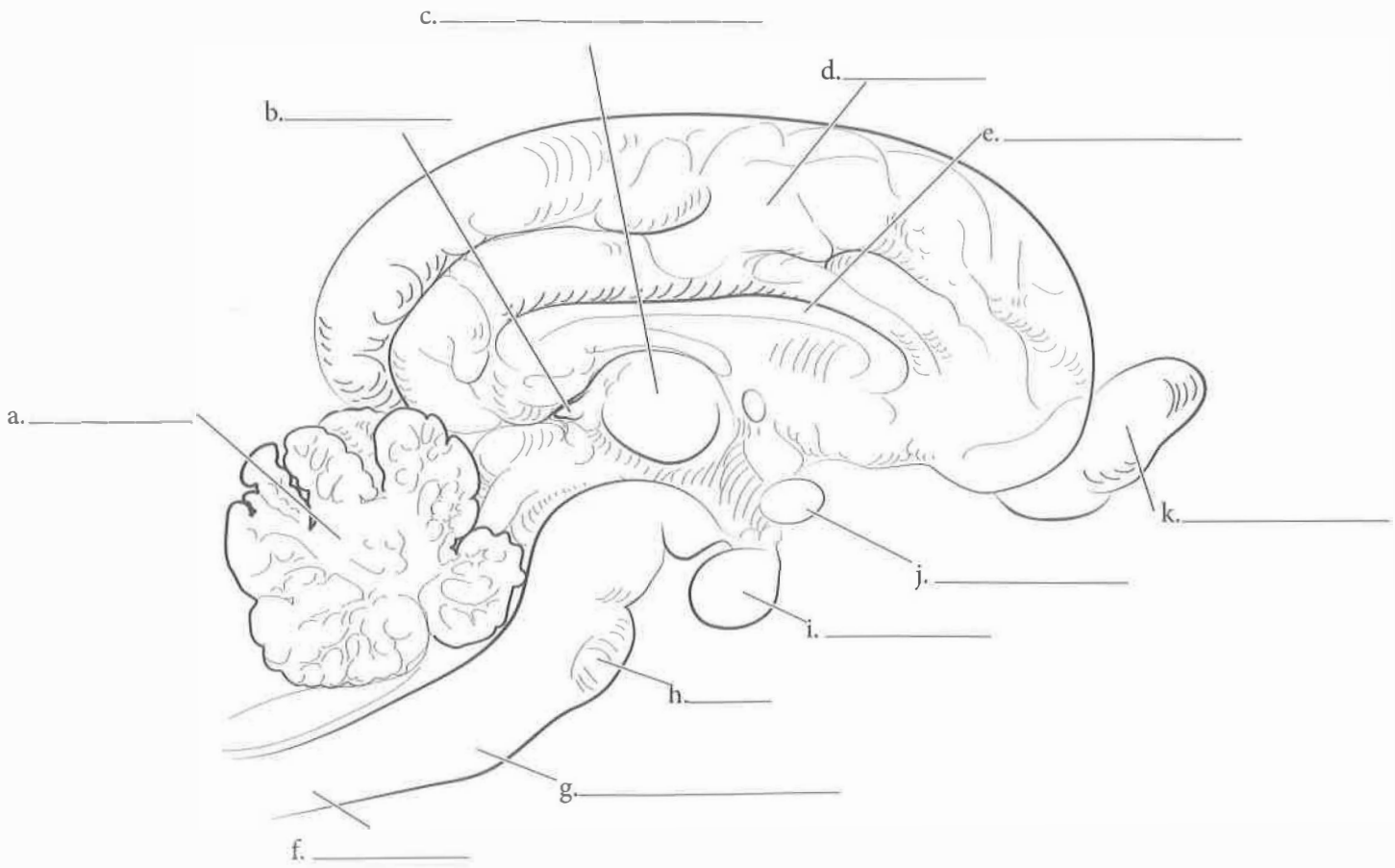
The surface of the cerebral cortex is highly convoluted and densely packed with nerve cells; its area is increased by having a series of ridges called **gyri** and creases called sulci. The cerebrum is divided into left and right halves by the **longitudinal cerebral fissure**. Each region of the cerebral cortex has specific functions that may be sensory, motor, or associative in nature. Within these regions, each point may control or receive input from a specific part of the body.



SAGITTAL BRAIN

A midsagittal view of the brain shows structures deep within the brain that are not obvious from the surface. The **corpus callosum** is a region with bundles of nerve fibers on the base of the longitudinal fissure that function in connecting the two hemispheres of the cerebrum. The **pineal body** is a stalked gland that releases the hormone melatonin during darkness; this is thought to influence rhythms of activity. The **interthalamic adhesion** consists of tissue that contacts the medial surfaces of the thalamus regions on both sides of the brain. The **optic chiasma** is the point where the two optic nerves cross before entering the brain—visual information from the right eye enters the left side of the brain and vice versa.

In the region of the brain just anterior to the spinal cord and medulla oblongata lies the pons, which contains fibers that connect the two hemispheres of the cerebellum. Loosely attached at the base of the brain is the pituitary gland; the posterior pituitary secretes hormones made in the hypothalamus (oxytocin and antidiuretic hormone) while the anterior pituitary makes and secretes a number of hormones, including growth hormone, thyroid-stimulating hormone, and follicle-stimulating hormone.



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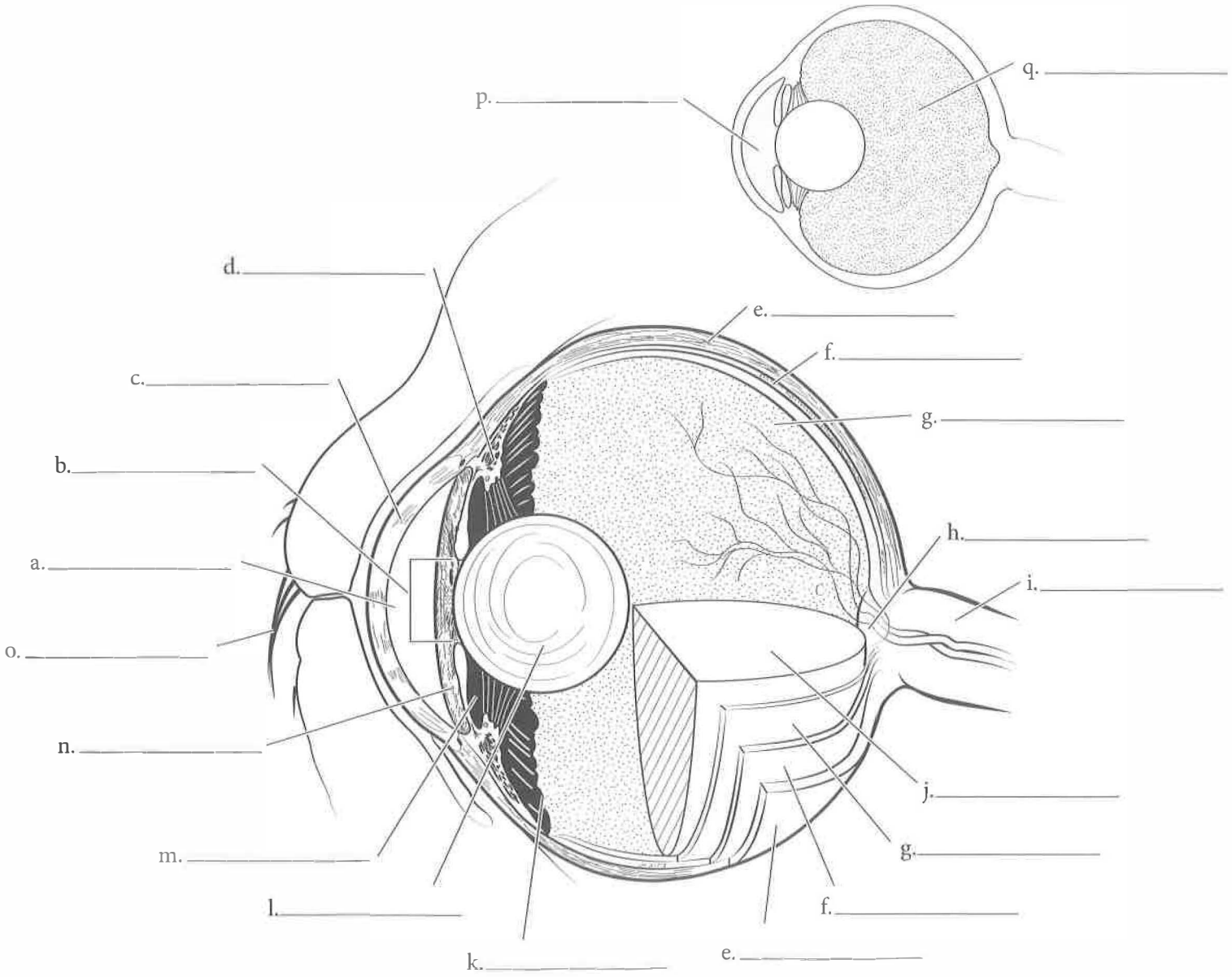
EYE

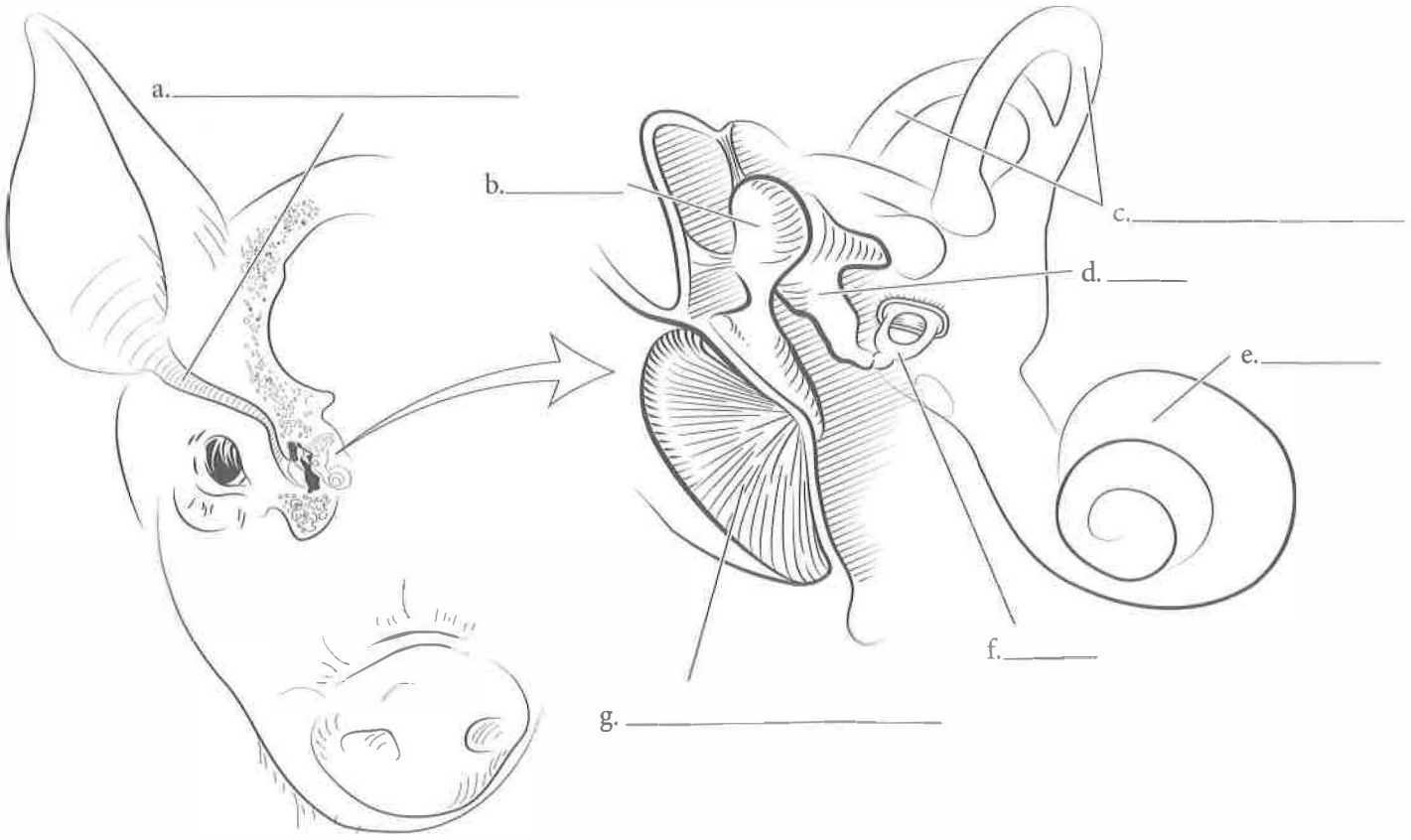
The path of light entering the mammalian eye begins with passage through the clear **cornea** and enters the posterior chamber through a hole in the **iris** called the **pupil**. Light then passes through the **lens** which inverts and focuses the image on the sensory cells of the **retina**, which is complex and multilayered. When a photon activates a retinal cell, an impulse is generated and sent to the brain through the optic nerve. At the opening to the optic nerve, called the optic disc, there are no light receptors.

The lens is held in place, and its shape changed to focus the image, by a muscular **ciliary body located** just behind the iris. The irregular junction of the ciliary body with the complex layers of the retina is a zone called the **ora serrata**. The eyeball wall consists of the outer tough, white **sclera** (which is clear in front to form the cornea), the black **choroid**, and the internal, complex, sensory retina. The cavity posterior to the lens is filled with **vitreous humor**, a clear, gelatinous material that fills the eyeball to maintain its shape while allowing light to pass.



EAR

The **external auditory** canal leads from the external ear, or pinna, into the inner ear. At the end of the auditory canal is the **tympanic membrane,** which vibrates when sound waves impact it. The vibration of the tympanic membrane is transmitted sequentially through a series of three small bones: the **malleus, incus,** and **stapes**. Vibration of the stapes, in turn, vibrates the oval window of the **cochlea**; fluid in the cochlea then vibrates certain sensory cells in the organ of Corti to send auditory sensory messages to the brain via the auditory nerve. Another part of the inner ear consists of the semicircular ducts, a set of three fluid-filled canals set approximately perpendicular to each other in three separate planes; movement of the fluid in these ducts provides information crucial to balance.



The pancreas is an endocrine organ as well as a digestive organ since it provides both digestive enzymes that are transported directly into the small intestine and the hormones insulin and glucagon that regulate glucose metabolism throughout the body. Insulin is released when glucose levels are high in the blood; it induces all cells to take up and metabolize glucose and makes the liver take up excess glucose to store in the form of glycogen. Glucagon has the opposite effect on the liver, inducing glycogen breakdown and release to increase blood levels of glucose.

Sex organs also release hormones. The testes release testosterone in the male, while the ovary produces estrogens and progestins.

The **thyroid gland** in the neck region secretes an iodine-containing hormone that generally increases metabolic activity in all cells. The nearby **parathyroid gland** secretes hormones that regulate calcium uptake or deposition within the bones. The **adrenal glands** are located at the anterior tip of the kidneys, and they secrete several hormones. The adrenal medulla produces epinephrine and norepinephrine (also called adrenaline and noradrenalin) that prepare the body for emergencies—increasing heart rate, blood pressure, and blood glucose levels while diverting blood flow away from the skin and digestive organs. This is known as the "flight or fight" response. The adrenal cortex produces cortisol, a steroid hormone that controls certain aspects of glucose metabolism that are important during fasting or intense exercise. Cortisol also has an anti-inflammatory influence on the immune system. In addition, the adrenal cortex provides a hormone that influences the kidney to reabsorb more sodium to decrease sodium loss in the urine, as well as low levels of several steroid sex hormones.