the CRANIAL NERVES

Together with the 31 pairs of spinal nerves, the 12 pairs of cranial nerves make up the peripheral nervous system. Two pairs of cranial nerves originate at the cerebrum and 10 pairs originate at the brain stem. All the nerves pass through the skull foramina to their destinations or from the organs they service. Both names and Roman numerals are used to designate the cranial nerves, with the Roman numerals used to designate the nerves that arise from the brain beginning at the anterior and proceeding to the posterior. Distribution or function of the nerve is indicated by its name.

Looking over the plate, you will note that we only show one nerve of the pair in order to simplify the diagram. In some cases the nerve is coming from the left side of the brain, while in others it originates from the right side. However, you should realize that each nerve is accompanied by its partner nerve. To complete this plate, use a bold color to color the nerve itself. The brain may be colored in a light color, but be careful to avoid obscuring the sources of the nerves. Light colors may also be used for the destination of the nerves in the body tissues, and you may label these tissues as you recognize them. Begin by coloring the main title The Cranial Nerves.

Some of the cranial nerves contain only sensory fibers and carry impulses toward the brain. Other cranial nerves are mixed nerves because they contain both sensory and motor fibers. The nuclei within the brain contain the cell bodies of motor neurons, while the cell bodies of sensory neurons are located outside the brain.

The first cranial nerve is cranial nerve I, the **olfactory nerve (A)**. This sensory nerve originates in the mucous membrane of the nose, as the plate shows, and terminates at the olfactory bulb of the cerebrum.

Cranial nerve II is the **optic nerve (B)**. This sensory nerve conveys impulses that result in vision and originates at the retina of the eye. It terminates in the lateral geniculate body of the thalamus and the superior colliculus of the midbrain. It and the olfactory nerve are the two cranial nerves of the cerebrum.

Cranial nerve III is the **oculomotor nerve (C)**. As the plate indicates, this nerve originates at the midbrain and is distributed to the extrinsic muscles of the eyeball, where it controls movement of the eyeball and focusing of the lens. It is a motor nerve.

Cranial nerve IV is the **trochlear nerve (D)**. This motor nerve originates at the midbrain and innervates the superior oblique muscle of the eye to control eye movements.

We have begun the discussion of the cranial nerves with surveys of the first four nerves. We now continue with the next few nerves, indicating their origin, distribution, and function. Continue your coloring as before, and select bold colors to color over the nerves. Next, we consider a complex nerve.

Cranial nerve V is the **trigeminal nerve (E)**. The nerve is both sensory and motor. It originates at the pons and is distributed to areas of the forehead, maxillary region, and mandibular region. Different colors may be used for these regions to indicate their distributions.

Cranial nerve VI is the **abducens nerve (F)**, seen on the right side of the plate. This nerve carries impulses from the pons to the lateral rectus muscle of the eye and effects lateral movement of the eye.

We now move to the left side of the plate and examine other cranial nerves servicing areas of the face. Continue your coloring as before and locate the nerves as you read about them.

The **facial nerve (G)** is cranial nerve VII. This nerve has both autonomic and somatic motor functions. It originates at the pons and is distributed to the tastebuds and muscles that control facial expression. It also has a role in the control of salivation.

The next nerve is cranial nerve VIII, the **vestibulocochlear nerve (H)**. This is a sensory nerve originating at the medulla and having distribution at the cochlea of the inner ear. This is the snail-like structure. It also carries impulses from the semicircular canals shown as projections from the cochlea. The nerve is also known as the auditory nerve and functions in hearing and maintaining equilibrium.

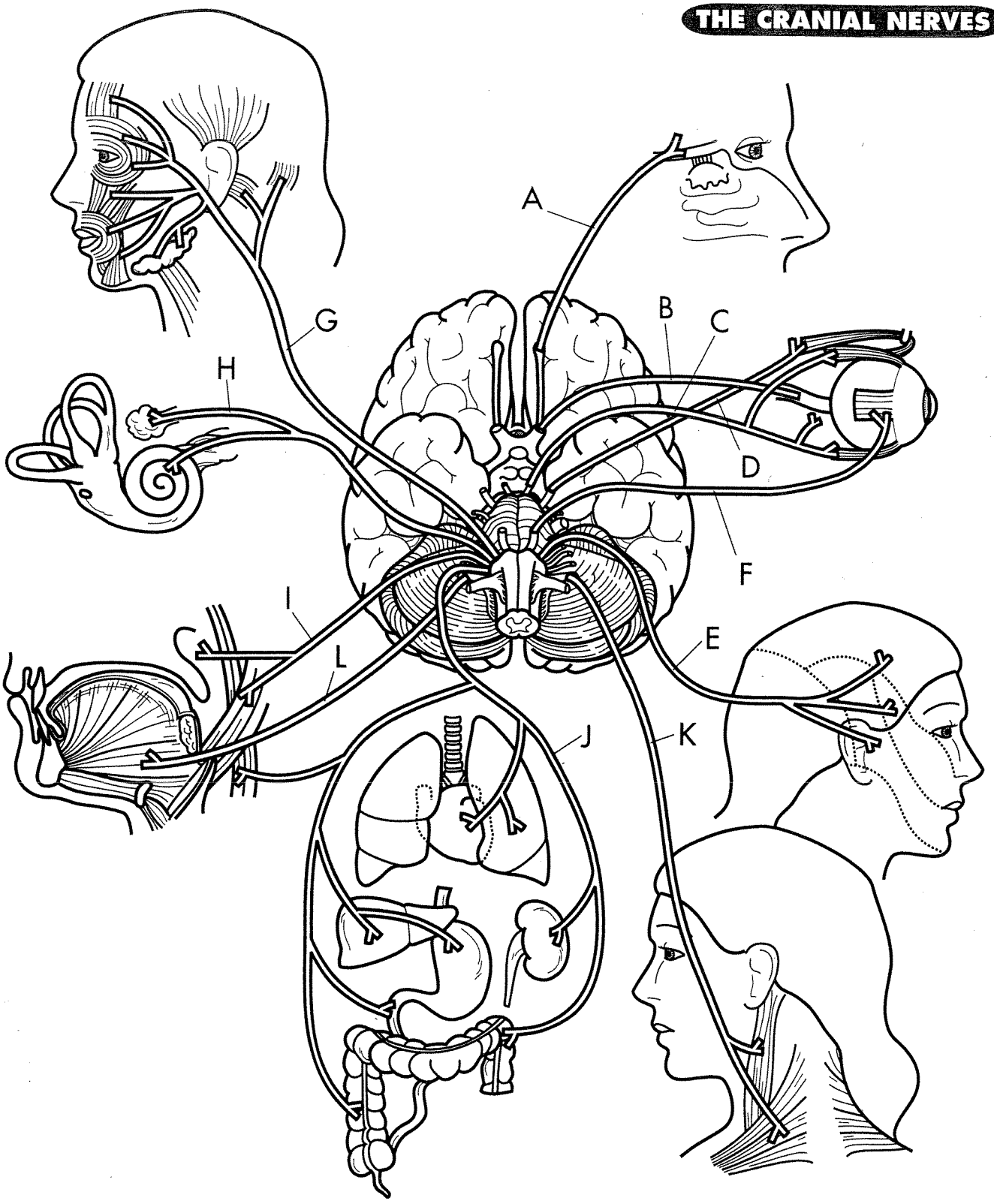
The **glossopharyngeal nerve (I)** is cranial nerve IX. A mixed nerve, it arises from the medulla and is distributed to the tongue, pharynx, and parotid gland. Taste sensations and saliva secretions are associated with it.

We conclude with three cranial nerves originating in the medulla and being of the mixed or motor variety. These nerves innervate areas of the lower jaw, neck, and viscera. Continue your reading, and continue your coloring pattern.

Cranial nerve X is the **vagus nerve (J)**. This mixed nerve arises at the medulla and is distributed to numerous organs as the plate shows. It carries sensations from and to the soft palate, heart muscle, stomach, kidney, and intestine. The nerve is associated with blood pressure, numerous visceral activities, and swallowing.

Cranial nerve XI is the **spinal accessory (K)**. Arising at the medulla, this motor nerve is distributed through muscles of the larynx, neck, and shoulder. It functions in movement of the shoulders, head, and in the production of sound.

The final cranial nerve, XII, is the **hypoglossal nerve (L)**. The last nerve to emerge from the brain, it arises at the medulla. It is a motor nerve distributed through muscles of the tongue, where it plays a role in speech, swallowing, and other movements of the tongue.



Olfactory nerve	A	○
Optic nerve	B	○
Oculomotor nerve	C	○
Trochlear nerve	D	○
Trigeminal nerve	E	○
Abducens nerve	F	○

Facial nerve	G	○
Vestibulocochlear nerve	H	○
Glossopharyngeal nerve	I	○
Vagus nerve	J	○
Spinal accessory	K	○
Hypoglossal nerve	L	○

the AUTONOMIC NERVOUS SYSTEM (SYMPATHETIC)

The nervous system has two principal divisions: the central nervous system (CNS) consisting of the brain and spinal cord, and the peripheral nervous system (PNS) composed of the peripheral and cranial spinal nerves. The PNS is further divided into a somatic nervous system (SNS), which conveys impulses to and from cutaneous and special senses (especially in the head) and the brain, and the autonomic nervous system (ANS), which conveys impulses to and from the visceral organs. The responses to the SNS are under voluntary control, while those to the ANS are involuntary.

The motor portion of the ANS consists of two branches, the sympathetic division and the parasympathetic division. Visceral organs receive impulses from the CNS via both divisions. Usually the two divisions have opposing actions. For instance, neurons in the sympathetic division increase the heart rate, while neurons from the parasympathetic division slow it down. This plate features the anatomy of the sympathetic division.

At first glance, the plate may appear somewhat complex because many organs are represented. However, close inspection shows that it consists of the CNS (brain and spinal cord) connected to several organs by a system of nerves constituting the sympathetic division of the ANS. As you read about this division, color the appropriate titles and the structures. In this plate, we have not listed the organs in the titles list, but you may color them as you identify them.

The basic function of the sympathetic division is to regulate visceral functions not usually subject to our conscious control. The system begins at the **spinal cord (a)**, which may be colored a single light color. Arising from the spinal cord is a set of **preganglionic nerve fibers (A)** seen on both the right and left sides of the spinal cord. These fibers arise from the thoracic and spinal nerves (the cranial and sacral nerves supply the parasympathetic division in the next plate).

Axons in the preganglionic fibers move to a set of autonomic ganglia lying along both sides of the spinal cord like a chain of beads. These ganglia are called **sympathetic (vertebral) ganglia (B)**. A single color should be used for both ganglionic chains. The cell bodies of preganglionic neurons are in the spinal cord, and their axons end at the sympathetic ganglia. Here they synapse with another set of neurons in the **postganglionic nerve fibers (C)**. The postganglionic neurons have their cell bodies in the sympathetic ganglia. Their axons then extend out to the organs shown on the right.

We have now discussed the basic makeup of the sympathetic division including the preganglionic nerve fibers, sympathetic ganglia, and postganglionic nerve fibers. We now continue the discussion with more details of the system.

When a preganglionic nerve fiber arrives at a sympathetic ganglion, it may follow any of three patterns. In some cases, the axons run up or down the chain of ganglia before emerging toward the organs. For example, axons may arise from the thoracic region, then emerge at the cervical ganglia. The **superior cervical (B_1)**, the **middle cervical (B_2)**, and the **inferior cervical (B_3)** ganglia are points where postganglionic fibers emerge. The diagram shows the fibers moving out to the eye, heart, and lungs.

In some cases, a preganglionic fiber passes through the sympathetic ganglia without synapsing. Instead, it extends out to a **collateral (prevertebral) ganglion (D)**, which is out in the tissues. One such collateral ganglion is the **celiac ganglion (D_1)** near the celiac artery. Here a synapse with the postganglionic nerve fiber takes place. Another possibility is the **superior mesenteric ganglion (D_2)**, and a third is the **inferior mesenteric ganglion (D_3)**. Light colors should be used to highlight these ganglia.

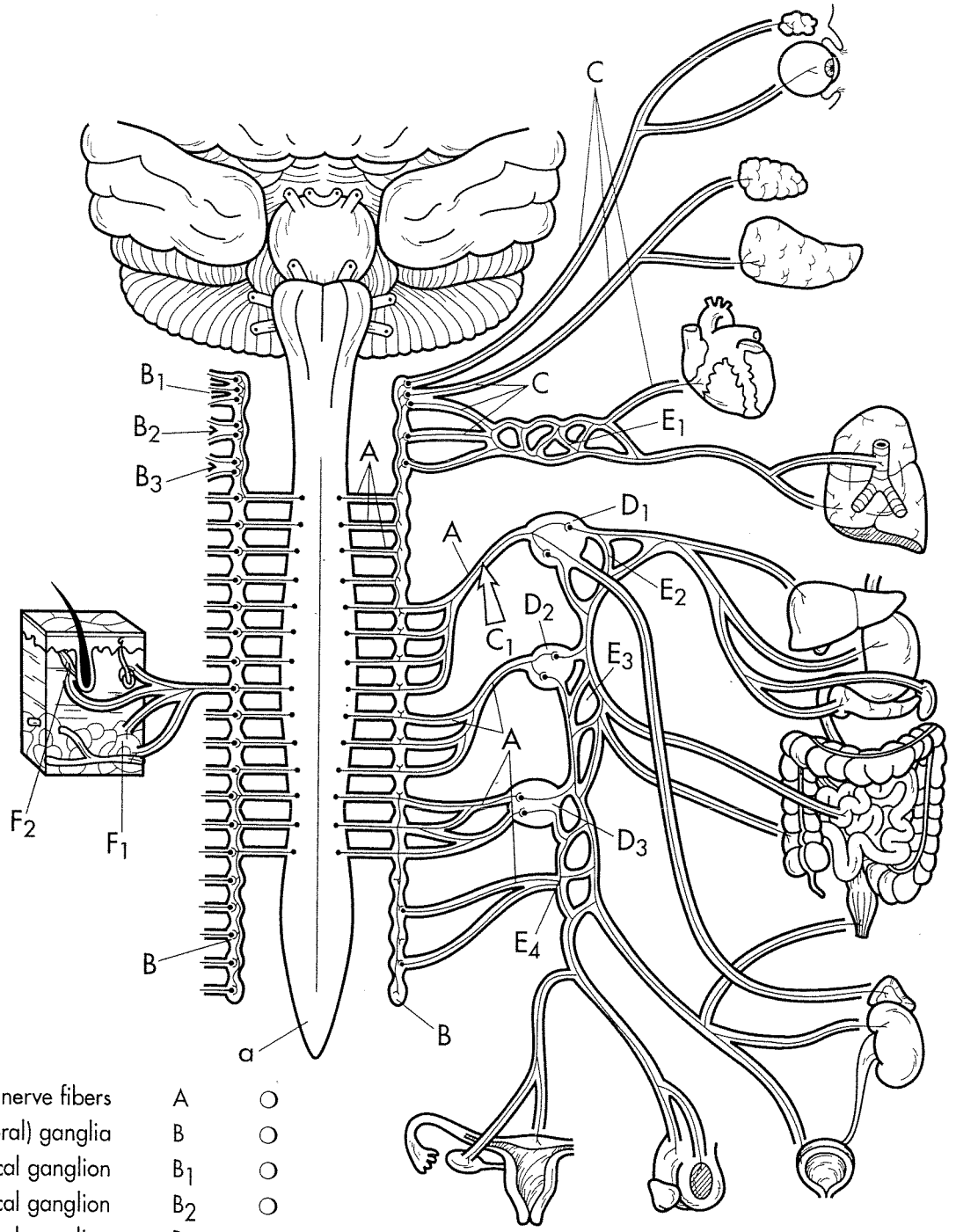
Preganglionic fibers passing through the sympathetic ganglia without terminating are called **splanchnic nerves (C_1)**. An arrow points to an example of these. Splanchnic nerves extend to the celiac and other collateral ganglia. The greater splanchnic nerve passes to the celiac ganglion, and the lesser splanchnic nerve passes to the superior mesenteric.

Many nerve fibers form networks similar to those formed by the arteries and veins. Some of these networks are mentioned in the next paragraph, and a brief view is given of a less complex part of the system. Continue your coloring in the plate.

After passing through the sympathetic ganglia, nerve fibers may pass directly to their target organs, or they may enter a network called a plexus for redistribution. Four of these plexuses are seen in the plate, including the **cardiopulmonary plexus (E_1)**, the **celiac plexus (E_2)**, the **superior mesenteric plexus (E_3)**, and the **inferior mesenteric plexus (E_4)**. Light colors may be used to highlight these networks.

As noted above, many nerve fibers pass through the sympathetic ganglia, then move to terminate directly at the effector organ. In the example shown, nerve fibers are arriving at the skin to bring about a sympathetic response, such as fright, to a situation. The nerve fibers innervate the blood vessels of the **skin (F_1)** to make the skin pale, and the **arrector pili muscles (F_2)** receive impulses to pull the hairs upright. These are typical responses mediated by the sympathetic division.

THE AUTONOMIC NERVOUS SYSTEM (SYMPATHETIC)



Preganglionic nerve fibers	A	○
Sympathetic (vertebral) ganglia	B	○
Superior cervical ganglion	B_1	○
Middle cervical ganglion	B_2	○
Inferior cervical ganglion	B_3	○
Postganglionic nerve fibers	C	○
Splanchnic nerve	C_1	○
Collateral (Prevertebral) ganglia	D	○
Celiac ganglion	D_1	○
Superior mesenteric ganglion	D_2	○
Inferior mesenteric ganglion	D_3	○
Plexuses	E	○
Cardiopulmonary plexus	E_1	○
Celiac plexus	E_2	○
Superior mesenteric plexus	E_3	○
Inferior mesenteric plexus	E_4	○
Skin blood vessel	F_1	○
Arrector pili muscle	F_2	○
Spinal cord	a	○

the AUTONOMIC NERVOUS SYSTEM (PARASYMPATHETIC)

The peripheral nervous system (PNS) contains somatic and autonomic divisions. The somatic nervous system (SNS) receives impulses and delivers them to the body surface, while the autonomic nervous system (ANS) services the visceral organs. There are two divisions of the ANS: the sympathetic division, which is discussed in the previous plate, and the parasympathetic division, discussed in this plate. Visceral organs generally receive impulses from both divisions, but while the sympathetic division increases the activity of visceral organs, the parasympathetic neurons slow them down. Both the sympathetic and parasympathetic divisions generally operate without conscious control.

As you look over the plate, note that it shows the central nervous system of the spinal cord together with a system of nerves extending to the right and moving out to various organs of the body. A similar system occurs on the opposite side of the body. As you read about the parasympathetic division in the following paragraphs, you may color the appropriate nerves and structures. Be sure to contrast this division with the sympathetic division in the previous plate, and note the differences in the anatomical construction. We have not labeled the organs in this plate, but you should recognize them, and you may color them in using appropriate colors.

Both the sympathetic and parasympathetic divisions of the ANS arise from the **spinal cord (a)**. A single light color may be used here. The parasympathetic division is composed of fibers emerging from the brain stem and sacral portion of the spinal cord. The sympathetic division has thoracic and lumbar origins. Like the sympathetic division, there is a preganglionic nerve fiber, a ganglion, and a postganglionic nerve fiber. In the parasympathetic division, however, the preganglionic nerve fibers are extremely long, and the terminal ganglia are small collections of cells close to or in the organs innervated. The postganglionic fibers are equally short and within the organs. For that reason, the terminal ganglia and postganglionic fibers are not seen in this plate, with some exceptions.

We begin with the cranial portion of the parasympathetic division, and note that four cranial nerves supply the preganglionic nerve fibers. Fibers from the cranial nerves are shown on the right side. The root of the fiber is shown on the left side of the plate. The four nerves involved are the third cranial nerve, the **oculomotor** (A_1), the seventh cranial nerve, the **facial** (A_2), the ninth cranial nerve, the **glossopharyngeal** (A_3), and the tenth cranial nerve, the **vagus nerve** (A_4).

As the diagram shows, the first three nerves extend to **terminal ganglia (B)** near the organs innervated. The **ciliary ganglion** (B_1) lies near the orbit of the eye. A **postganglionic nerve fiber (E)** extends to the smooth muscles of the eyeball. The **pterygopalatine ganglion** (B_2) is near a foramen in the skull. It receives a preganglionic nerve fiber from the facial nerve and sends a postganglionic nerve fiber to the lacrimal glands to control tearing.

The third ganglion is the **submandibular ganglion** (B_3), located near the duct from the submandibular salivary gland. Finally, the **otic ganglion** (B_4) is found near the foramen ovale. Its postganglionic fiber extends to the parotid salivary gland, as shown.

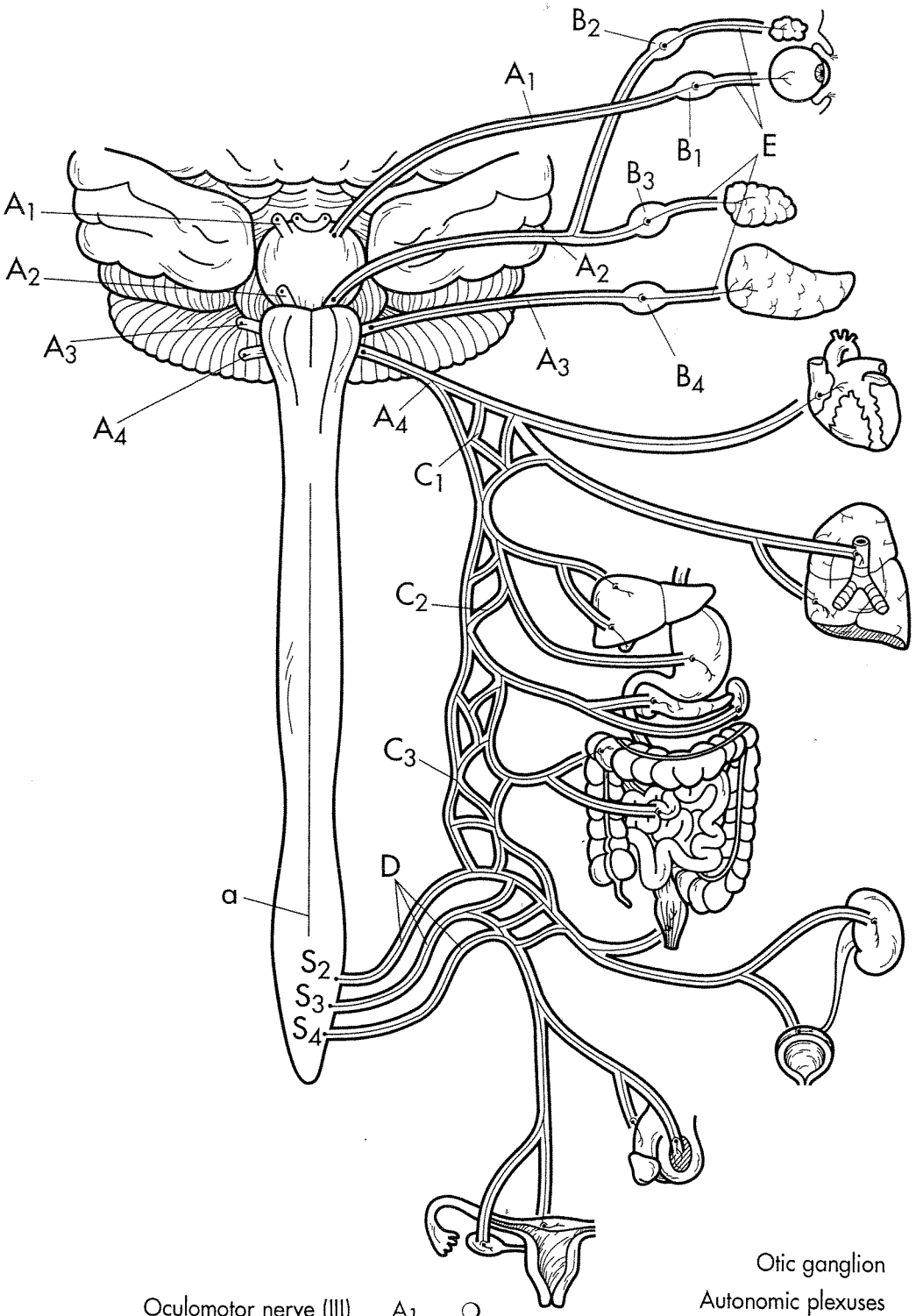
We now concentrate on the outflow from the vagus nerve as it participates in the parasympathetic division. Here we note several plexuses. Continue as before, but plan to use light colors to indicate the plexuses. The organs may also be colored as you proceed, and they may be identified from the reading as well as from your knowledge from other plates.

Impulses carried over the vagus nerve extend through the preganglionic fibers to numerous portions of the viscera. As the plate indicates, there are many interlaced networks involved before the nerves reach the terminal ganglia in the visceral organs. These networks are called **autonomic plexuses (C)**. For example, the vagus nerve extends to the **cardiopulmonary plexus** (C_1), which may be colored in a light color. The fibers then continue to the heart and lungs as shown and reduce their activity at the end of the flight-fright phenomenon.

Another important plexus is the **celiac plexus** (C_2). This is also called the solar plexus. It is the largest mass of nerve cells outside the CNS. Lying outside the aorta, it is the network from which preganglionic fibers pass to the liver, stomach, pancreas, gallbladder, and other abdominal organs. A connection is also made to the **hypogastric plexus** (C_3). Here, a branching network extends out to the terminal ganglia in the small and large intestines, and a branch is also made with the splanchnic nerves that follow.

We close the plate by examining the sacral flow of nerves to the lower visceral organs. Continue reading about these nerves, and color the appropriate sections in the plate. Try to identify the visceral organs involved, and color them also.

The **second, third,** and **fourth sacral nerves** (S_2-S_4) form the **pelvic splanchnic nerves (D)**. As the plate shows, these nerves extend to the hypogastric plexus, then their branches course to such organs as the rectum, kidney, urinary bladder, and reproductive organs. The terminal ganglia are located within the walls of these organs, with the result that the preganglionic nerve fibers tend to be very long. The postganglionic nerve fibers, by contrast, are extremely short.



Oculomotor nerve (III)	A_1	○
Facial nerve (VII)	A_2	○
Glossopharyngeal nerve (IX)	A_3	○
Vagus nerve (X)	A_4	○
Terminal ganglia	B	○
Ciliary ganglion	B_1	○
Pterygopalatine ganglion	B_2	○
Submandibular ganglion	B_3	○
Otic ganglion	B_4	○
Autonomic plexuses	C	○
Cardiopulmonary plexus	C_1	○
Celiac plexus	C_2	○
Hypogastric plexus	C_3	○
Pelvic splanchnic nerves	D	○
Postganglionic nerve fibers	E	○
Pelvic splanchnic nerves	D	○
Sacral nerves	S_2-S_4	○
Spinal cord	a	○