SEM IV ZOOA

CC8 UNIT 6:
NERVOUS SYSTEM AND SENSE ORGANS
(Part - 2)

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Cranial Nerves

Cranial nerves have roots enclosed in the braincase. Most are named and numbered by Roman numerals from anterior to posterior. The conventional system for numbering these nerves is sometimes inconsistent. For instance, most anamniotes are said to have ten numbered cranial nerves plus six pairs of unnumbered, lateral line cranial nerves. A few anamniotes and all amniotes are said to have 12. In fact, there is an additional terminal nerve at the beginning of this series. If counted at all, it is numbered 0 to avoid renumbering the conventionally numbered sequence. Further, the second cranial nerve (II) is not a nerve at all but an extension of the brain. Nevertheless, by convention it is called the optic "nerve." The eleventh cranial nerve (XI) represents the merger of a branch of the tenth cranial nerve (X) with elements of the first two spinal nerves (C-1 and C-2). Despite its composite structure, it is called the spinal accessory nerve and designated by Roman numeral XI. In addition to these numbered cranial nerves, up to six pairs of unnumbered, lateral line cranial nerves are present in jawed fishes and many amphibians.

Phylogenetically, the cranial nerves are thought to have evolved from dorsal and ventral nerves of a few anterior spinal nerves that became incorporated into the braincase. Dorsal and ventral nerves fuse in the trunk but not in the head, and they produce two series: dorsal cranial nerves (V, VII, IX, and X) and ventral cranial nerves (III, IV, VI, and XII). Like spinal nerves, the cranial nerves supply somatic and visceral tissues and carry general sensory and motor information. Some cranial nerves consist of only sensory or only motor fibers. Other nerves are **mixed,** containing both types. Cranial nerves concerned with localized senses (e.g., sight, hearing, lateral line, olfaction, taste) are called **special cranial nerves** to distinguish them from those concerned with the sensory or motor innervation of the more widely distributed viscera, **general cranial nerves.**

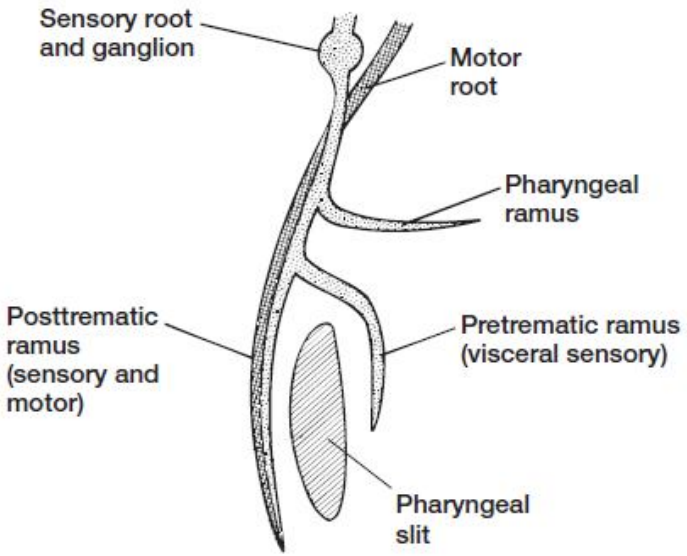
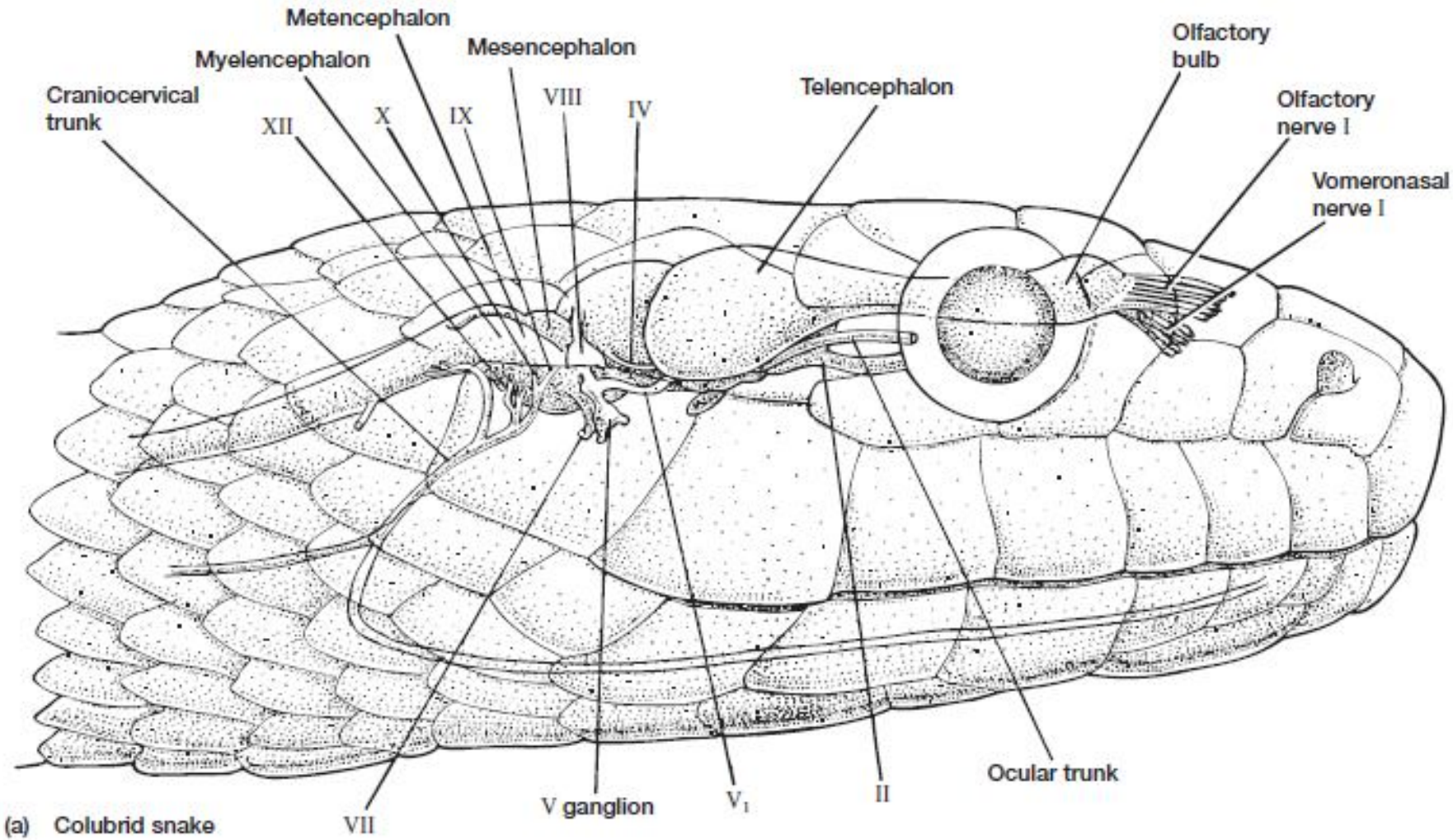


FIGURE 16.10 Components of a cranial nerve in a fish. The pharyngeal ramus, to the lining of the pharynx, and the small pretrematic ramus, to the front of the pharyngeal slit, both carry visceral sensory fibers. The dorsal ramus from the skin is composed of somatic sensory fibers. The posttrematic ramus running down the back of the pharyngeal slit includes both sensory and motor fibers. Rostral is to the right of the figure.

Primitively, all cranial nerves serving the branchial pouches formed three branches per pouch: **pretrematic, posttrematic,** and **pharyngeal** (figure 16.10). In amniotes, these tend to be lost or their homologies become uncertain.

Most anamniotes possess 17 cranial nerves. The first few spinal nerves behind the braincase become housed in the skull of later derived groups. But in anamniotes, these anterior spinal nerves are still partially outside the skull.


Metencephalon
Myelencephalon
Mesencephalon
Craniocervical trunk
XII
X
IX
VIII
IV
Telencephalon
Olfactory bulb
Olfactory nerve I
Vomeronasal nerve I
Ocular trunk
II
V_1
V ganglion
VII
(a) Colubrid snake

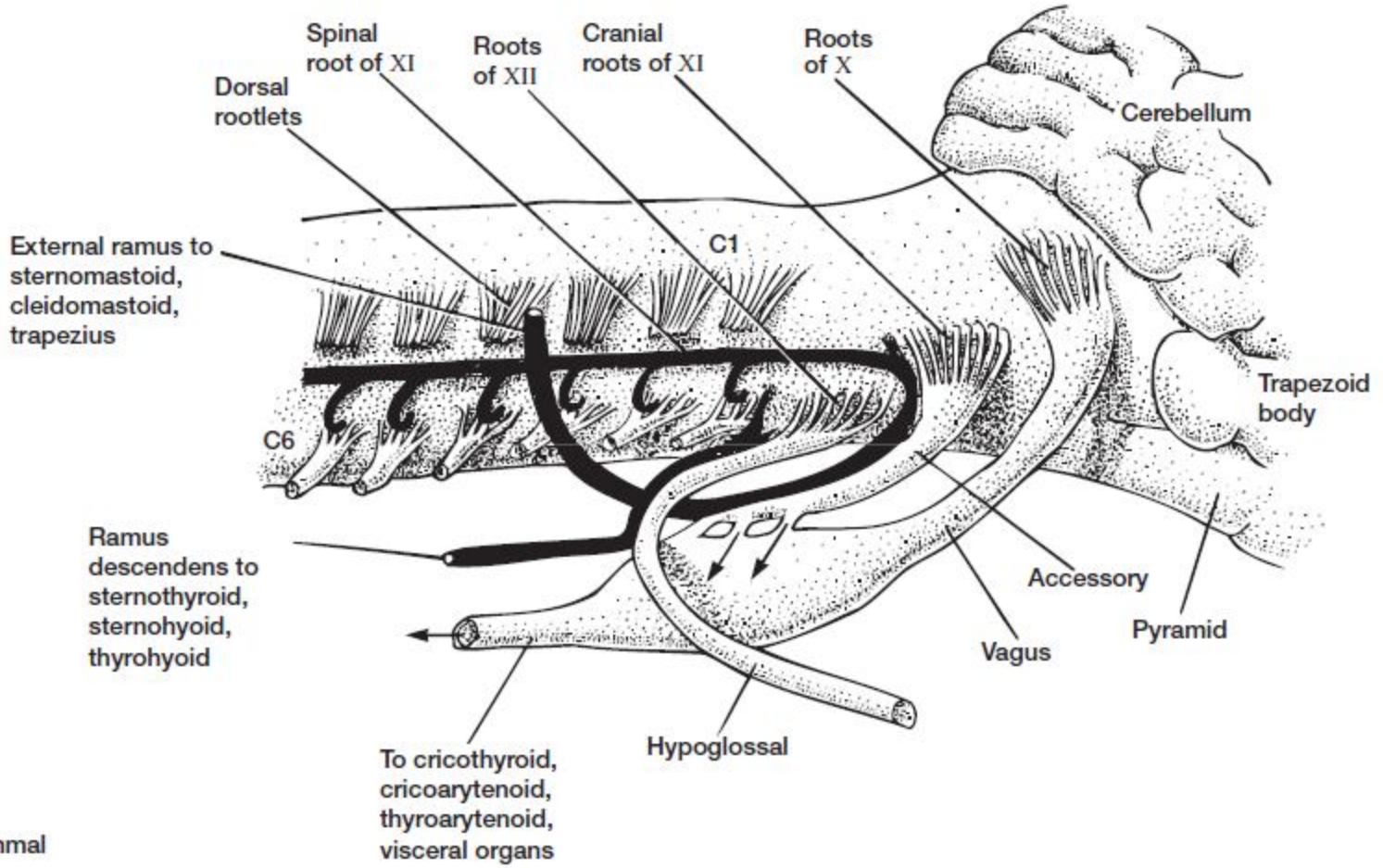


FIGURE 16.11 **Posterior cranial nerves.** (a) Colubrid snake. The glossopharyngeal (IX), vagus (X), hypoglossal (XII), and one of the spinal nerves join to form the craniocervical trunk. Unlike most other amniotes, snakes appear to lack a spinal accessory nerve (XI). (b) Mammal. The roots of the hypoglossal nerve are in series with the ventral roots of the preceding spinal nerves. Spinal nerve contributions to the accessory (XI) and hypoglossal (XII) nerves are shown in solid black. The vagus receives contributions from the accessory nerves (arrows).

(b) After Kent

In cyclostomes, these anterior spinal nerves outside the skull are called **occipitospinal nerves.** In other fishes and amphibians, the anterior spinal nerves become partially incorporated into the braincase. They exit via foramina in the occipital region of the skull and are called **occipital nerves.** Occipital nerves unite with the next few cervical spinal nerves to form the composite **hypobranchial nerve** that supplies hypobranchial muscles in the throat (figure 16.11a,b).

Latimeria (coelacanth) and many amphibians have 17 cranial nerves. In amniotes, the lateral line nerves are lost and the occipitospinal nerves are incorporated into the skull and modified. Their roots shift from the spinal cord forward into the medulla. In this way, amniotes derive the eleventh and twelfth cranial nerves. The 12 numbered cranial nerves are illustrated in figures 16.12 through 16.15. They are described in more detail next, and their functions are summarized in table 16.1.

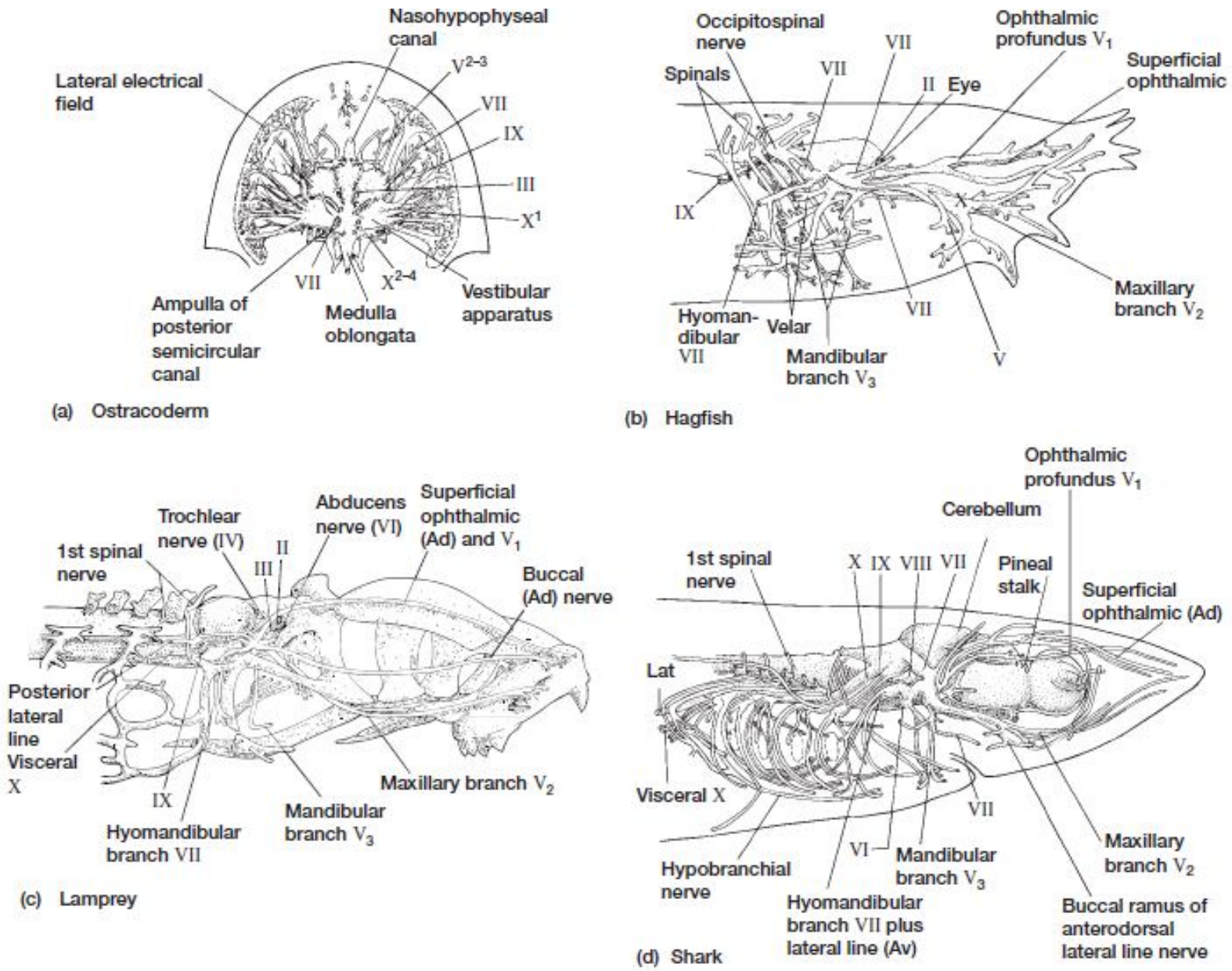
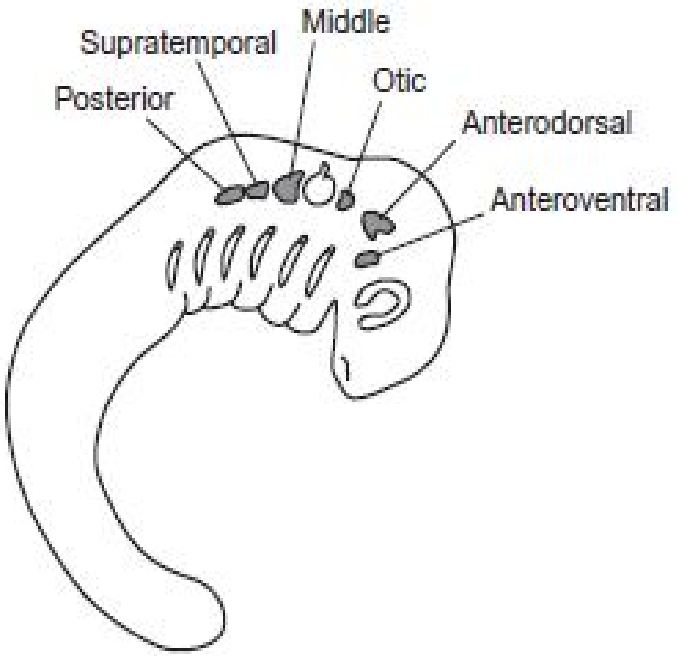


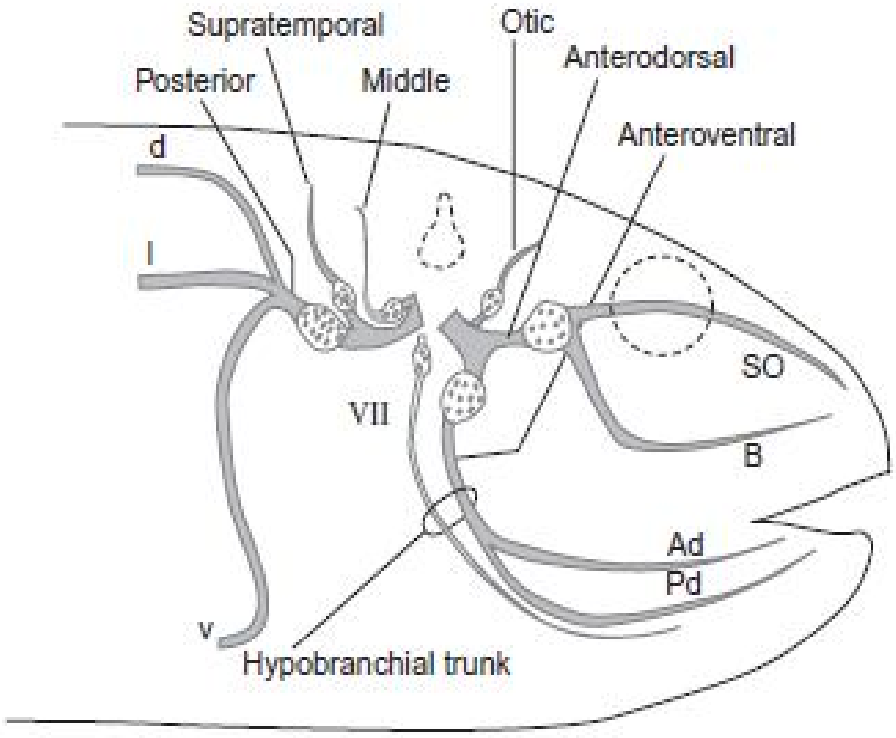
FIGURE 16.12 **Cranial nerves of vertebrates.** (a) Ostracoderm, *Kiaeraspis*. (b) Hagfish, *Myxine*. (c) Lamprey. (d) Lateral view of cranial nerves in the shark, *Squalus*. Abbreviations: anterodorsal lateral line nerve (Ad), anteroventral lateral line nerve (Av).

Dorsolateral Placodes

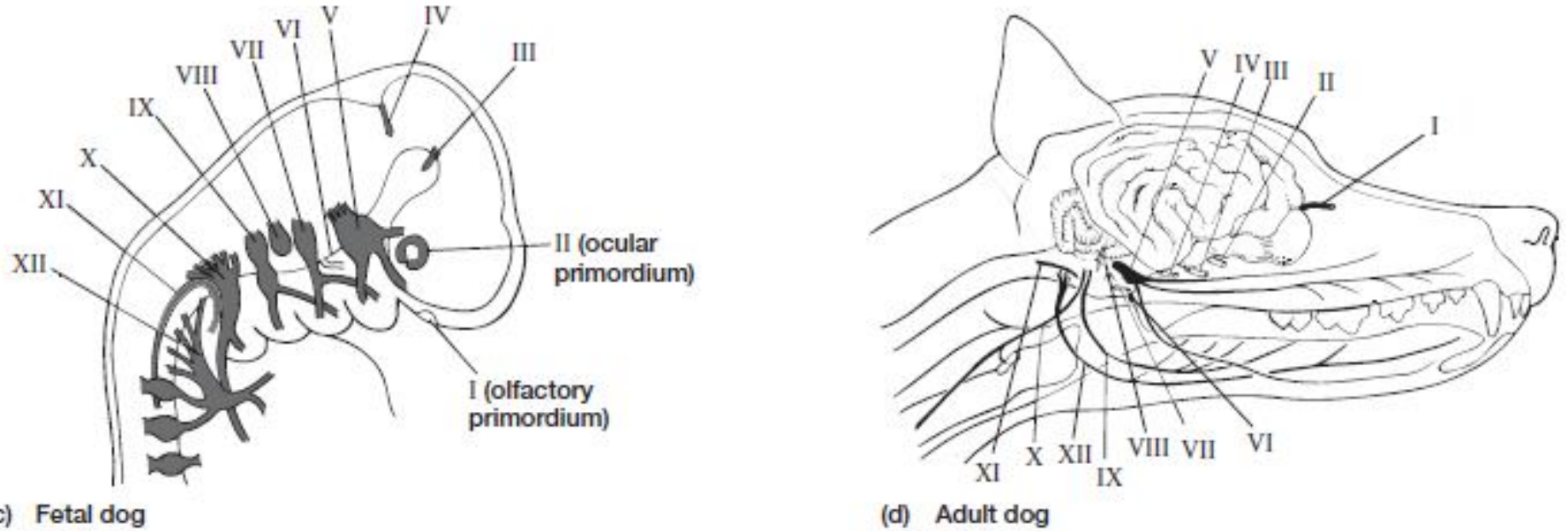


(a)

Lateral Line Nerves



(b)



(c) Fetal dog

(d) Adult dog

FIGURE 16.13 Embryonic development of cranial nerves. (a) The lateral line cranial nerves arise from the dorsolateral placodes. (b) Generalized number and innervation pattern of lateral line nerves in jawed fishes. Ganglia are represented by expanded areas with small circles inside. Relative position of eye (dashed circle) and otic vesicle (dashed pear-shape) are indicated. Hypobranchial trunk includes the lateral line nerve and the facial cranial nerve VII. (c) Fetal dog. (d) Adult dog. The posterior lateral line nerve has three rami: dorsal (d), lateral (l), and ventral (v). The anterodorsal lateral line nerve has two major rami: the superficial ophthalmic (SO) and buccal (B). The anteroventral lateral line nerve produces two major rami: the anterior (Ad) and posterior (Pd) divisions.

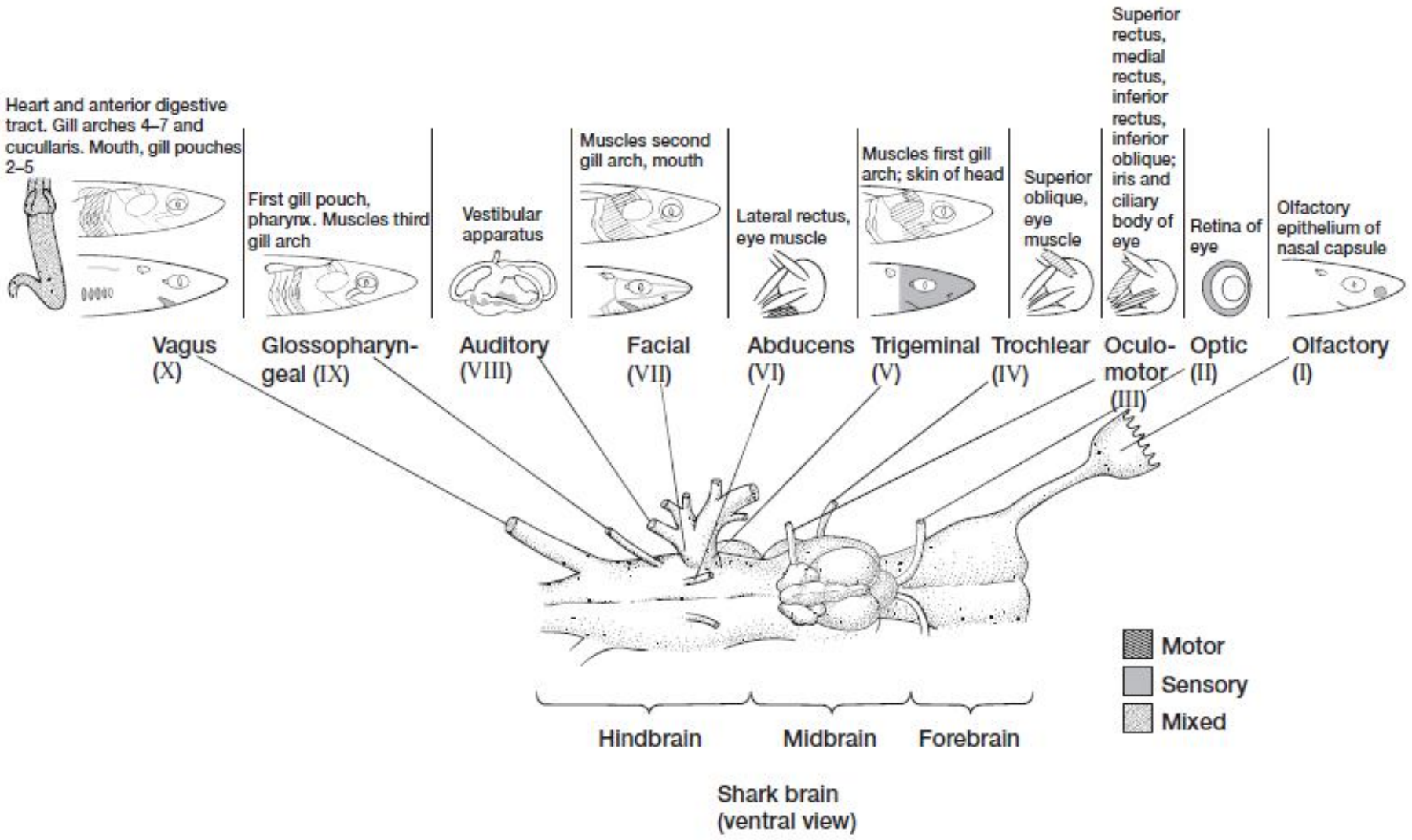


FIGURE 16.14 **Distribution of cranial nerves in the shark *Squalus*.** Enlarged views of the innervated structures of cranial nerves II, III, IV, VI, and X. Lateral views of the head with and without skin indicate the location of the first ten cranial nerves.

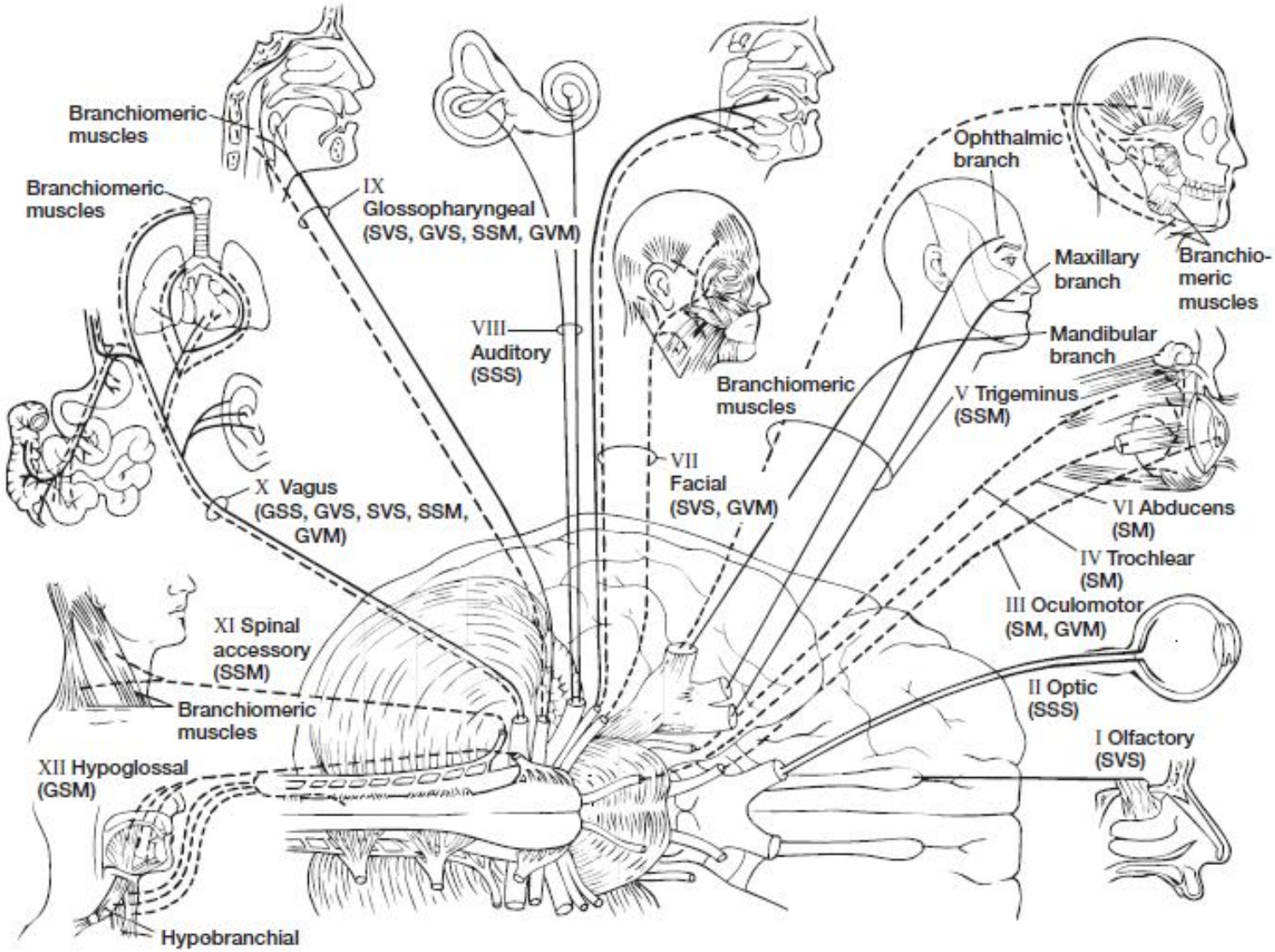


FIGURE 16.15 **Distribution of cranial nerves in a mammal, *Homo sapiens*.** Sensory (solid lines) and motor (dashed lines) nerve fibers are indicated. Enlarged views of innervated structures of cranial nerves are shown around the human brain in ventral view. Abbreviations: general somatic sensory (GSS), general visceral sensory (GVS), general somatic motor (GSM), general visceral motor (GVM), special somatic sensory (SSS), special somatic motor (SSM), special visceral sensory (SVS).

TABLE 16.1 Functional Components of Cranial Nerves in Amniotes

		Somatic Sensory		Visceral Sensory		Visceral Motor		Somatic Motor	
Cranial	Nerve	General	Special	General	Special	General	Special	General	Special
0	Terminal	X		X					
I	Olfactory				X				
II	Optic		X						
III	Oculomotor					(X)		X	
IV	Trochlear							X	
V_1	Trigeminal	X							
$V_{2,3}$	Trigeminal proper	X							X
VI	Abducens								
VII	Facial	(X)		X	X	X			X
VIII	Auditory		X						
IX	Glossopharyngeal	(X)		X	X	X			X
X	Vagus	X		X		X			X
XI	Spinal accessory								X
XII	Hypoglossal							X	
	Lateral line		X						

Note: Parentheses indicate variable or negligible function in the category indicated.

Nervus Terminalis (0) The terminal nerve may be testimony to an ancient anterior head segment that has been lost. The terminal nerve is a nerve, or perhaps a complex of nerves, that arises from olfactory placodes. It is present in all classes of gnathostomes except birds. It runs to blood vessels of the olfactory epithelium in the olfactory sac and carries visceral sensory and some motor fibers. A role in reproduction is suspected.

Olfactory Nerve (I) The olfactory nerve is a sensory nerve concerned with the sense of smell. Olfactory cells lie in the mucous membrane of the olfactory sac. A short axon leads from each cell to the olfactory bulb. Each axon constitutes an olfactory fiber. Collectively, the olfactory fibers form the short olfactory nerve, which is the only cranial nerve composed of the axons of the receptor cells themselves.

Optic Nerve (II) Strictly speaking, the **optic nerve** is not a nerve but a sensory tract. That is, it is not a collection of peripheral axons; it is a collection of fibers in the CNS. Embryologically, it develops as an outpocketing of the brain. However, once it is differentiated, it lies outside the brain. Its fibers synapse in the thalamus and midbrain.

Oculomotor Nerve (III) The **oculomotor nerve** primarily supplies extrinsic eye muscles (superior rectus, medial rectus, inferior rectus, and inferior oblique muscles) derived from preotic myotomes. It is a motor nerve that also carries a few visceral motor fibers to the iris and ciliary body of the eye. Fibers arise in the oculomotor nucleus in the floor of the midbrain.

Trochlear Nerve (IV) The **trochlear nerve** is a motor nerve that supplies the extrinsic, superior oblique eye muscle. Fibers arise in the trochlear nucleus of the midbrain.

Trigeminal Nerve or **Trigeminus (V)** The **trigeminus** is so named because it is formed of three branches: **ophthalmic (V_1), maxillary (V_2),** and **mandibular (V_3)** in amniotes (figures 16.12c and 16.15). The ophthalmic nerve, sometimes called the deep ophthalmic (= profundus) nerve to distinguish it from a more superficial nerve, usually merges with the other two branches. However, in anamniotes, the ophthalmic nerve often emerges from the brain separately. This independent emergence was once taken as evidence that it anciently supplied an anterior branchial arch that had since been lost. However, the ophthalmic nerve (V_1) arises embryologically from a placode, unlike the maxillary (V_2) and mandibular (V_3) that arise from neural crest, suggesting an independent origin for the ophthalmic altogether without the need to postulate an association with a lost branchial arch. The other two branches, the maxillary ramus (V_2) to the upper jaw and the mandibular ramus (V_3) to the lower jaw, presumably represent pretrematic and posttrematic rami of a typical branchial nerve to the mandibular arch.

The mixed trigeminus includes sensory fibers from the skin of the head and areas of the mouth and motor fibers to derivatives of the first branchial arch. Sensory fibers of the trigeminus return to the brain from the skin, teeth, and other areas through each of the three branches. The mandibular branch also contains somatic motor fibers to muscles of the mandibular arch.

Abducens Nerve (VI) The **abducens** is the third of the three cranial nerves that innervate muscles controlling movements of the eyeball. It is a motor nerve that supplies the extrinsic, lateral rectus eye muscle. Fibers arise in abducens nucleus located in the medulla.

Facial Nerve (VII) The mixed **facial nerve** includes sensory fibers from taste buds as well as motor fibers that service derivatives of the second (hyoid) arch. This nerve also carries a substantial number of somatic sensory fibers to the skin. In fishes, the skin of the entire opercular complex is innervated by the facial nerve.

Octaval (= Auditory) Nerve (VIII) The sensory **octaval nerve** (acoustic, vestibulocochlear, statoacoustic) carries sensory fibers from the inner ear, which is concerned with balance and hearing. The nerve synapses in several regions of the medulla.

Glossopharyngeal Nerve (IX) The mixed **glossopharyngeal nerve** supplies the third branchial arch. It contains sensory fibers from the taste buds, the first gill pouch, and the adjacent pharyngeal lining. Motor fibers innervate muscles of the third branchial arch.

Vagus Nerve (X) The term **vagus** is Latin for wandering and aptly applies to this mixed nerve. The vagus meanders widely, serving areas of the mouth, pharynx, and most of the viscera. It is formed by the union of several roots across several head segments. Occasionally, additional nerves of the lateral line merge with the vagus.

Spinal Accessory Nerve (XI) In anamniotes, the **spinal accessory nerve** is probably composed of a branch of the vagus nerve and several occipitospinal nerves. In amniotes, especially in birds and mammals, it is a small but distinct motor nerve that supplies derivatives of the cucullaris muscle (cleidomastoid, sternomastoid, trapezius). A few of its fibers accompany the vagus nerve to supply part of the pharynx and larynx and perhaps the heart. Fibers arise from several nuclei within the medulla.

Hypoglossal Nerve (XII) The **hypoglossal nerve** is a motor nerve of amniotes that innervates hyoid and tongue muscles. Fibers originate in the hypoglossal nucleus within the medulla. In fishes and amphibians, the confluence of one or several occipital nerves (ventral roots of original spinal nerves) and often modified spinal nerves form the hypobranchial nerve. In amniotes it is incorporated into the skull and therefore more appropriately recognized as a cranial nerve, the hypoglossal nerve.

Lateral Line Nerves In addition to formally numbered cranial nerves, fishes possess preotic and postotic **lateral line cranial nerves** that are rooted in the medulla and supply the lateral line system. They were once thought to be components of the facial, glossopharyngeal, and vagal nerves, but they are now recognized as independent cranial nerves, derivatives of the dorsolateral placodes (octavolateralis placodes) (figure 16.13a). Unfortunately, this late recognition as distinct cranial nerves has left them without an identifying Roman numeral. In most jawed fishes and some amphibians, up to six pairs of lateral line nerves are present. Three are preotic (rostral to the otic vesicle, future inner ear): the anterodorsal, anteroventral, and otic lateral line nerves; three are postotic: the middle, supratemporal, and posterior lateral line nerves (figure 16.13a,b). Each of the dorsolateral placodes initially gives rise to a distinct sensory ganglion whose distal fibers innervate the lateral line receptors (neuromasts and ampullary organs) that themselves also arise from the same placode. Only rarely are any of the ganglia of the lateral line nerves fused with cranial nerves V, VII, IX, and X, but all preotic and all postotic lateral line nerves converge, entering the brain rostral and caudal to the otic vesicle, respectively. Frequently each converged nerve divides into a dorsal and ventral root. If present, the dorsal root only carries fibers that innervate ampullary organs and the ventral root only carries fibers that innervate the neuromast organs. Because

TABLE 16.2 Cranial Nerves and Their Associated Branchial Arches

Ancient Segment	Current Arch	Dorsal Root Representative	Ventral Root Representative
?		Terminal (0)	
0		Deep ophthalmic (V)	Oculomotor
—	Mandibular		
1		Superficial ophthalmic (skin; V) maxillary (pretrematic; V) mandibularis (posttrematic; V)	Trochlear
2	Hyoid	Facial (VII)	Abducens
3	Branchial 3	Glossopharyngeal (IX)	
4	Branchial 4	Vagus (X)	
5	Branchial 5	Vagus (X)	Hypoglossal
6	Branchial 6	Vagus (X)	Hypoglossal
7	Branchial 7	Spinal accessory (XI)	Hypoglossal

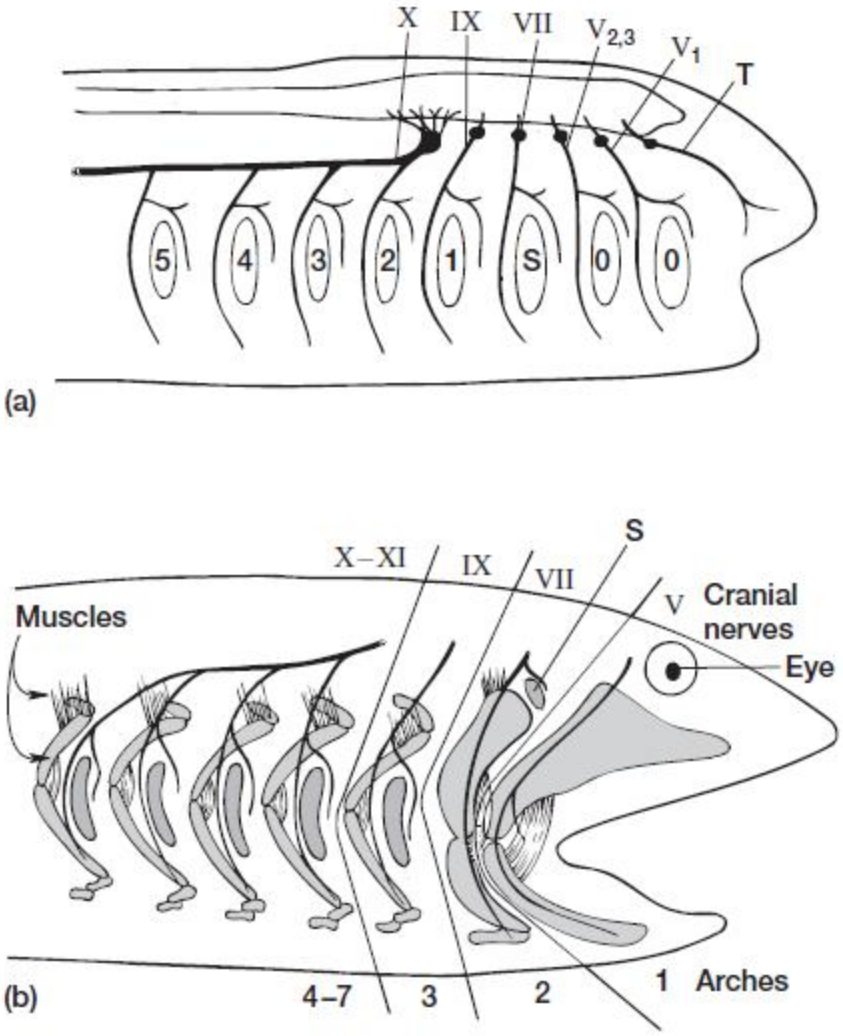


FIGURE 16.16 Phylogenetic derivation of cranial nerves. (a) Hypothesized primitive condition. Each pharyngeal slit was supplied by a nerve. The first, or terminal (T), nerve supplied an anterior arch that was lost early in vertebrate evolution. (b) Nerve supply to associated branchial arches. Cranial nerves V, VII, IX, and X–XI supply the following arches: mandibular (1), hyoid (2), third (3), and fourth–seventh (4–7), respectively. These associations between cranial nerves and their derivatives remain stable throughout teleosts and tetrapods. Abbreviations: gill slits lost in gnathostomes (0, 0′), gill slits usually present in gnathostomes (1–5), spiracular slit (S).

REFERENCES:

Kardong, K. Vertebrates. Comparative Anatomy, Function and Evolution. *The Nervous System*.