

BASIC SCIENCES • ANATOMY

— STUDY NOTES

Veterinary Neuroanatomy Notes: Brain, Spinal Cord and Cranial Nerves (PDF)

Neuroanatomy is the map; neurology is what you do on it. These notes are the map: the two ways the nervous system is divided and why you need both, what it is built from, how a plate becomes a tube and then five brain divisions, the parts of the brain and cord, how a pathway's name gives its route, the meninges and the spaces and the fluid between them, the twelve cranial nerves, how a spinal nerve is put together, the two autonomic outflows and where the species differ. Signs and lesion grading are left to the clinical pages.

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- 7 · Coverings, the twelve, and the two outflows

LEVEL

Vets & veterinary students

EDITION

2026-09-06

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LEARNING OBJECTIVES

After working through these notes you will be able to:

- ✓ **Divide** the nervous system two ways at once, and place any structure in both.
- ✓ **Distinguish** a nucleus from a ganglion, a tract from a nerve, and a root from a ramus.
- ✓ **State** what each of the three neural-tube layers and the two plates becomes.
- ✓ **Name** the five brain divisions and the adult part and cavity of each.
- ✓ **Derive** a pathway's route and direction from its name.
- ✓ **List** the twelve cranial nerves with their components and the openings they leave by.
- ✓ **Say** where the spinal cord ends in each domestic species, and why it matters.

TL;DR

Neuroanatomy is the map; neurology is what you do on it. These notes are the map: the two ways the nervous system is divided and why you need both, what it is built from, how a plate becomes a tube and then five brain divisions, the parts of the brain and cord, how a pathway's name gives its route, the meninges and the spaces and the fluid between them, the twelve cranial nerves, how a spinal nerve is put together, the two autonomic outflows and where the species differ. Signs and lesion grading are left to the clinical pages.

AT A GLANCE

THE BRANCH	Neuroanatomy = the structure; neurology = the method
CUT ONE, BY PLACE	CNS (brain + cord) vs PNS (nerves + ganglia)
CUT TWO, BY JOB	Afferent / efferent, each somatic / visceral
CELL BODIES	Nucleus inside the CNS, ganglion outside it
AXON BUNDLES	Tract inside the CNS, nerve outside it
GREY MATTER	OUTSIDE in the cerebrum, INSIDE in the cord
TUBE LAYERS	Ependyma → grey matter → white matter
ALAR / BASAL	Dorsal horn, sensory / ventral horn, motor
EPIDURAL SPACE	Real around the cord, absent inside the skull
AUTONOMIC	Wholly EFFERENT, and two neurons in series

01 1 • The branch, and the layer this is

- **Neuroanatomy** = how the nervous system is built and where its parts are. **Neurology** = what you do with a patient on that map.
- The whole continuous brain-and-cord is the **neuraxis** — a useful word because it refuses a division that does not exist in the tissue.
- In scope here: divisions, development, cells, brain and cord, pathways by route, meninges and fluid, cranial and spinal nerves, the autonomic outflows, species differences.
- Out of scope, deliberately: **signs, reflexes, lesion grading and disease** (clinical pages) and **how a neuron fires** (physiology).

02 2 • Two cuts, and the words that trip everyone

COMPONENT	DIRECTION	CARRIES	FOUND IN
GSA	In	Touch, temperature, pain, stretch	All spinal nerves; CN V
SSA	In	Vision, hearing, balance	Only CN II and VIII
GVA	In	Stretch and pressure from viscera and vessels	CN III, V, VII, IX, X; all spinal nerves
SVA	In	Smell and taste	Smell CN I; taste CN VII, IX and X
SE	Out	To striated muscle	All spinal nerves; every CN except I, II, VIII

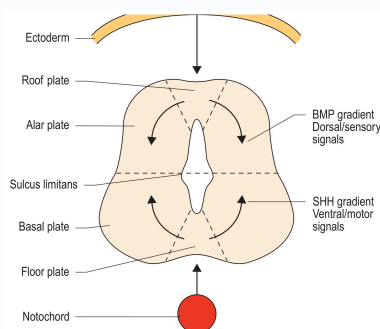
COMPONENT	DIRECTION	CARRIES	FOUND IN
GVE	Out	To smooth and cardiac muscle and glands — the autonomic system	Sympathetic: thoracolumbar. Parasympathetic: CN III, VII, IX, X and the sacral nerves

- **Cut one, anatomical:** the **central nervous system (CNS)** — brain and spinal cord — against the **peripheral nervous system (PNS)** — the cranial and spinal nerves and their ganglia. Dyce calls it the most fundamental. The PNS has **some capacity to regenerate**; the CNS does not.
- **Cut two, functional:** afferent (in) or efferent (out); each somatic (body wall, limbs) or visceral (organs); and afferent again general or special.
- ⚠ **Nucleus / ganglion** and **tract / nerve** are the same objects on opposite sides of the CNS boundary. It is why the **optic nerve is anatomically a tract**.
- ⚠ **Grey is outside in the cerebrum and cerebellum, inside in the cord.** Grey = cell bodies; white = myelinated axons.
- The **autonomic nervous system is not a third division**: it is the visceral efferent line of the table above.

03 3 • The cell and its company

- Three shapes: **multipolar** (most neurons, including every ventral horn motor neuron), **bipolar** (retina, olfactory epithelium), **unipolar** (all peripheral sensory neurons). Only the cell body's position on the line differs.
- **Neuroglia: astrocytes** (support, blood–brain barrier feet), **oligodendrocytes** (myelin inside the CNS, one cell to several axons), **Schwann cells** (myelin outside it, one cell to one internode — the gaps are the **nodes of Ranvier**), **microglia** (immune), **ependymal cells** (the lining of the ventricles and central canal).
- A **peripheral nerve** has three coats: **endoneurium** round a fibre, **perineurium** round a fascicle, **epineurium** round the nerve — the same three-tier scheme as a skeletal muscle's.

04 4 • From a plate to a tube to five divisions

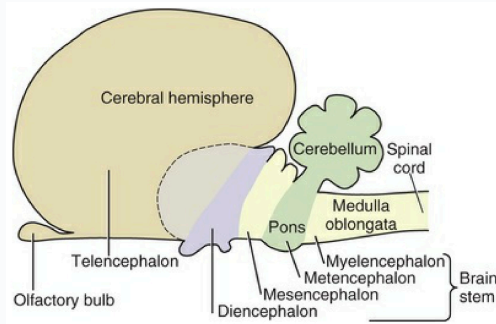


The neural tube in section: roof plate, alar plate, sulcus limitans, basal plate, floor plate, with the notochord below. Image — Thomson & Hahn, *Veterinary Neuroanatomy: A Clinical Approach*. Reproduced for educational reference.

VESICLE	DIVISION	BECOMES	CAVITY
Prosencephalon	Telencephalon	Cerebral hemispheres, cortex, basal nuclei, olfactory bulbs	Lateral ventricles
	Diencephalon	Thalamus, hypothalamus; the retina grows from it	Third ventricle
Mesencephalon	Undivided	Midbrain: tectum and tegmentum	Mesencephalic aqueduct
Rhombencephalon	Metencephalon	Pons from the basal plate, cerebellum from the alar plate	Fourth ventricle
	Myelencephalon	Medulla oblongata	Fourth ventricle, then the central canal

- **Neural plate** → folds → groove → **neural tube**. Closure starts at the future brain–cord junction; the **rostral neuropore closes first**. Failure rostrally gives anencephaly, caudally **spina bifida** with defective vertebral arches.
- **Neural crest** → peripheral ganglion neurons, the **enteric** neurons, the adrenal medulla, glia, skin melanocytes and craniofacial connective tissue.
- **Three layers**: neuroepithelial → **ependyma**; mantle → **grey**; marginal → **white**.
- **Alar plate** (dorsal) → sensory **dorsal horn**. **Basal plate** (ventral) → motor **ventral horn**. The groove between them is the **sulcus limitans**. They differ because two morphogens diffuse in from opposite sides: **SHH** from the notochord below (motor), **BMP** from the overlying ectoderm above (sensory) — and the floor and roof plates then take those signals over.

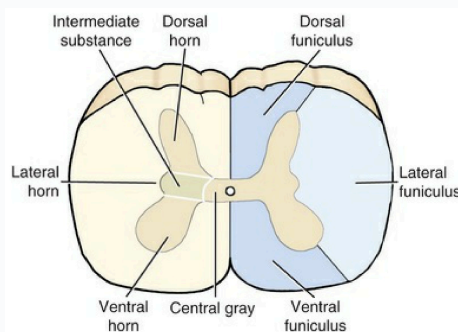
05 5 • The brain, division by division



The brain with both naming schemes on one outline — and the bracket showing what the brain stem includes.
Image — Evans & de Lahunta, Miller and Evans' *Anatomy of the Dog*, 5th ed. Reproduced for educational reference.

- **Brain stem, by subtraction:** remove the cerebral hemispheres and the cerebellum and what remains is the brain stem — diencephalon, mesencephalon, pons, myelencephalon. **The cerebellum is not in it**, although it shares a vesicle with the pons.
- **Telencephalon:** cortex outside, white beneath, **basal nuclei** deep. The **corpus callosum** bridges the hemispheres; the **septum pellucidum** separates the lateral ventricles. The **limbic system** is its emotional and memory ring.
- **Diencephalon:** **thalamus** (the relay almost every ascending pathway passes through) and **hypothalamus**, with the pituitary on its stalk.
- **Ridges are gyri, grooves are sulci**, and the cerebellum's finer folds are **folia**. Folding buys surface area, because the grey is on the surface.

06 6 • The spinal cord, and the roads through it



The cord in section: grey matter and its horns on the left, white matter and its funiculi on the right. Image — Evans & de Lahunta, Miller and Evans' *Anatomy of the Dog*, 5th ed. Reproduced for educational reference.

- Two **intumescences**, cervical and lumbar, for the limbs; then the taper of the **conus medullaris**.

-  **One more cervical spinal segment than cervical vertebra**, in every species. Every other region matches.
- **Horns**: dorsal (alar, sensory), ventral (basal, motor), and a **lateral** horn present only in the **thoracolumbar and sacral** regions — which is where the autonomic outflow leaves. Dyce notes "horn" is misleading: they run the length of the cord, so they are columns.
- **Three funiculi** — dorsal, lateral, ventral — bounded by where the roots attach. The **dorsal funiculus is almost entirely ascending**.
- **A pathway's name is its route**. *Spino*-thalamic, cord → thalamus. *Cortico*-spinal, cortex → cord. Ending in *-spinal* means it descends. The **medial lemniscus** is named for its shape and does not follow the rule.
- **Decussation** = crossing the midline; the great motor fibres cross at the **pyramids** of the medulla.

07

7 · Coverings, the twelve, and the two outflows

NO.	NAME	COMPONENTS	SERVES
I	Olfactory	SVA	Smell. Not one nerve but a set of filaments
II	Optic	SSA	Vision. Anatomically a brain tract
III	Oculomotor	SE + GVE	Four eye muscles and the eyelid levator; pupil and ciliary muscle
IV	Trochlear	SE	Dorsal oblique only. Decussates internally, emerges dorsally
V	Trigeminal	GSA + SE	The largest. Face sensation through V1, V2 and V3; first-arch muscles — jaw closers, and the tensors of the soft palate and eardrum
VI	Abducent	SE	Lateral rectus and retractor bulbi
VII	Facial	SE + GVE + SVA	Second arch: facial expression; lacrimal and two salivary glands; taste from the rostral two-thirds
VIII	Vestibulocochlear	SSA	Hearing and balance
IX	Glossopharyngeal	SE + GVE + SVA + GVA	Pharynx; parotid gland; taste from the root of the tongue
X	Vagus	SE + GVE + SVA + GVA	The widest distribution of the twelve: pharynx, larynx, the thoracic and abdominal viscera — and the third share of taste , from the epiglottis and the very back of the tongue
XI	Accessory	SE	Four neck and shoulder muscles. Its main root comes from the spinal cord
XII	Hypoglossal	SE	The tongue muscles

- **Three meninges:** dura, arachnoid, pia. Three spaces: **epidural** (outside the dura), **subdural** (a potential space), **subarachnoid** (holds the cerebrospinal fluid).
- ⚠️ **No epidural space inside the skull** — the cranial dura is fused to the periosteum, and the venous sinuses lie inside the fused layer.
- **Cerebrospinal fluid** is made mostly at the **choroid plexuses** by ultrafiltration. It leaves by the **lateral apertures of the fourth ventricle** into the subarachnoid space and returns to the blood at the **arachnoid villi**. More potassium and calcium than plasma, less sodium and protein — and the barrier keeps out larger molecules, **many antibiotics among them**.
- **Three cranial nerve groups:** special sense (I, II, VIII, purely sensory); somitic head muscles (III, IV, VI, XII); pharyngeal arch (V, VII, IX, X, XI).
- **Grouped by the opening they leave through** — which is the shape the question usually takes: cribriform plate **I** · optic canal **II** · **orbital fissure III, IV, VI and V1** (so one lesion there can take out every eye movement at once) · round foramen **V2** · oval foramen **V3** · internal acoustic meatus **VII and VIII**, VII leaving again at the stylomastoid foramen · **jugular foramen IX, X and XI** · hypoglossal canal **XII**.
- **Root before the junction, ramus after it.** Roots are pure, rami are mixed. A **plexus** recombines the ventral rami of several segments, which is why a named limb nerve never matches one segment.

	SYMPATHETIC	PARASYMPATHETIC
Leaves	Thoracolumbar — about T1 to L3 in the dog	Craniosacral — brain stem nuclei and sacral segments 2–4
Which nerves	Thoracolumbar spinal nerves, then the sympathetic trunk	Only CN III, VII, IX, X and the pelvic nerves
Ganglion sits	Close to the CNS — the chain, or on the aorta	Close to or inside the target organ
Response	General; the adrenal medulla adds a bloodborne mass response	Discrete and local
Reaches the limbs?	Yes — the body wall and limbs are supplied only by postganglionic sympathetic fibres	No

SPECIES	CORD ENDS	DURAL TUBE ENDS	NOTE
Dog	Usually L7 , sometimes L6	S1–S2	S1 in some breeds, the German Shepherd among them
Cat, pig	L7	S1–S2 (cat)	—
Horse	S1–S2	S4	Lumbosacral puncture is feasible
Ox	S1 adult, S3 calf	S4	CSF drawn between L6 and S1; about 3–4 mm of space, 7 cm from skin
Sheep	S1	S3	Only four sacral vertebrae

KEY TERMS — QUICK GLOSSARY

Cauda equina

The last lumbar, sacral and caudal nerves running caudally inside the canal past the end of the cord, before leaving at their own vertebrae.

Cisterna magna

The wide part of the subarachnoid space between cerebellum and medulla, reached through the atlanto-occipital space.

Denticulate ligaments

Triangular ligaments crossing the subdural space of the cord, suspending it inside the dural tube.

QUICK REVISION — REMEMBER THESE

- 1 **Two cuts, and both apply to everything.** Central or peripheral, then afferent or efferent, then somatic or visceral — and on the afferent side, general or special.
- 2 **Nucleus / ganglion and tract / nerve are the same objects with two names.** The only difference is which side of the boundary of the central nervous system they sit on. It is why the optic nerve is anatomically a brain tract.
- 3 **Grey outside in the brain, grey inside in the cord.** Grey is cell bodies, white is myelinated axons, and the arrangement reverses between the two.
- 4 **The adult arrangement is a developmental one.** Three tube layers become ependyma, grey and white; the alar plate becomes the sensory dorsal horn and the basal plate the motor ventral horn; three vesicles become five divisions.
- 5 **A pathway's name is its route.** First half where it starts, second half where it ends. If the second half is *spinal*, it descends.
- 6 **There is no epidural space inside the skull** — the cranial dura is fused to the periosteum. Around the cord it is a free tube with fat and veins outside it.
- 7 **Root before the junction, ramus after it.** Roots are pure; every ramus is mixed.

MEMORY AIDS

The name is the route — **Spino**-thalamic starts in the cord and ends in the thalamus. **Cortico**-spinal starts in the cortex and ends in the cord. First half, where it starts; second half, where it ends — and anything ending in *-spinal* descends.

O-O-O-T-T-A-F-V-G-V-A-H — The twelve in order: **O**lfactory, **O**ptic, **O**culomotor, **T**rochlear, **T**rigeminal, **A**bducens, **F**acial, **V**estibulocochlear, **G**lossopharyngeal, **V**agus, **A**ccessory, **H**ypoglossal. **Use it for the order only** — the sensory/motor mnemonics beside it are written for human anatomy.

TEST YOURSELF — ACTIVE RECALL

Cover the answers and try to retrieve each one from memory first — self-testing beats re-reading.

1. Name the two ways the nervous system is divided, and say what each one tells you.
2. Which cranial nerves carry no somatic efferent fibres, and which carry special somatic afferent?
3. What is the difference between a nucleus and a ganglion, and between a tract and a nerve?
4. Name the three layers of the neural tube wall and what each becomes.
5. In which region does the number of spinal segments not match the number of vertebrae?
6. Where is there no epidural space, and why not?
7. What is the difference between a root and a ramus?
8. Why is a sympathetic response diffuse and a parasympathetic one precise?

ANSWERS

1. By **place** — central (brain and cord) versus peripheral (cranial and spinal nerves and their ganglia). By **job** — afferent or efferent, each somatic or visceral, and the afferent side again general or special. The first says where a part is, the second what it carries.
2. No somatic efferent: **I, II and VIII**, the three that are purely sensory. Special somatic afferent: only **II and VIII** — the retina and the inner ear are the only two organs that produce that kind of information.
3. Only the side of the boundary of the central nervous system. Cell bodies inside it are a **nucleus**, outside it a **ganglion**; axon bundles inside it are a **tract**, outside it a **nerve**. It is why the optic nerve is anatomically a tract.
4. **Neuroepithelial** → the **ependyma** lining the central canal and ventricles. **Mantle** → the **grey matter**. **Marginal** → the **white matter**. That is why the cord has grey inside and white outside.
5. The **cervical** region, in every species: there is always **one more cervical spinal segment than cervical vertebra**, because the first cervical nerve emerges in front of the atlas. A dog with seven cervical vertebrae has eight cervical spinal nerves.
6. **Inside the skull**. The cranial dura is fused with the inner periosteum, which obliterates the space and encloses the venous sinuses within the fused layer. Around the cord the dura is a free tube with a real epidural space outside it, holding fat and the internal vertebral venous plexus.
7. A **root** exists before the two join and is pure — dorsal sensory, ventral motor. A **ramus** exists after they have joined and is always **mixed**. It is why cutting a dorsal root gives a purely sensory deficit and cutting a named limb nerve never does.
8. Because of where the ganglion sits. Parasympathetic ganglia lie **close to or inside the target organ**, so the postganglionic fibre is short and the transmitter acts locally. Sympathetic ganglia lie **close to the central nervous system**, so postganglionic fibres are long and radiate widely — and the adrenal medulla adds a bloodborne mass response.

WHEN TO REFER OR ESCALATE

- A cerebrospinal fluid sample: two sites exist because the subarachnoid space is wide in two places — the **cerebellomedullary cistern**, through the atlanto-occipital space, and the **lumbosacral** space, where the cord has already ended.
- A drug that must reach the central nervous system: the blood–cerebrospinal fluid barrier is **impermeable to larger molecules**, which include many antibiotics.
- A needle at the lumbosacral junction in the ox: the subarachnoid space there measures about **3 to 4 mm** dorsoventrally, with about **7 cm** from skin to cord.
- An epidural in the ox: usually between **Ca1 and Ca2**. Injecting at or in front of the lumbosacral junction risks reaching the cerebrospinal fluid, in which local anaesthetics mix freely and spread much further forward than intended.
- A rabbit or rodent brain that looks nothing like a dog's: it is **lissencephalic** — smooth, without gyri.
- Any question about signs, reflexes or grading a deficit: that is clinical neurology, and it is a different page.

SOURCES

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