

2003

CVM 6100
Veterinary
Gross Anatomy

General Anatomy
&
Carnivore Anatomy
Lecture Notes

by

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Connective Tissue Structures

Histologic types of connective tissue (c.t.):

- 1] Loose areolar c.t. — low fiber density, contains spaces that can be filled with fat or fluid (edema)
[found: throughout body, under skin as superficial fascia and in many places as deep fascia]
- 2] Dense irregularly arranged c.t. — high density of collagen fibers, oriented in variable directions
[found: dermis; deep fascia in some locations; periosteum; fibrous joint capsule]
- 3] Dense regularly arranged c.t. — high density of parallel fibers, forming sheets, bands, or cords
[found: aponeuroses; ligaments; tendons]

Connective tissue structures identifiable in gross anatomy:

Dermis [G. skin] — the physically tough/strong component of skin (deep to epidermis)

Tendon — attaches muscle to bone (called *aponeurosis* when sheet-like)

Ligament — attaches bone to bone (usually thickenings of fibrous joint capsules)

[Note: *visceral ligaments* located in body cavities are entirely different structures]

Fascia [L. band] — collagenous fibrous tissue that hold the body together

superficial fascia = subcutaneous tissue between skin & muscles/bone (body wall)

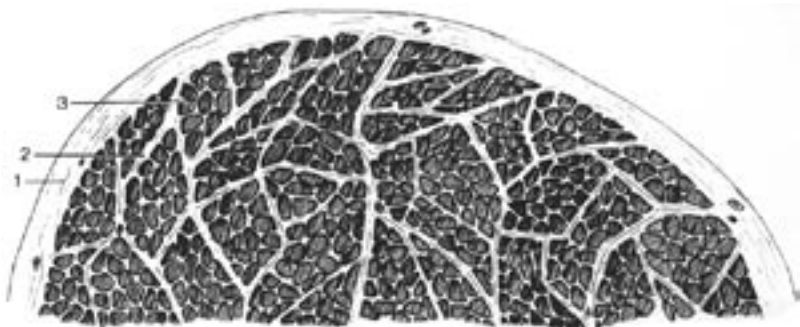
- regionally variable in amount (site for subcutaneous injection)
- contains: cutaneous muscle, mammary tissue, fat (also edema fluid)
[e.g., cutaneous trunci m.; superficial muscles of facial expression]

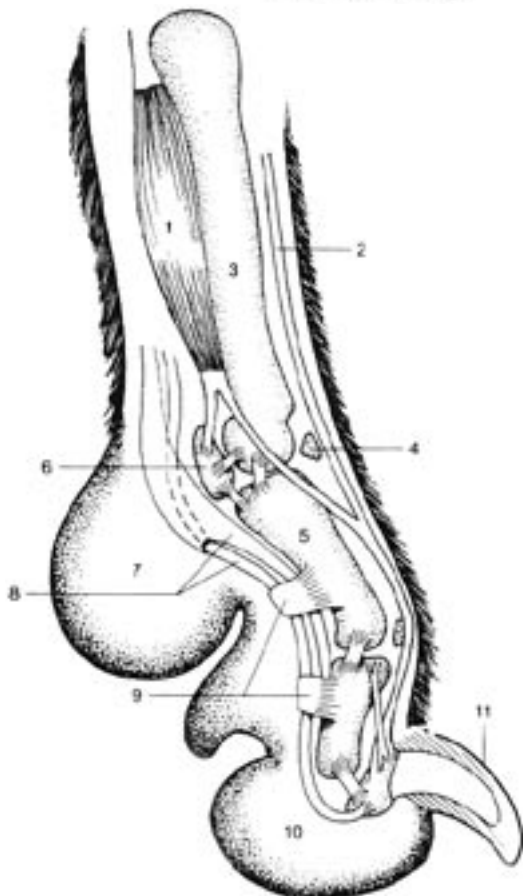
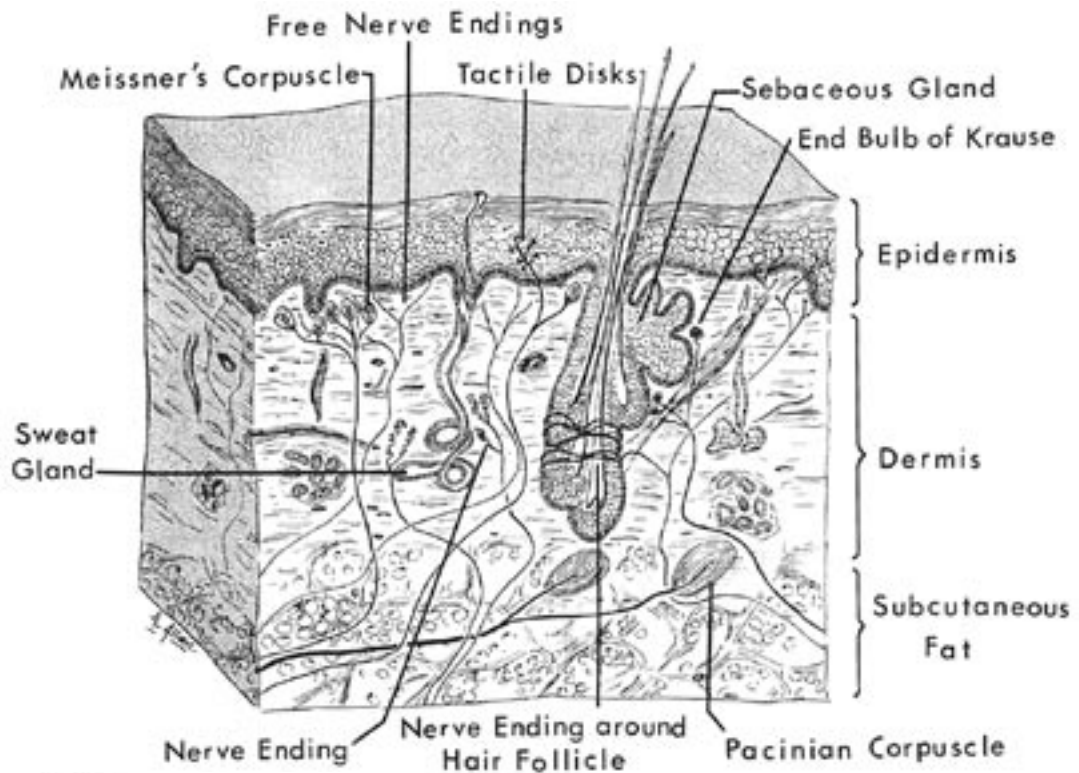
deep fascia = packing/binding tissue surrounding muscles, bones, & organs

- serves to compartmentalize skeletal muscles
- forms several named structures, viz.,
 - named regional fascia, e.g., thoraco-lumbar fascia, fascia lata, etc. (fascia is named where it is thick & distinct (i.e., dense c.t. vs. loose areolar c.t.))
 - retinaculum [L. rope or cable] fascia that binds passing tendons to the surface of the carpus or tarsus (also, transverse humeral retinaculum)
 - raphe [G. seam] fascia that joins right and left counterparts of a particular muscle at the midline (e.g., ventral abdomen = linea alba)
 - epimysium [G. on + muscle] fascia covering the surface of a muscle, depending on the muscle, it may be thin (transparent) or dense (opaque & white); also,
perimysium = c.t. around muscle fascicles; and
endomysium = c.t. within muscle fascicles)

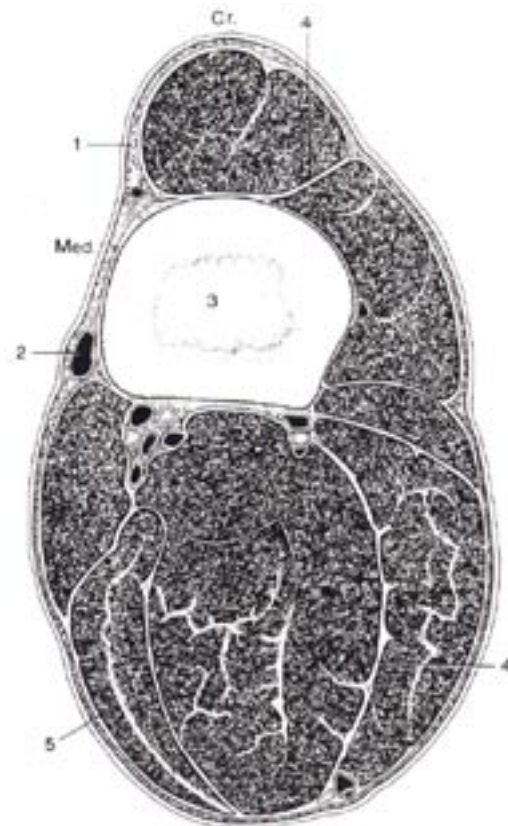
Transverse section through a skeletal muscle:

- 1 = epimysium;
- 2 = perimysium;
- 3 = endomysium





Axial section through metacarpus and digit:
 1 = interosseus m.; 2 = digital extensor tendon;
 3 = metacarpal bone; 4 = dorsal sesamoid bone;
 5 = proximal phalanx; 6 = proximal sesamoid
 bone; 7 = metacarpal pad; 8 = digital flexor
 tendons; 9 = digital annular ligaments; 10 = digital
 pad; 11 = unguis (nail)



Transverse section through antebrachium (horse):
 1 = superficial fascia; 2 = cephalic vein; 3 =
 radius (bone); 4 & 5 = deep fascia (compartmentalizing
 muscles); Med. = medial; Cr. = cranial

Osteology...

The dog has 321 bones.

Bone Classification Schemes

Development:

Endochondral bones — develop from cartilage precursors
[most bones]

Intramembranous bones — directly from mesenchyme (fascia)
[bones of calvaria & face]

Location:

Axial skeleton — head, vertebral column (including tail),
ribs & sternum

Appendicular skeleton — bones of limbs, including
scapula & os coxae(hip bone)

Heterotopic bones — os penis [carnivore; rodent]
os cardis [cattle]

Shape:

Long bones — length greater than diameter

Short bones — approximately equivalent dimensions

Flat bones — e.g., scapula, os coxae, many bones of skull

Irregular bones — short & multiple processes (vertebrae)

Sesamoid bones — small “seed-like” within tendons,
e.g., patella (knee cap)

Bone Functions

Support

body shape & weight

Levers

to perform work

Protection

of vulnerable organs

Ca⁺⁺ & PO₄⁻

reservoir for ions

Red Marrow

source of blood cells

Bone Composition

Collagen fibers

by weight: 1/3 of bone

by volume: 1/2 of bone

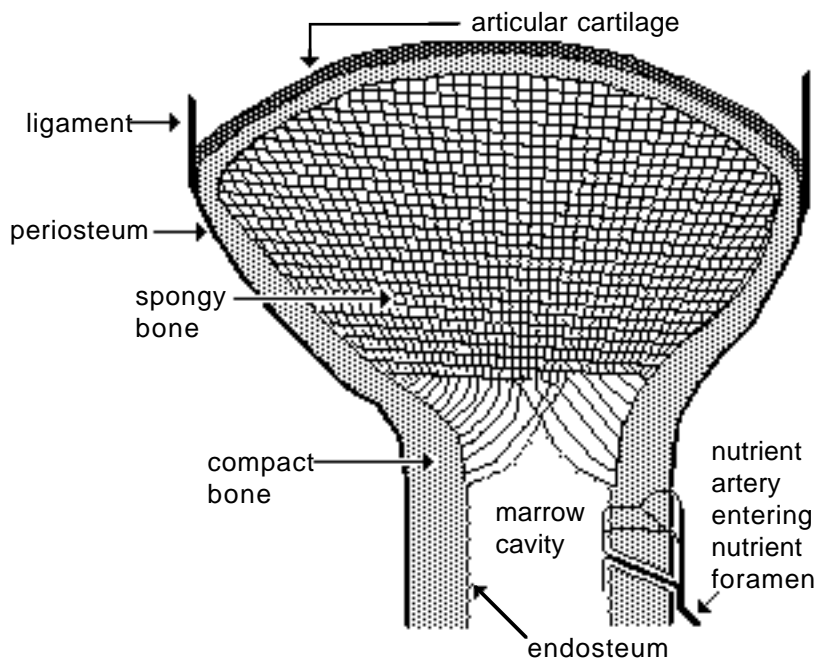
Hydroxyapatite crystals



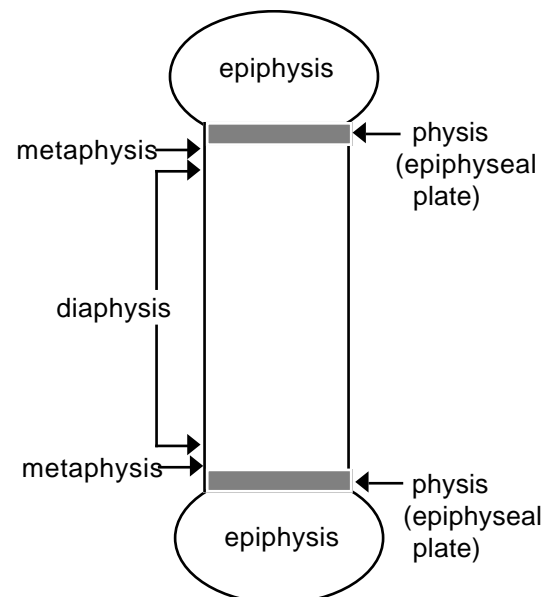
95% solid (vs. water)

65% mineral; 35% organic

Structure of a Long Bone



Regions of a Long Bone



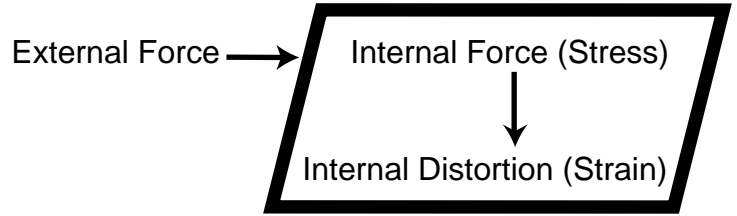
Mechanical Considerations

Strength = amount of strain a bone can withstand without breaking.

Bone is best at withstanding compression, especially against the "grain" (compressing long axes of osteones)

Tensile strength = 1/2 of compression; comparable to tendons & ligaments

Shear strength = 1/4 of compression; most fracture are the result of shear forces

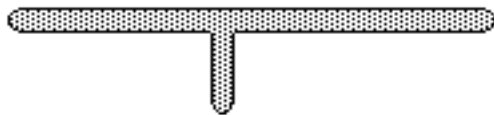


General Principle:

Bones are designed to provide adequate strength with minimal material (minimal mass or weight).

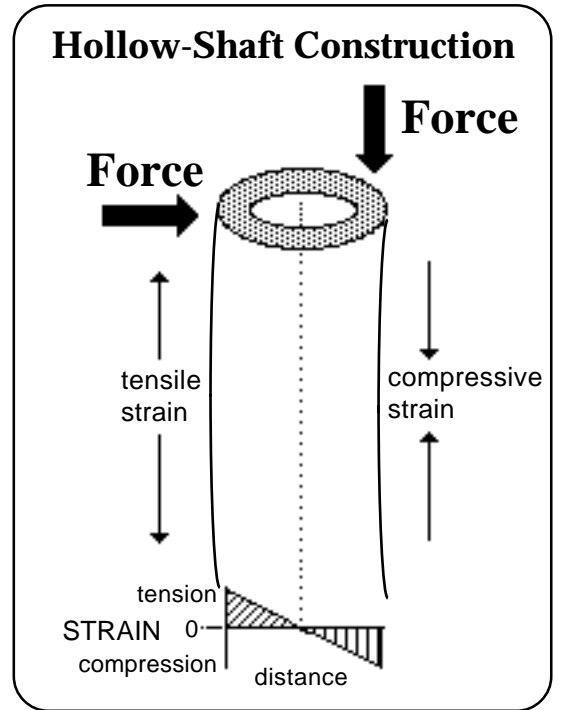
Such an economy of bone mass/weight offers evolutionary advantages; viz., faster reaction capability; reduced metabolic requirements.

Flat Scapula Reinforced (transverse section)



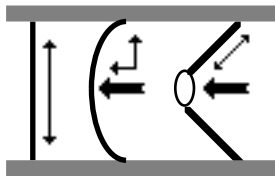
Scapula strengthened with only a spine

Hollow-Shaft Construction

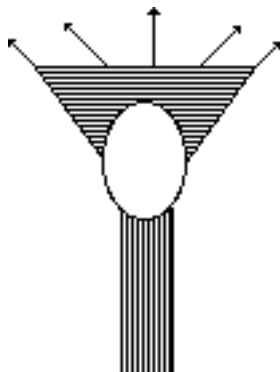


Sesamoid bone — Patella

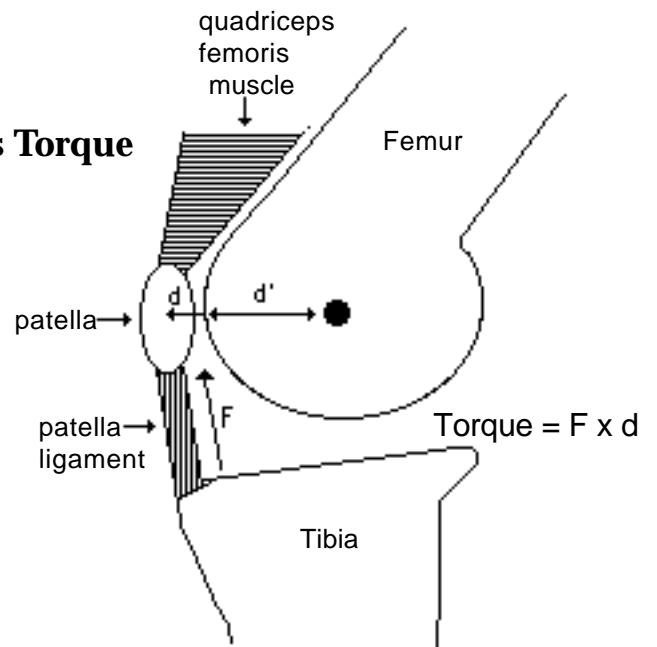
1] Eliminates tendon shear



2] Redirects lines of force



3] Increases Torque



Arthrology

(Joint = Articulation = Union of two or more bones)

Classification:

Fibrous joints — immobile joints, united by fibrous tissue, may ossify with age.

Three types are recognized:

- 1] Suture = [L. seam] undulating seams between bones of the skull
- 2] Gomphosis = tooth in an alveolus, united by periodontal ligament
- 3] Syndesmosis = bones joined by ligaments, e.g., [radius & ulna] and [tibia & fibula]

Cartilaginous joints — immobile joints, united by cartilage, ossify with age.

Two types are recognized:

- 1] Symphysis = [G. grow together] fibrocartilage union,
e.g., pelvic symphysis; mandibular symphysis; (also, intervertebral disk)
- 2] Synchondrosis = hyaline cartilage union, e.g., physis

Synovial joints — mobile joints, fibrous tissue enclosing a synovial cavity

Classified on the basis of...

Number of bones:

Simple joint = formed by two bones, e.g., shoulder joint

Compound joint = formed by more than two bones, e.g.,
elbow joint, carpal joint

Shape:

Hinge (ginglymus) joint = movement in one plane

Ball & socket (spheroid) joint = capable of circumduction

Plane joint = gliding action, e.g., vertebral articular processes
also, Ellipsoid, Saddle, Condylar, Trochoid

Synovial Joint Structure:

[synovia = G. with + egg (white)]

Joint features...

- articular (hyaline) cartilage covers the opposing surfaces of the bones
- synovial membrane lines a synovial cavity that separates the bones
— the membrane secretes synovial fluid into the cavity
- fibrous (collagenous tissue) layer located external to synovial membrane
— mechanically joins the bones, blends with periosteum
— selectively thickened to form ligaments

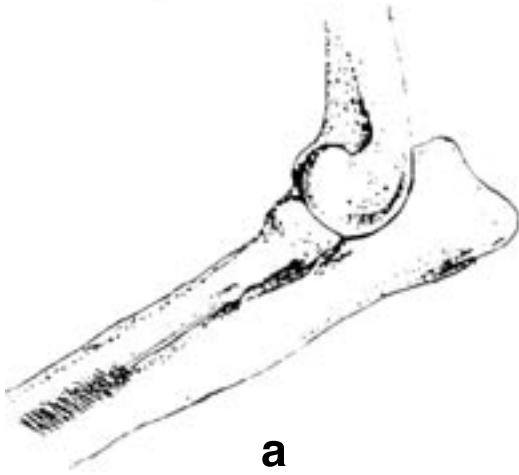
NOTE: **Joint Capsule** = fibrous layer and synovial membrane together.

Additional features found in some synovial joints...

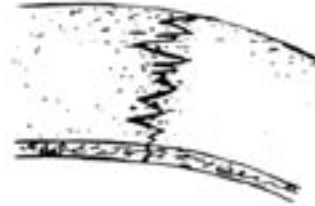
- meniscus = fibrocartilage in the synovial cavity, interposed between the bones
(one meniscus in temporomandibular joint; two semilunar menisci in stifle)
- internal ligaments that appear to be within the joint cavity (such ligaments are actually surrounded by synovial membrane and thus they are outside the synovial cavity itself)
- fat pads between the fibrous & synovial layers produce synovial folds that may protrude into the joint cavity

Types of Fibrous Joints

- a = syndesmosis [G. ligament]
- b = suture [L. seam]
- c = gomphosis [G. bolt togethert]



a

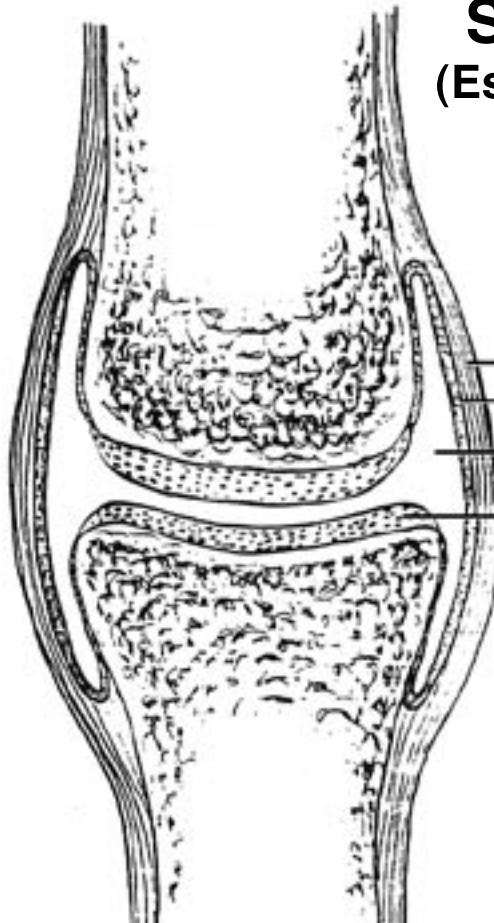


b



c

Synovial Joint (Essential Structures)



Joint capsule:

fibrous layer

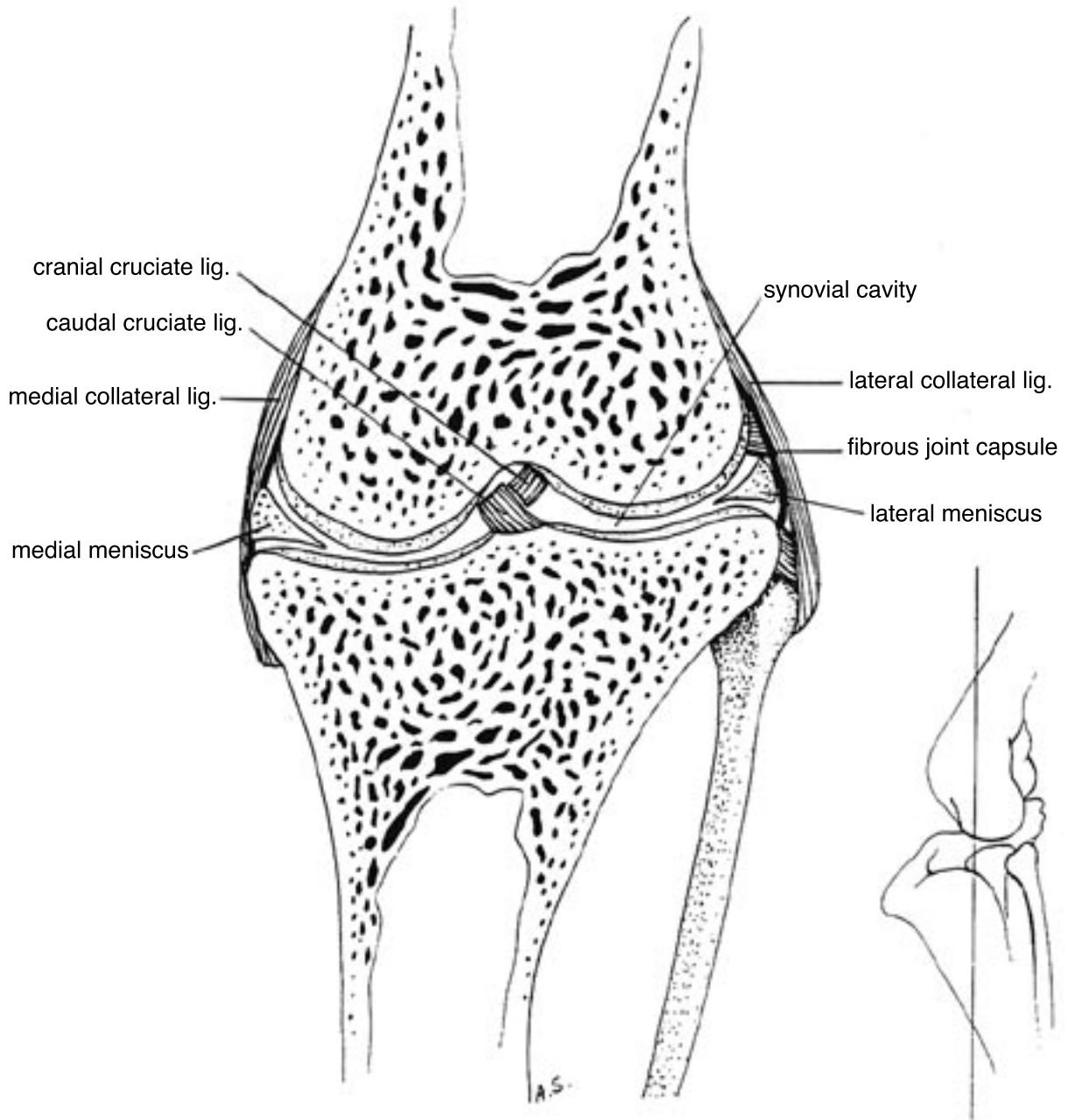
synovial membrane

Joint cavity

Articular cartilage

Stifle Joint of the Dog

(left stifle, cranial view of a transverse section)



Myology

There are three categories of muscle tissue:

- 1] *smooth muscle* = not striated; associated with viscera (gut, vessels, glands, etc.)
- 2] *cardiac muscle* = striated; musculature of the heart
- 3] *skeletal muscle* = striated; generally attached to bone; usually under voluntary control

Skeletal Muscle

Skeletal (striated) muscle is composed of elongate, multinucleated cells (muscle fibers). Different types of muscle fibers are found among the skeletal muscles of the body, e.g.,

- slow contracting, fatigue resistant, aerobic metabolism (Type I)
- fast contracting, fatigue resistance, aerobic metabolism (Type 2A)
- fast contracting, fatigue susceptible, anaerobic metabolism (Type 2B)

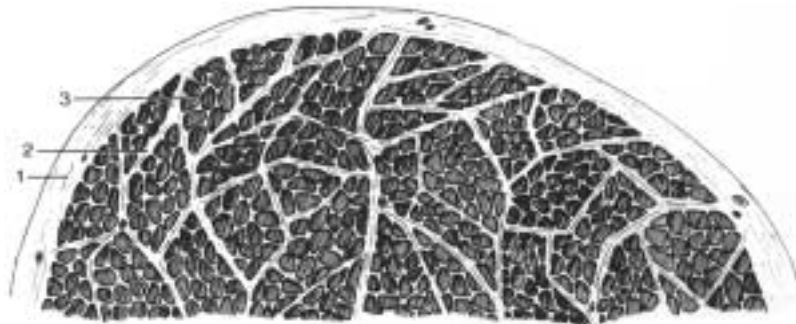
Note: Skeletal muscle will not contract in the absence of a functional nerve supply (denervation atrophy occurs). One neuron innervates a variable number of muscle fibers. The neuron plus the muscle fibers it innervates constitute a **motor unit**. To produce a stronger contraction, the nervous system activates more motor units.

Muscle-related connective tissue:

Muscle fibers are within a connective tissue framework that is continuous with tendons. As a result, passive muscles are able to serve as ties that reinforce joints & oppose forces on bones.

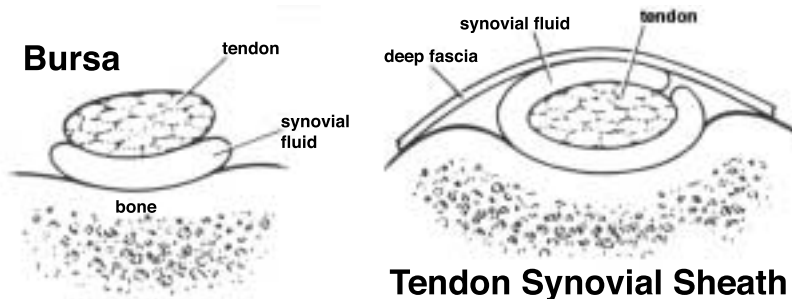
Muscle associated fascia:

1. *epimysium* = loose or dense connective tissue surrounding an entire muscle
2. *perimysium* = loose connective tissue defining muscle fascicles
3. *endomysium* = small amounts of loose c.t. surrounding individual muscle fibers



Tendon protection:

- A. *bursa* = synovial pocket inserted between a tendon and a bony prominence
- B. *tendon synovial sheath* = lubrication where tendons are bound, e.g., by retinaculum



Muscle names:

Muscle names may be latinized (flexor digitorum profundus) or anglicized (deep digital flexor). Muscles are named (originally in the human) for their shape (deltoid) or location (brachialis) or attachments (sternohyoid) or structure (biceps) or function (supinator) or combinations of these (pronator quadratus; superficial digital flexor; serratus ventralis; flexor carpi radialis; etc.)

Muscle roles within a given movement (classification of involved muscles):

- *agonist* = prime mover or principal muscle(s) executing the particular joint movement
- *antagonist* = muscle(s) that oppose the action of the agonist on the joint(s)
- *synergist* = muscle(s) that assist the agonist; e.g., *fixators* stabilize distant joints.

Muscle architecture:

Multiple muscles and multiple parts or heads (head = a separate belly and origin) exist to distribute (as opposed to concentrate) stresses on bones and to provide movement diversity.

Fascicle & fiber arrangement:

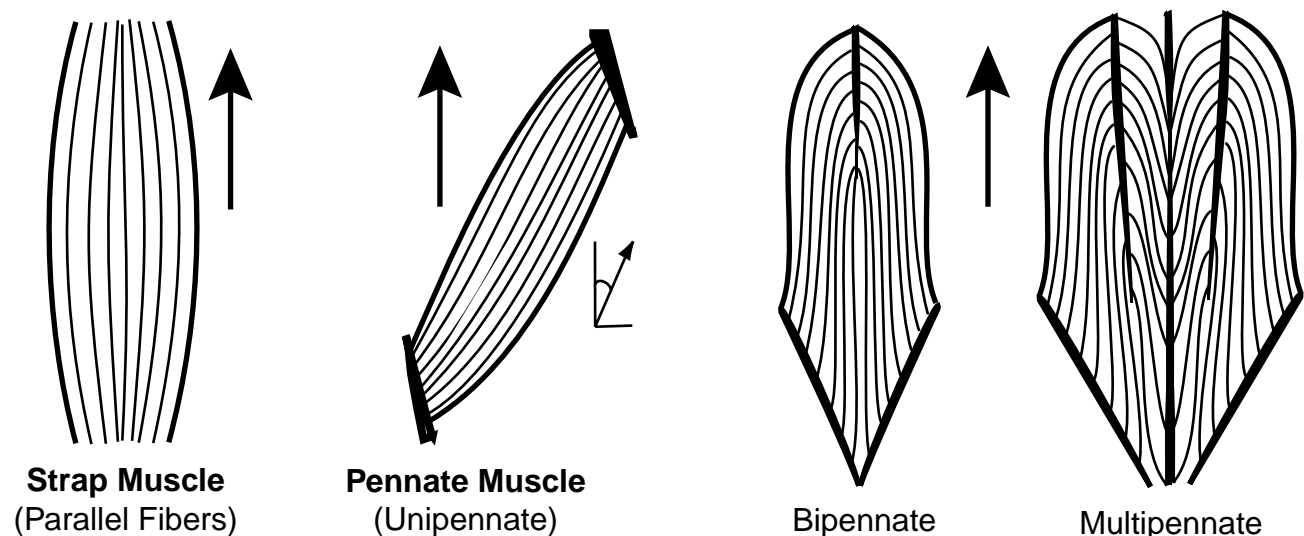
Parallel arrangement, e.g., strap or spindle arrangement, fibers/fascicles arranged parallel to the tendon of insertion. This results in a greater range of shortening and thus yields greater movement velocity (distance per time).

Pennate arrangement = fibers/fascicles arranged at an angle to the direction in which the tendon moves. This results in a greater area of muscle fibers along axes of contraction and produces more strength (at the expense of a reduced range of contraction).

Note: The amount of force that a muscle can generate is proportional to the area of muscle fibers, i.e., number of contractile protein molecules, multiplied by the cosine of the muscle-tendon angle.

Three types of pennate arrangement are:

- unipennate, e.g., ulnar & radial heads of the deep digital flexor muscle;
- bipennate, e.g., infraspinatus muscle;
- multipennate, e.g., humeral head of the deep digital flexor muscle.



Biomechanics & Locomotion

Animals are subject to the same physical laws as inanimate objects.

For your reference . . .

Force = Mass • Acceleration = Mass • Velocity / Time

Torque [L. twist] = Force • Distance

Momentum = Force • Time = Mass • Velocity

Pressure = Force / Area

Work = Force • Distance

Power = Work / Time = Force • Velocity

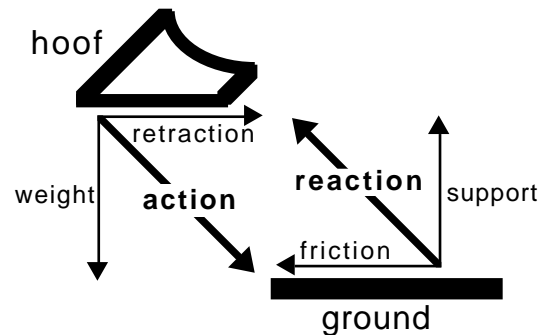
Kinetic energy = 1/2 Mass • Velocity²

Linear Force:

Force is a vector quantity — it has magnitude, direction, & point of application. As a vector, force can be partitioned into component forces, e.g., into vertical (body weight) and horizontal (propulsion; braking) forces.

Action evokes reaction: the ground supports body weight and, via friction, the ground provides the actual propulsion or braking force — which is why veterinarians should pay attention to the condition of the ground.

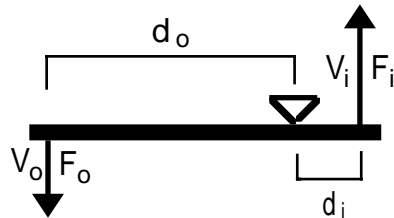
Dynamic forces (when an animal is moving) can be hundreds of times greater than static forces. Bones, ligaments, tendons, etc. are designed to withstand dynamic forces.



Rotary Force (Torque):

Within an animal, movements are angular rather than linear, i.e., rotations about fulcrums. Torque (angular force) depends on both the linear force and where the force is applied (perpendicular distance from the fulcrum). For a lever system:

Torque_{in} = Torque_{out} (ignoring losses to heat)

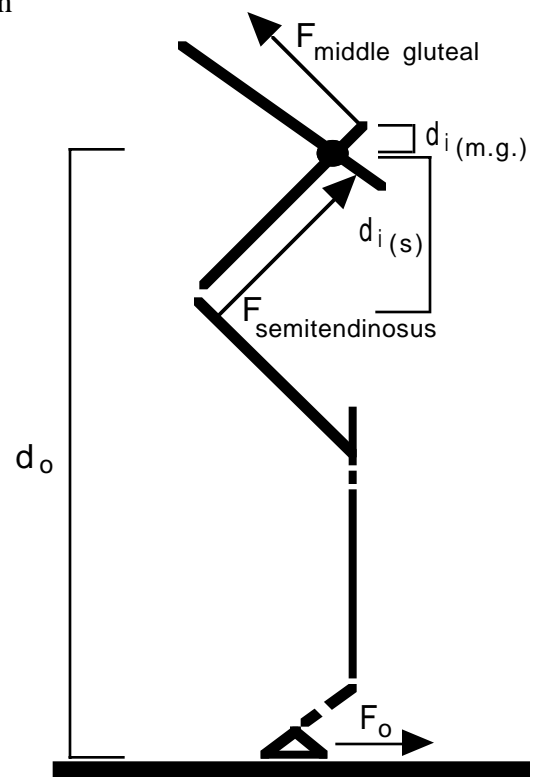


$$F_i \cdot d_i = F_o \cdot d_o$$

$$\& \quad F_o = F_i \cdot d_i / d_o$$

for velocity: $V_o = V_i \cdot d_o / d_i$

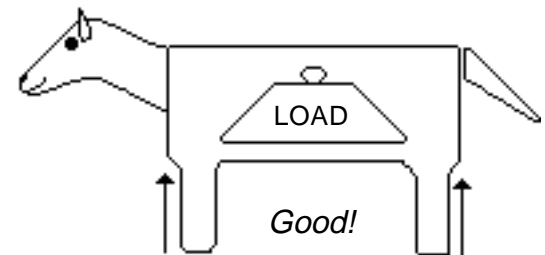
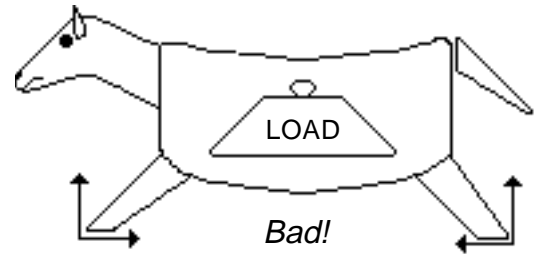
The expression d_o / d_i is a gear ratio. Low gear muscles (e.g., semitendinosus) are used when the limb is bearing weight; high gear muscles (e.g., gluteal mm.) are better suited for speed than for bearing weight.



Trunk Biomechanics:

Functional goals —

- unimpeded limb movement:
 - self-contained [box vs. beanbag]
 - only vertical forces on limbs
- adjust to variable loads
- flexible during locomotion (carnivores)



Design analogy:

Trunk design may be thought of as analogous to a “bow and string”

- vertebral column = “bow”

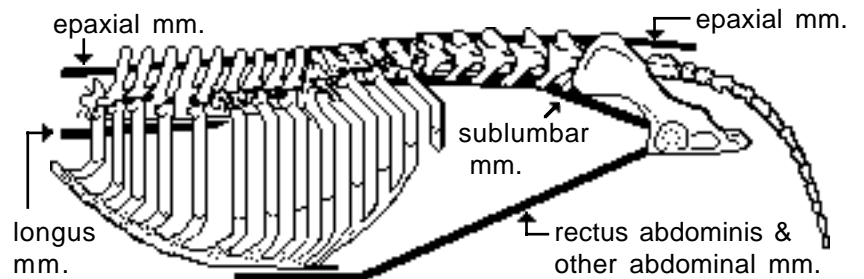
- three muscular “strings”

— two stabilize the “bow”:

- 1) epaxial mm.
- 2) longus mm. & sublumbar mm.

— one flexes the “bow”:

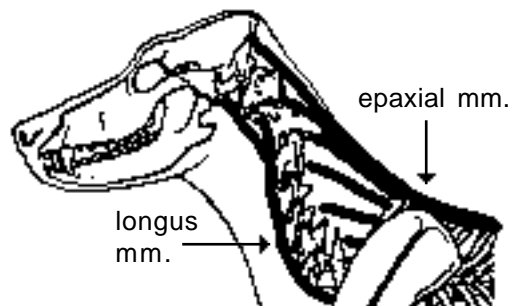
- 3) rectus abdominis & other abdominal mm. (antagonize 1&2)



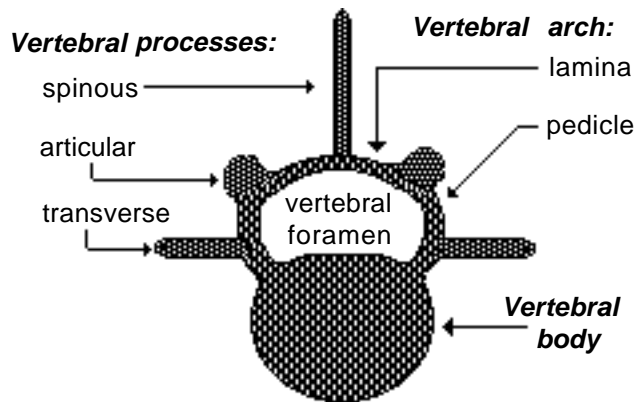
- neck forms an inverted “bow”

— stabilized by longus mm.

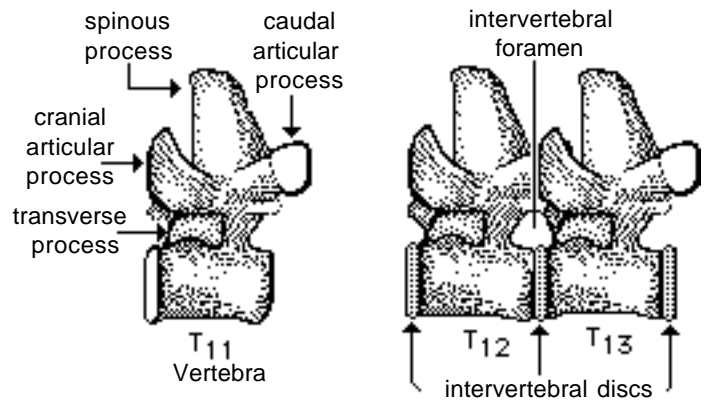
— dorsiflexed (extended) by epaxial mm. & ligamentum nuchae (which is absent in the cat)



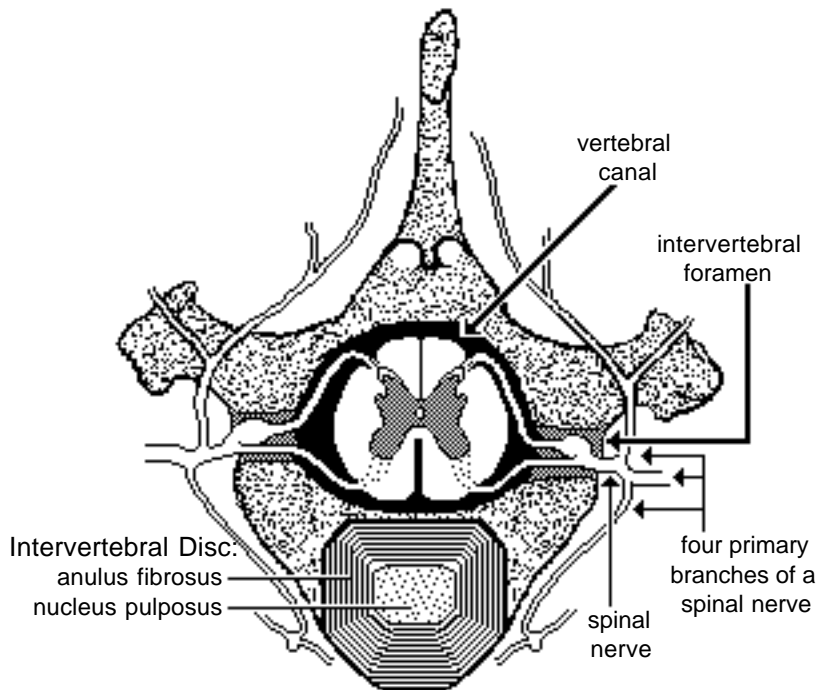
Features of Vertebrae



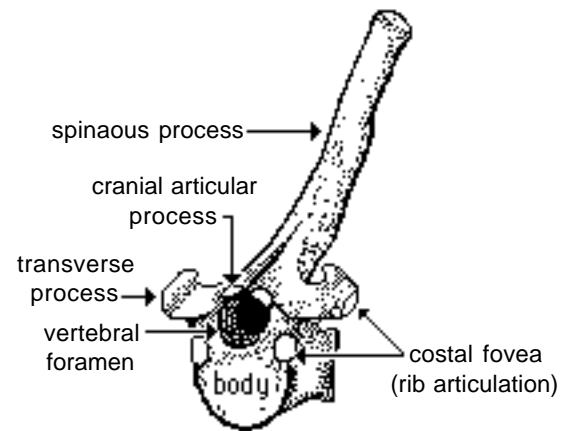
Transverse Section Through A Vertebra



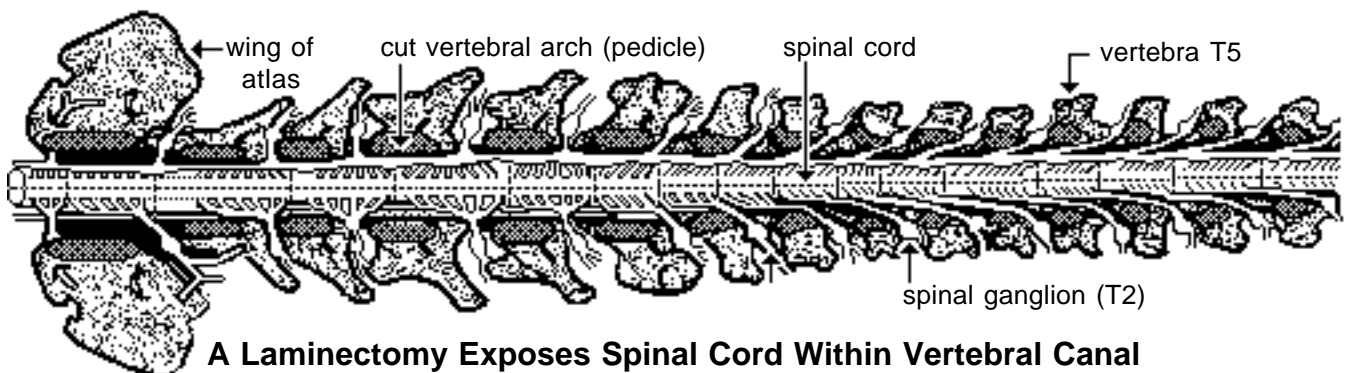
Lateral View of Vertebrae



Transverse Section through an Intervertebral Disc



Cranio-lateral View of a Thoracic Vertebra



A Laminectomy Exposes Spinal Cord Within Vertebral Canal

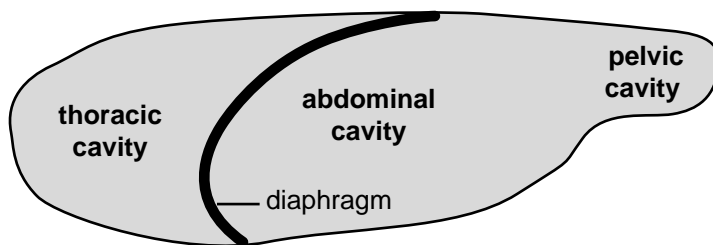
Serous Membranes & Cavities

Body Cavities

The major cavities of the body are within the trunk. They contain visceral organs and *serous membrane* cavities:

Thoracic cavity — is lined by endothoracic fascia.

Abdominal & pelvic cavities — are lined by transversalis fascia.



Serous Membrane Cavities

- are lined by serous membrane
- are normally empty (except for microscopic cells and a film of fluid)
- function to preclude adhesions among organs, thereby allowing organs to move freely relative to one another.

A **serous membrane** consists of a single layer of flattened mesothelial cells applied to the surface of a thin layer of collagenous tissue that attaches to underlying endothoracic/transversalis fascia. The mesothelium of the serous membrane forms the lining of a closed serous membrane cavity.

Serous membrane lining the wall of a serous cavity is designated *parietal* while that covering viscera is called *visceral*. *Connecting* serous membrane runs between parietal and visceral components.

The serous membranes are:

Peritoneum — the peritoneal cavity is found within the abdominal & pelvic body cavities.

Connecting peritoneum forms:

- mesentery
- ligament.

Pleura — two pleural cavities (separated by mediastinum) are found within the thoracic cavity.

Parietal pleura is further subdivided into:

- costal pleura
- diaphragmatic pleura
- mediastinal pleura & — pleural cupula.

Connecting pleura forms the *pulmonary ligament*.

Visceral pleura is also called *pulmonary pleura*.

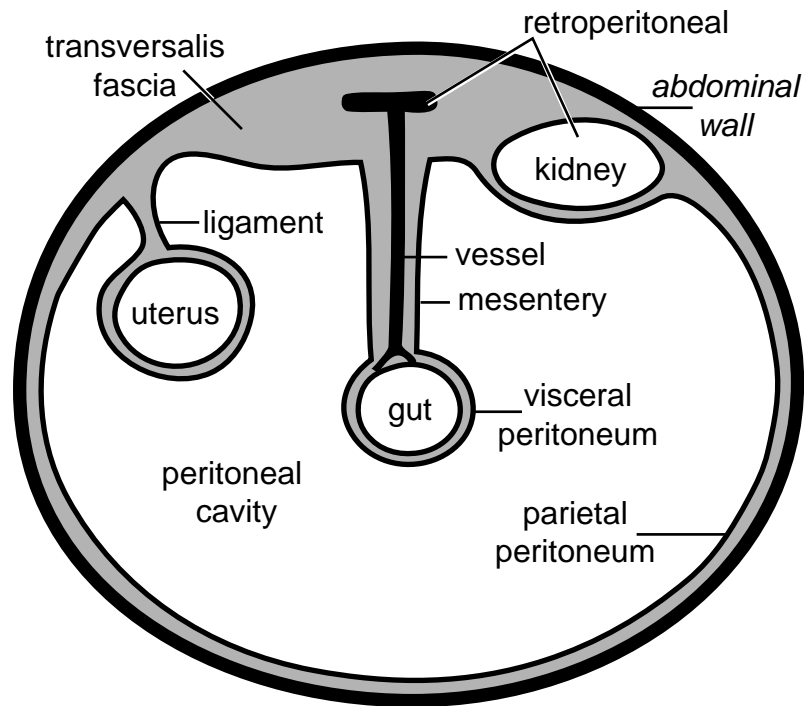
Pericardium — the pericardial cavity is found within the mediastinum of the thoracic cavity.

Visceral pericardium is also called *epicardium*.

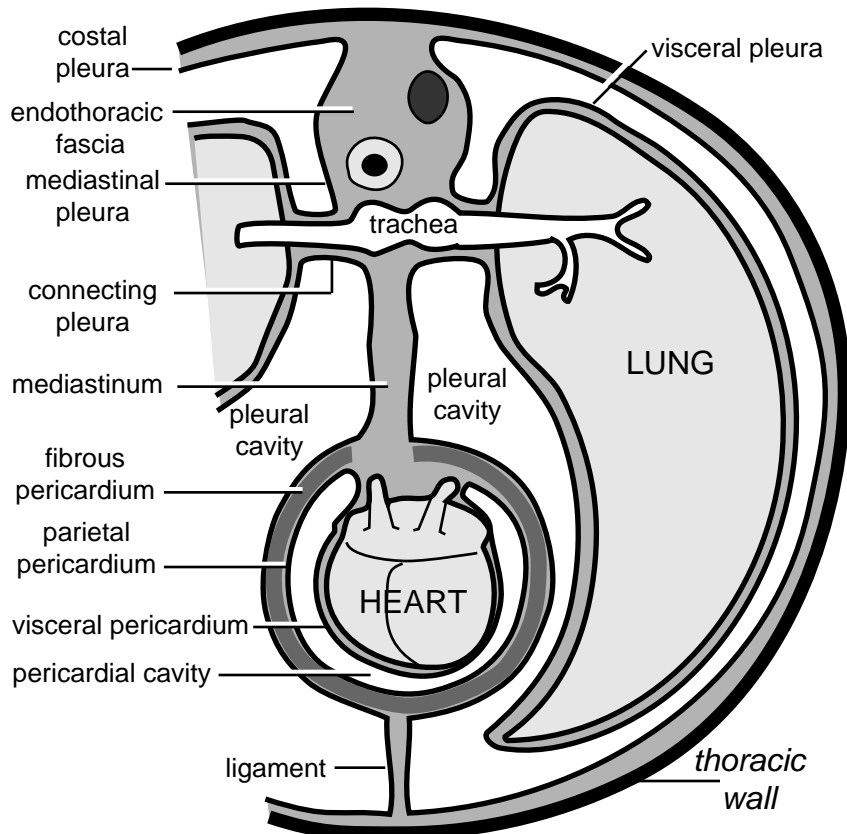
Vaginal tunics — the cavity of the vaginal process begins at the vaginal ring and extends into the scrotum around the spermatic cord & testis.

- Connecting vaginal tunic forms:
- mesorchium
 - mesoductus deferens.

Peritoneal Cavity



Pleural (two) & Pericardial Cavities



Formation of Body (Serous) Cavities

Serous cavities are cavities lined by serous membrane (mesothelium). In the adult, serous cavities are: the *pericardial* cavity, two *pleural* cavities, and the *peritoneal* cavity (including vaginal cavity extensions of the peritoneal cavity).

Acquiring a three-dimensional understanding of how serous cavities are formed is a challenging exercise. Serous cavity formation may be summarized as follows:

- all of the serous cavities develop from a common embryonic coelom and thus the cavities are continuous until partitions develop to separate them;
- the individual serous cavities are formed by inward growth of tissue folds from the body wall (partitions) and by outgrowth of coelomic cavity into the body wall (excavation).

Coelom Development:

During gastrulation, the space between ectoderm and endoderm (and between trophoblast and hypoblast) is filled by inflow of primary mesenchyme that becomes mesoderm. Cavitation occurs in lateral mesoderm, establishing the **coelom** bounded by somatopleure and splanchnopleure.

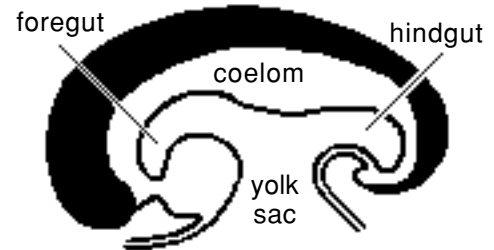
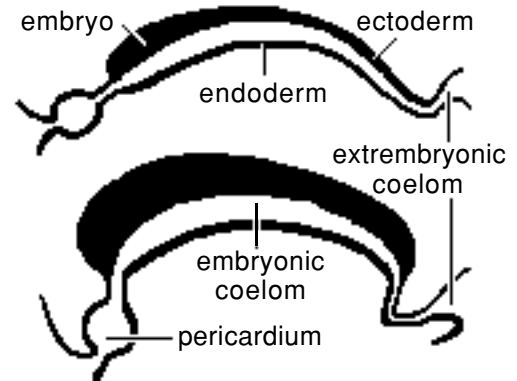
As head and tail processes develop and lateral body folds merge medially (except at the umbilicus), embryonic and extra-embryonic compartments of the coelom can be differentiated. The former becomes the serous cavities, the latter is filled by allantoic fetal membrane.

Formation of the head process brings the heart and pericardial coelom within the embryo, positioned ventral to the foregut. Right and left sides of the embryonic coelom are separated by gut and by dorsal and ventral mesenteries, the latter fails to develop at the level of the midgut.

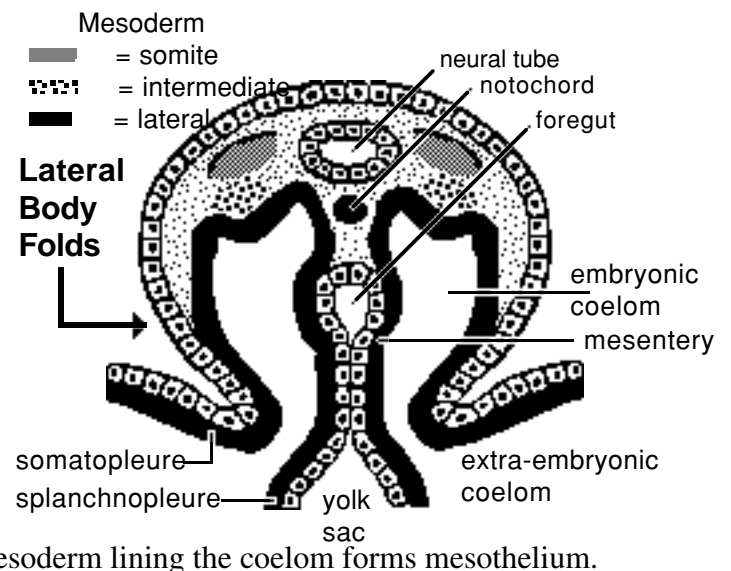
Thus, the *embryonic coelom* features an anterior-ventral *pericardial* compartment, a caudal *peritoneal* compartment, and bilateral *pleural* compartments (channels) connecting the pericardial and peritoneal compartments. Mesoderm lining the coelom forms mesothelium.

Separation of Peritoneal and Pleural Cavities:

In the adult, peritoneal and pleural cavities are separated by the diaphragm. The diaphragm is formed by a *septum transversum*, paired *pleuroperitoneal folds*, and somatic mesoderm. Diaphragmatic musculature is derived from somites in the cervical region ($C_{5,6,7}$), where the diaphragm is initially formed.



Coelom (Longitudinal View)



Details of diaphragm formation include:

— the septum transversum originates as mesoderm in front of the heart; as the heart shifts ventral to the foregut, the septum becomes incorporated into the ventral body wall and ventral mesentery caudal to the heart; it grows dorsally and forms a transverse partition ventral to the level of the gut

— dorsal to the gut, bilateral pleuroperitoneal folds grow medially and meet at the dorsal mesentery

— subsequent growth of the pleural cavity into somatic mesoderm (mesenchyme) will result in body wall mesoderm forming the marginal regions of the diaphragm (diaphragm musculature).

Separation of Pericardial and Pleural Cavities:

In the adult, pericardial and pleural cavities are separated by fibrous pericardium.

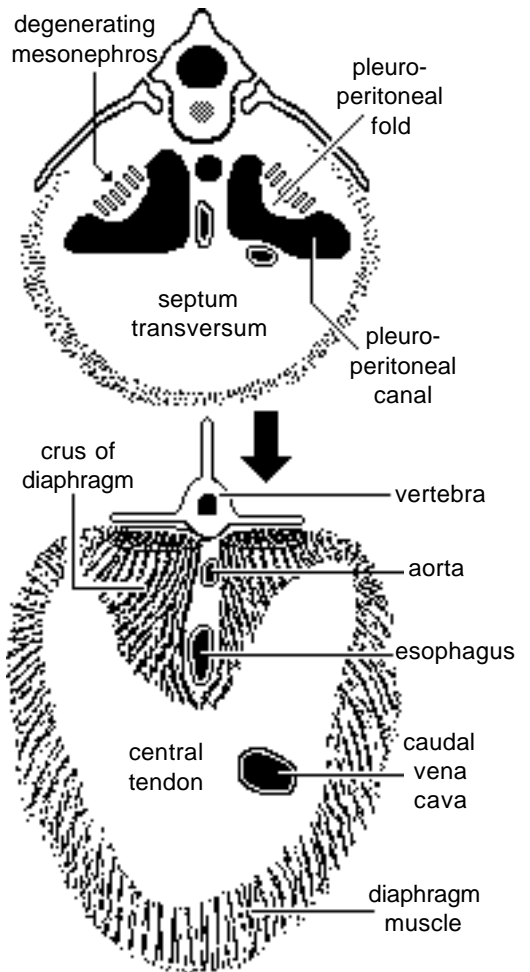
Originally in the embryo, the pericardial coelomic cavity communicated with two dorsally positioned pleural cavities (canals). Subsequently, the cavities become partitioned by paired *pleuropericardial folds* and then somatic mesoderm. Details of the separation include:

— bilateral pleuropericardial folds (membranes), which accompany common cardinal veins as they join the heart, converge medially to unite with the mediastinum (ventral mesentery) and partition the ventral pericardial cavity from the dorsal pleural canals;

— subsequent ventrolateral growth of the pleural cavities into the body wall incorporates somatic mesoderm (mesenchyme) into the future fibrous pericardium.

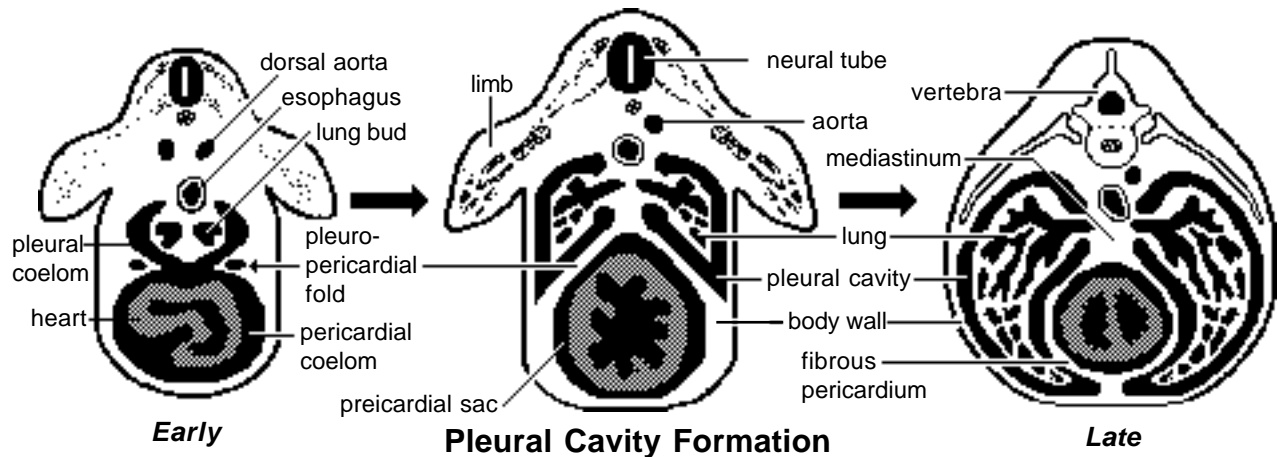
NOTE: Mediastinum is formed initially by dorsal and ventral mesenteries of the esophagus.

Diaphragm Formation (Caudal View)



Growth of Pleural Cavities:

Initially the pleural cavities are small canals into which the lung buds project. As the lungs grow, the pleural cavities enlarge and appear to carve into the body wall (into somatic mesoderm/ mesenchyme). As a result, somatic mesoderm forms partitions (fibrous pericardium and diaphragm) that wall off the pleural cavities.



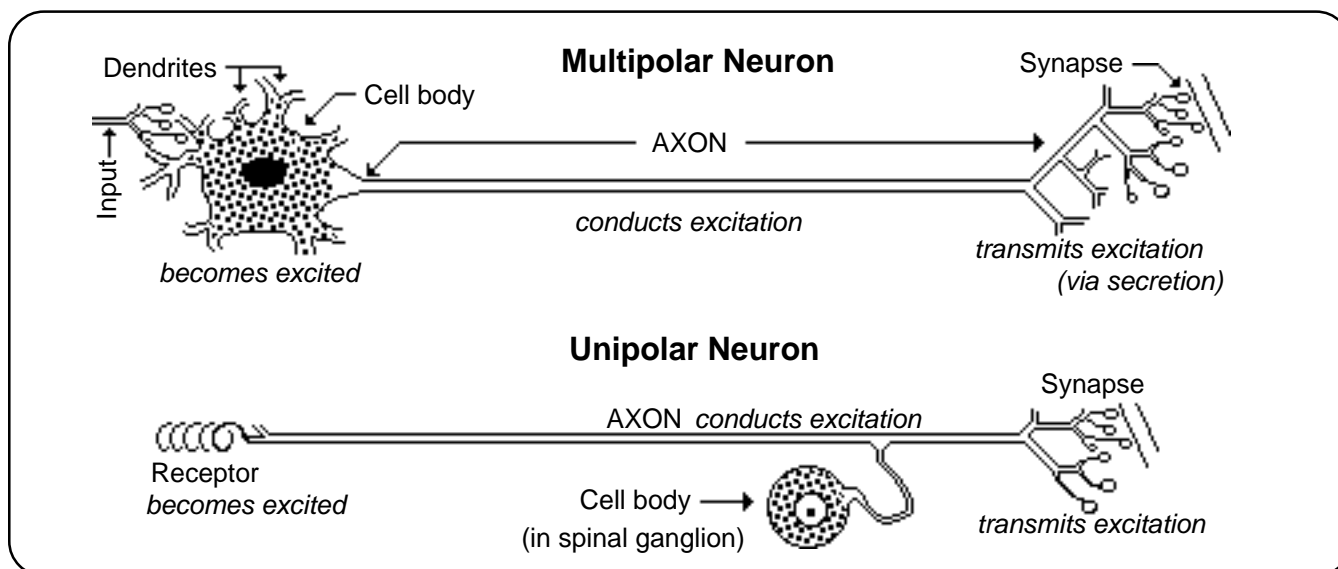
Nervous System

Neuron = functional cell of Nervous System:

- receives excitation (at a synapse or at a receptor);
- conducts excitation (along an axon);
- transmits excitation (via release of chemical at a synapse).

Most neurons are *multipolar* — cell body is located where input excitation occurs

Sensory neurons are *unipolar* — cell body is located along the axon (in a spinal ganglion)



Definitions:

Nerve = bundle of axons ensheathed by supporting cells and enveloped by connective tissue

Root = nerve that is adjacent to the CNS and enveloped by meninges

Ganglion = localized site where a nerve is enlarged due to a collection of cell bodies:

Spinal ganglia — contain unipolar cell bodies (located on dorsal roots of spinal nn.)

Autonomic ganglia — contain multipolar cell bodies that innervate viscera.

Nervous System Divisions:

Central (CNS): brain and spinal cord

Peripheral (PNS): 12 pairs of *cranial nerves* (attached to brain);

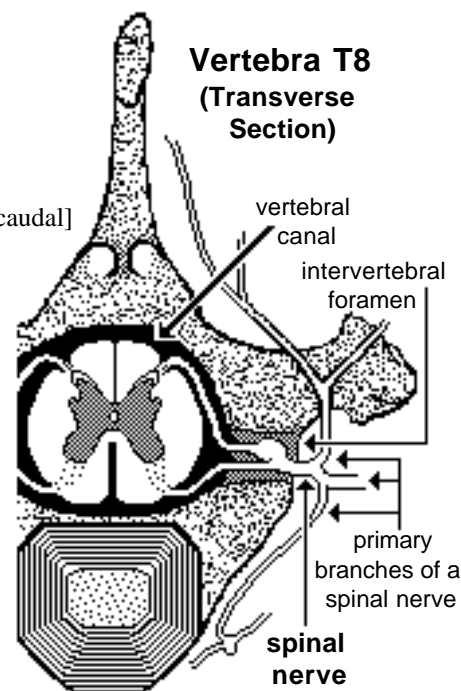
36 pairs of *spinal nerves* in the dog & cat (attached to spinal cord). [8 cervical; 13 thoracic; 7 lumbar; 3 sacral; & 5 caudal]

Spinal Nerve:

The spinal cord and spinal roots are located within the vertebral canal of the vertebral column. Dorsal and ventral spinal roots unite to form a *spinal nerve* (bilaterally).

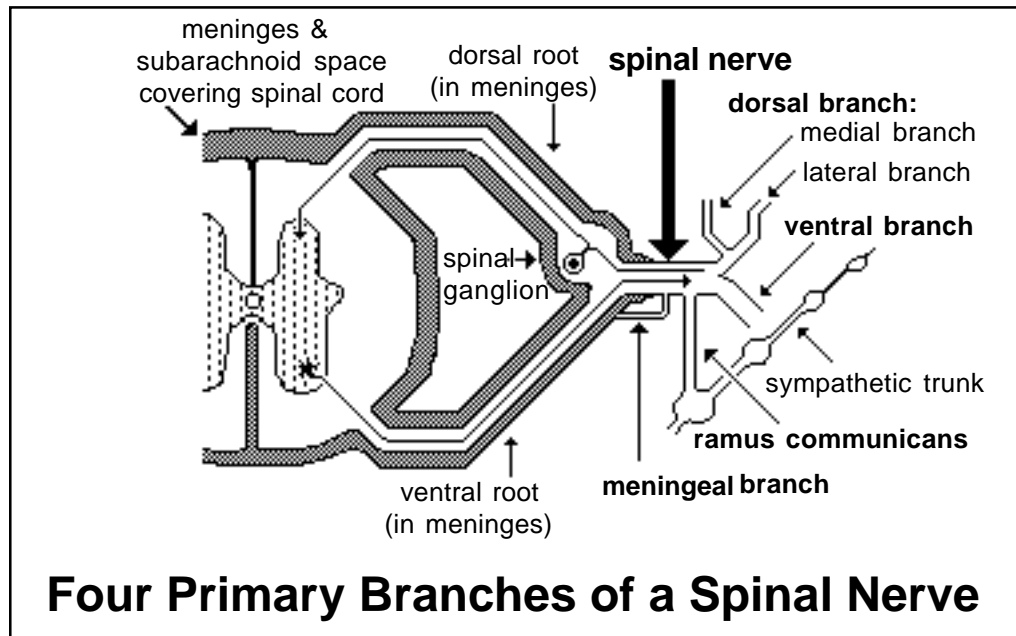
Adjacent vertebrae combine to form an *intervertebral foramen* (dorsal to an intervertebral disc). The spinal nerve is found within the intervertebral foramen, from which it exits the vertebral canal.

The *spinal nerve* is enveloped by connective tissue (epineurium, perineurium, & endoneurium). In contrast, the spinal cord and the dorsal and ventral *spinal roots* are surrounded by cerebrospinal fluid enclosed within meninges.



Spinal Nerve: *typical pattern*

- short (<1 cm); located at an intervertebral foramen
- connected to the spinal cord by two roots (each comprised of rootlets):
 - dorsal root* — composed of afferent (sensory) axons; the site of a spinal ganglion
 - ventral root* — composed of efferent axons that innervate muscle & gland
- divides into four primary branches:
 - meningeal branch* — small; sensory to meninges
 - ramus communicans* — connects to sympathetic trunk & innervates viscera
 - ventral branch* — largest branch; hypaxial mm. & lateral and ventral cutaneous nn.
 - dorsal branch* — medial & lateral branches.; epaxial mm. & dorsal cutaneous nn.



Fiber types: *types of nerve fibers (axons) found in a spinal nerve and its branches*

- Afferent (sensory) — axons associated with receptors and unipolar cell bodies in spinal ganglia
 - General Somatic Afferent (GSA): receptors in skin & muscles, tendons, joints
 - General Visceral Afferent (GVA): receptors in viscera
- Efferent (motor) — axons that innervate muscle & gland;
 - cell bodies are located in the spinal cord (or in some cases autonomic ganglia)
 - Somatic Efferent (SE): innervates skeletal muscle
 - Visceral Efferent (VE): innervates cardiac m., smooth m., & gland

Note: In older literature, SE & VE fiber types are designated GSE and GVE, preceded by the adjective General.

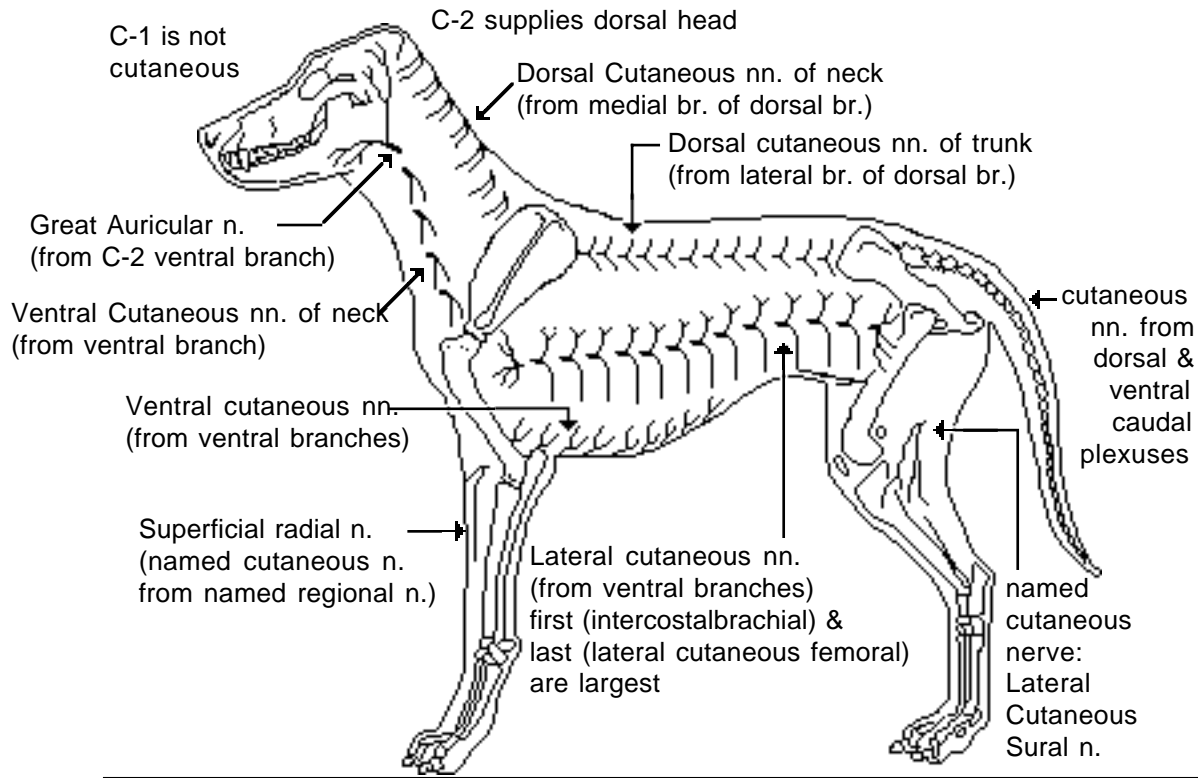
Autonomic Nervous System (ANS) = VE (sometimes the ANS includes GVA as well as VE fibers)

The VE pathway, from the CNS to a visceral organ, is unique in that it is composed of two multipolar neurons (the other efferent pathway and the two afferent pathways have just a single neuron).

The first neuron in the pathway has its cell body in the CNS (brain or spinal cord). The cell body of the second neuron is located within an autonomic ganglion in the peripheral nervous system. The autonomic nervous system operates largely at a subconscious level [auto-nomic = self-rule].

Cutaneous innervation:

- Neck — series of dorsal and ventral cutaneous nn.
- Thorax — series of dorsal, lateral and ventral cutaneous nn.
- Abdomen — series of dorsal and lateral cutaneous nn.
- Limbs — individually named cutaneous branches of regional nerves that originate from nerve plexuses (brachial or lumbosacral) to the limbs.
- Face — named cutaneous branches of cranial nerves.

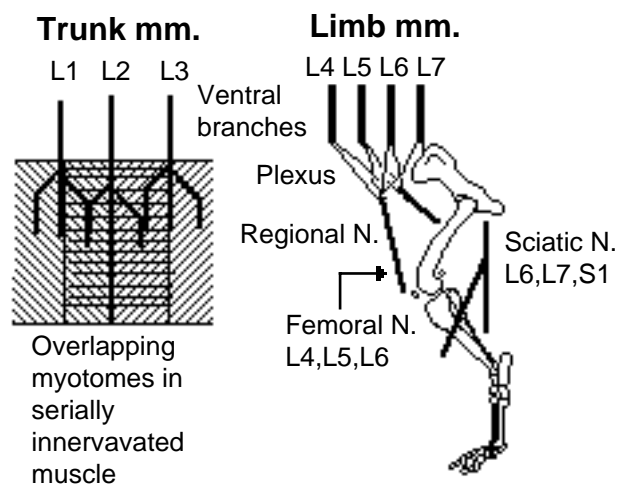


Brachial and Lumbosacral nerve plexuses:

Individual muscles are composed of multiple myotomes that overlap in forming the muscle.

In the case of trunk muscles, which are generally broad, multiple dorsal or ventral branches of spinal nerves can be seen to serially innervate each individual muscle. The innervations overlap within the muscle because of myotome overlap.

In the case of limb muscles, each muscle is innervated by the branch of a single regional nerve. Because of multiple myotomes per muscle, the regional nerves must contain axons from ventral branches of multiple spinal nerves. The exchange of axons among ventral branches as they form regional nerves produces a nerve plexus for each limb.

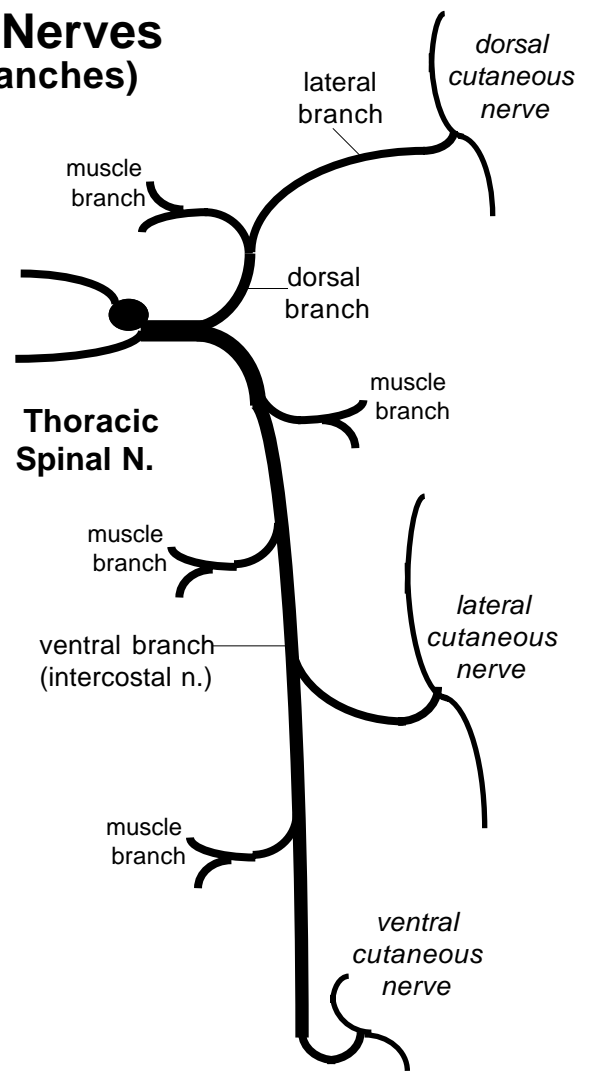
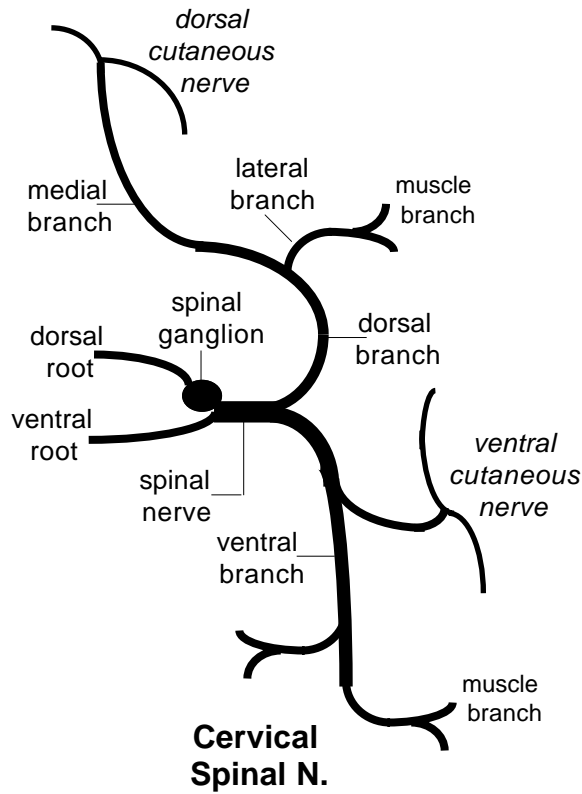


From a Gross Anatomy perspective ...

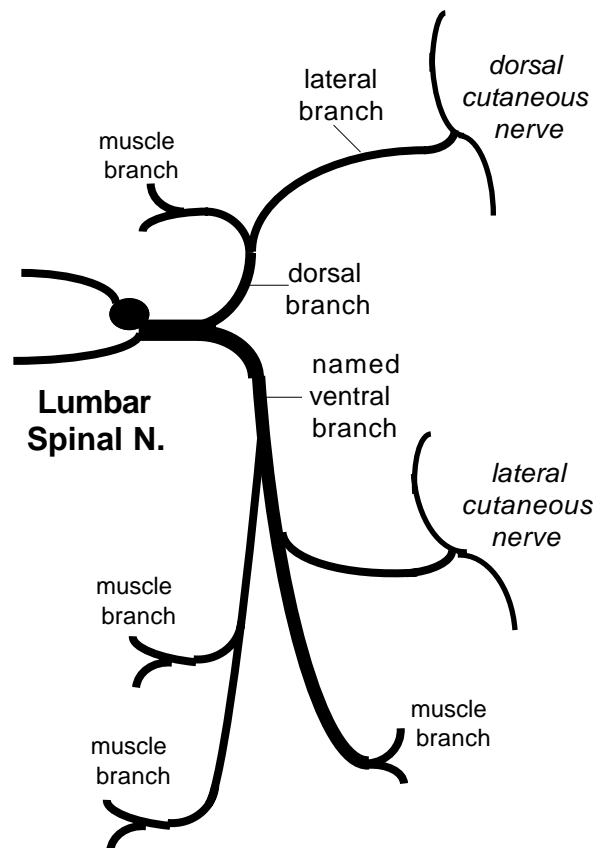
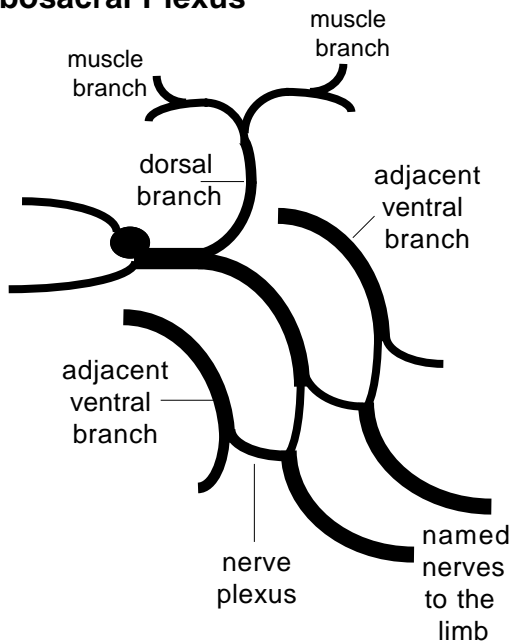
MYOTOME = musculature derived from one somite and thus innervated by a single spinal nerve per body half.

DERMATOME = skin derived from one somite and thus innervated by a single spinal nerve per body half.

Regional Configurations of Spinal Nerves (Showing Roots and Dorsal & Ventral Branches)



Spinal N. Contributing to the Brachial or Lumbosacral Plexus



NOTE: named nerves give off named cutaneous and muscle branches within the limb

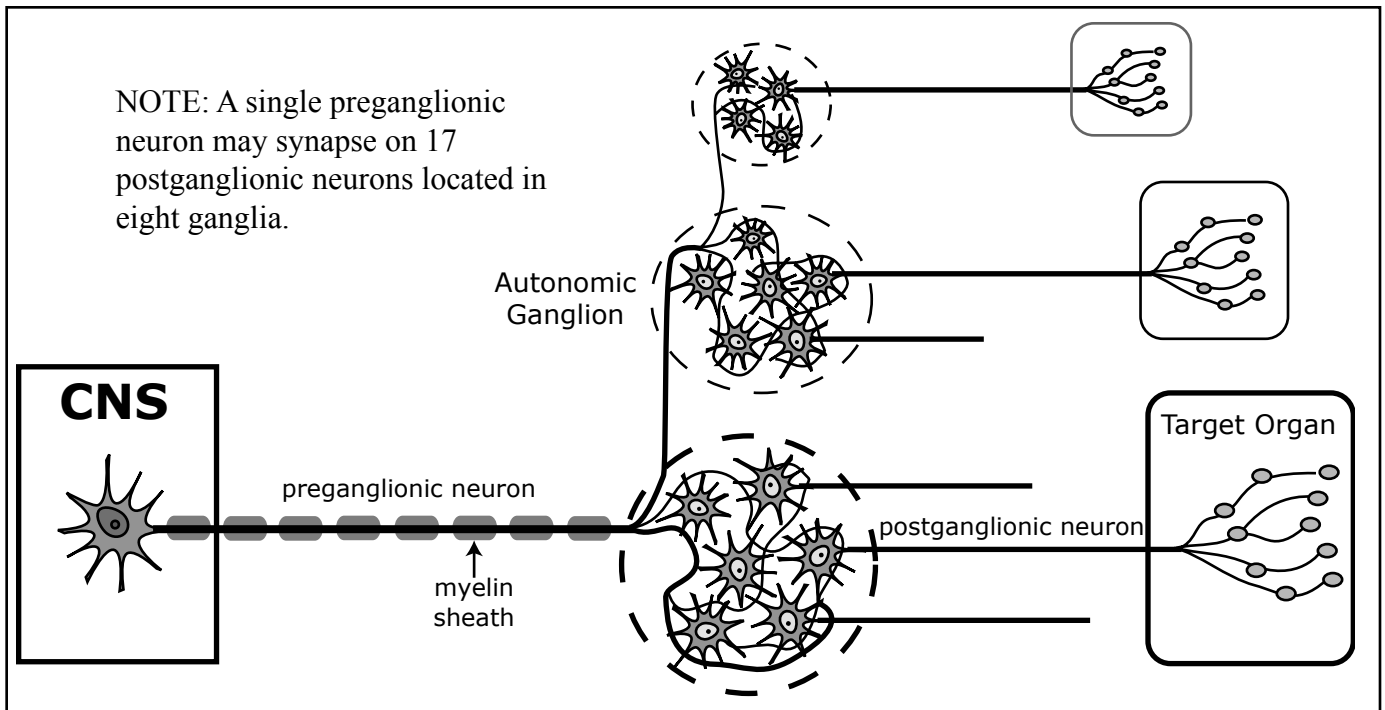
Autonomic Nervous System (ANS)

(Note: In addition to VE nerurons, GVA neurons (and even CNS components) may be included under ANS.)

Visceral Efferent (VE) Pathway: involves 2 neurons

- 1) *preganglionic* neuron — cell body located in CNS; axon synapses in an autonomic ganglia
- 2) *postganglionic* neuron — cell body in an autonomic ganglion; axon innervates smooth muscle, cardiac muscle or gland

Note: The preganglionic neuron always releases acetylcholine at its synaptic terminals. The postganglionic neuron releases acetylcholine or norepinephrine (noradrenalin) as its transmitter chemical to excite target cells.



ANS Divisions: basis for recognizing two divisions

<u>Feature</u>	<u>Sympathetic</u>	<u>Parasympathetic</u>
Distribution: -----	whole body -----	viscera in body cavities; in head -----
Preganglionic origin: -----	thoracolumbar spinal cord -----	sacral spinal cord & brainstem -----
Postganglionic neuron: -----	usually adrenergic -----	always cholinergic -----
(Transmitter released: -----	norepinephrine -----	acetylcholine) -----
Functional role: -----	“fight or flight” -----	routine visceral operations -----

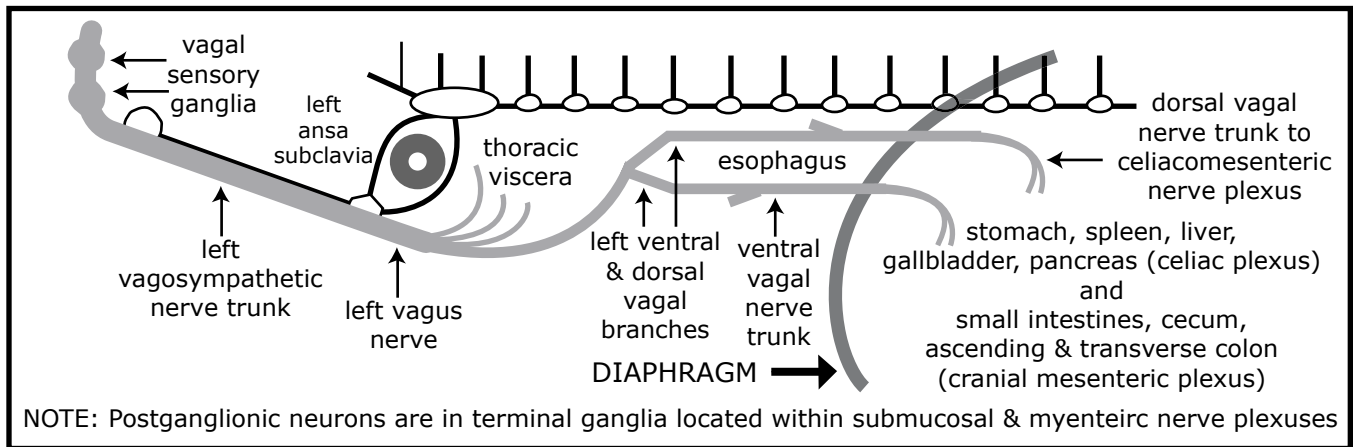
Functional Differences:

<u>Structure</u>	<u>Sympathetic</u>	<u>Parasympathetic</u>
iris (pupil)-----	dilate -----	constrict -----
heart -----	increase rate -----	decrease rate -----
bronchi -----	dilate -----	constrict -----
gut & bladder wall -----	inhibit motility -----	excite contraction -----
gut & bladder sphincters -----	contract -----	relax -----
cutaneous vessels -----	constrict -----	<i>doesn't innervate</i> -----
muscle vessels -----	dilate (cholinergic) -----	<i>doesn't innervate</i> -----
sweat glands -----	secrete -----	<i>doesn't innervate</i> -----
ALSO:	semen ejaculation -----	penis erection -----
	glucose release (liver) -----	secretion stomach/pancreas -----

The **sympathetic** division is activated when the brain perceives a situation that is "life threatening", i.e., a situation that calls for mobilization of physiological resources in preparation for a great expenditure of energy to escape or combat the threat. The **parasympathetic** role is to restore & maintain routine visceral operations.

Autonomic Pathways

NOTE: Visceral afferent axons use same pathways as visceral efferents



Parasympathetic pathways:

1] **Cranial nerves III, VII, and IX** later in the course.

2] **Cranial nerve X (vagus nerve)** innervates thoracic and abdominal viscera:

Preganglionic pathway: the vagus n. branches travel to organs being innervated

Synapse: occurs within organs innervated, in microscopic terminal ganglia

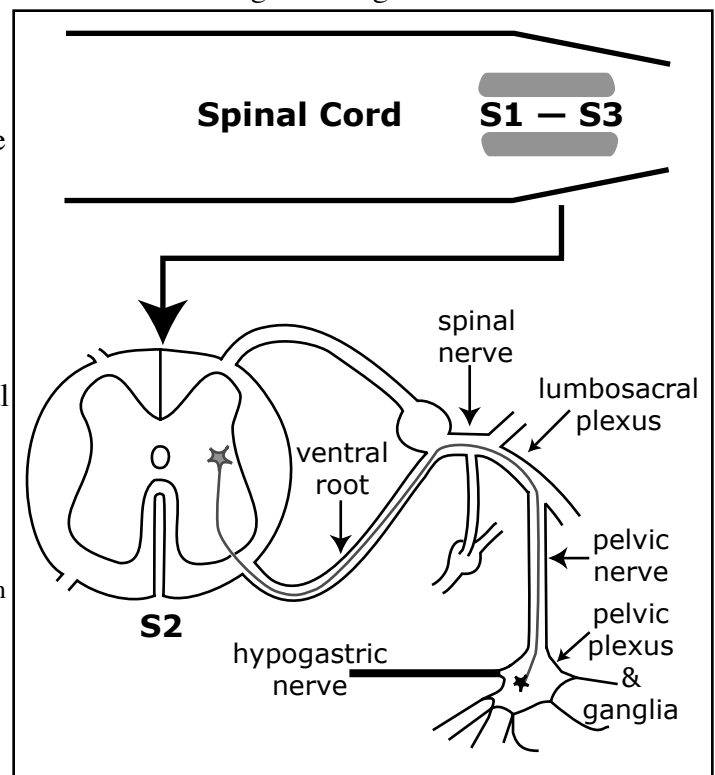
Postganglionic pathway: axons course in submucosal or myenteric plexuses to reach innervation targets (smooth m., cardiac m. or gland cells).

3] **Sacral spinal cord** innervates pelvic viscera:

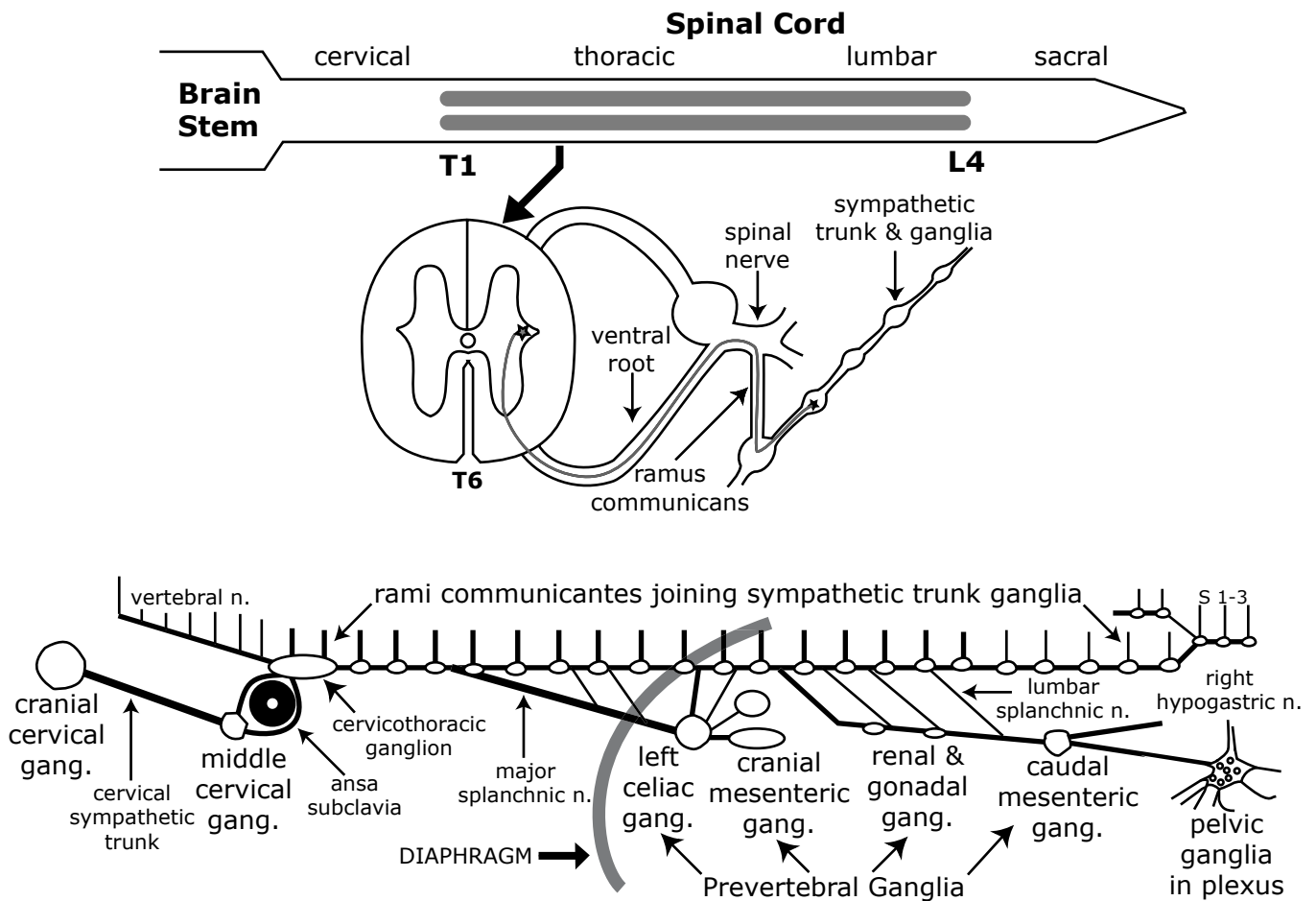
Preganglionic pathway: from the sacral cord to pelvic plexus (via ventral root; spinal nerve; ventral branch; sacral plexus; pelvic nerve).

Synapse: occurs in a pelvic ganglion within the pelvic plexus (or in the organ innervated)

Postganglionic pathway: branches from the pelvic plexus run directly to pelvic viscera.



Sympathetic Preganglionic Pathways



Sympathetic Pathways to Six Regions

Head Region

Presynaptic path:

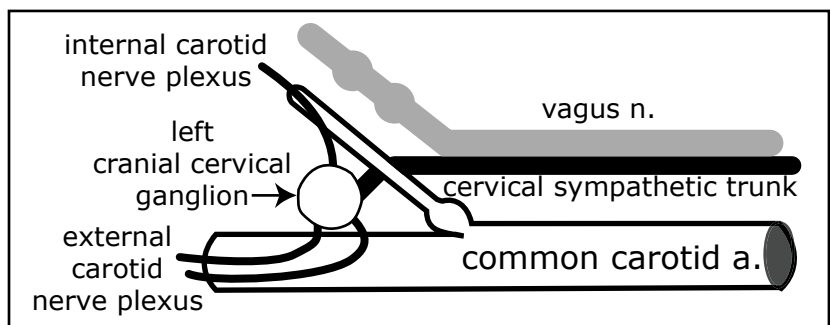
ventral root; spinal n.; ramus communicans; sympathetic trunk; ansa subclavia; and cervical sympathetic trunk

Synapse:

cranial cervical ganglion

Postsynaptic path:

nerve plexuses run on external & internal carotid arteries and their branches to reach target structures



Neck Region

Presynaptic path:

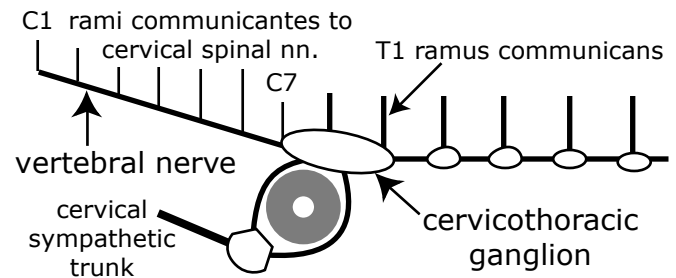
ventral root; spinal n.; ramus communicans; sympathetic trunk

Synapse:

cervicothoracic ganglion

Postsynaptic path:

vertebral nerve; rami communicantes; cervical spinal nn.; dorsal or ventral branches to muscles & skin



Body Wall and Limbs and Tail

Presynaptic path:

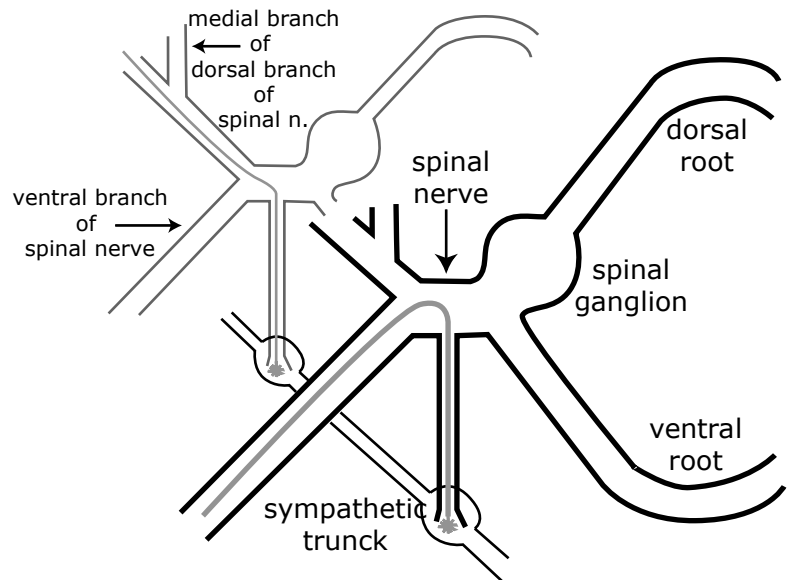
ventral root; spinal n.; ramus communicans; sympathetic trunk

Synapse:

sympathetic trunk ganglia (paravertebral ganglia)

Postsynaptic path:

rami communicantes; spinal nn.; dorsal or ventral branches to muscles & skin



Thoracic Viscera

Presynaptic path:

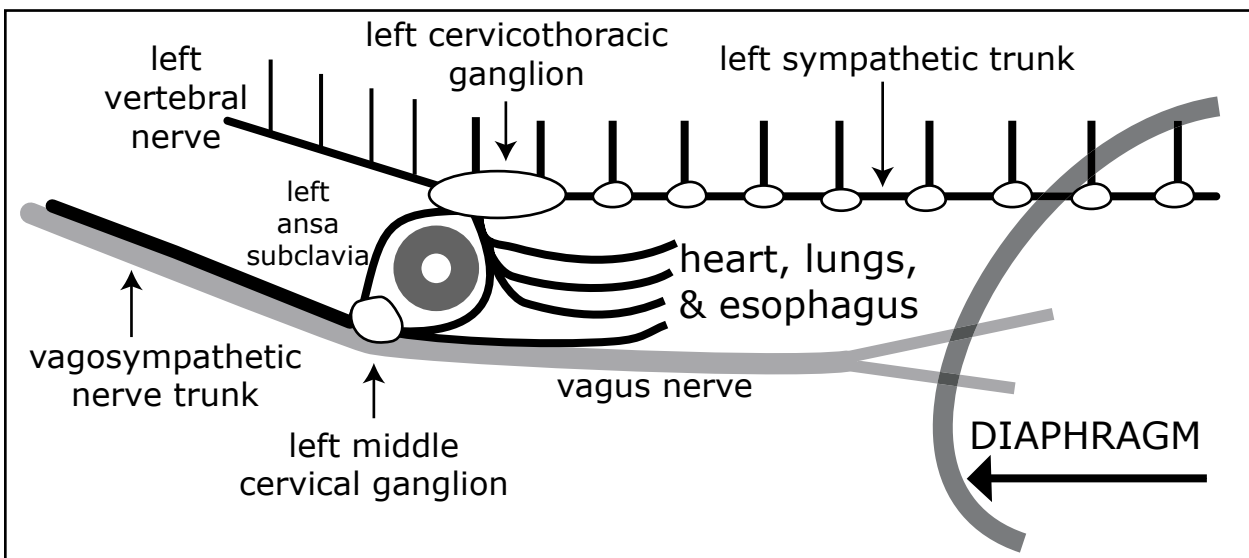
ventral root; spinal n.; ramus communicans; sympathetic trunk

Synapse:

cervicothoracic & middle cervical ganglia

Postsynaptic path:

cardiosympathetic nn. branch from ansa subclavia (also, branches that run with vagus n.)

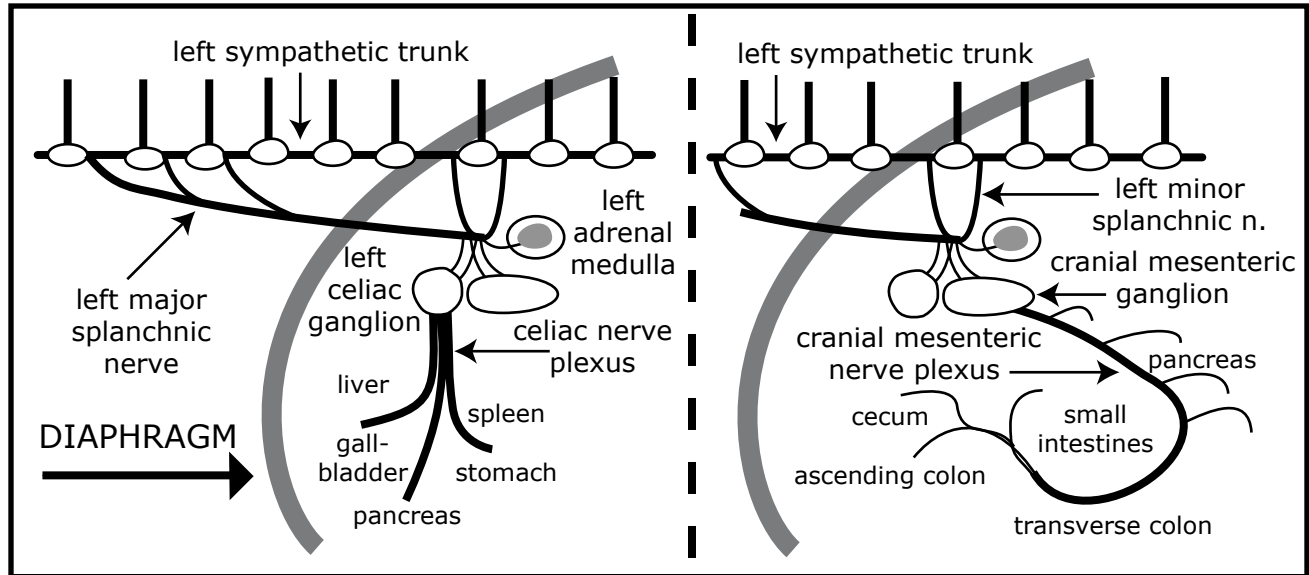


Abdominal Viscera

Presynaptic path: ventral root; spinal n.; ramus communicans; sympathetic trunk; splanchnic nn.

Synapse: prevertebral ganglia (left/right celiac, cranial mesenteric, caudal mesenteric, renal, and gonadal ganglia) located in nerve plexuses along the aorta

Postsynaptic path: nerve plexuses on abdominal arteries supplying particular organs

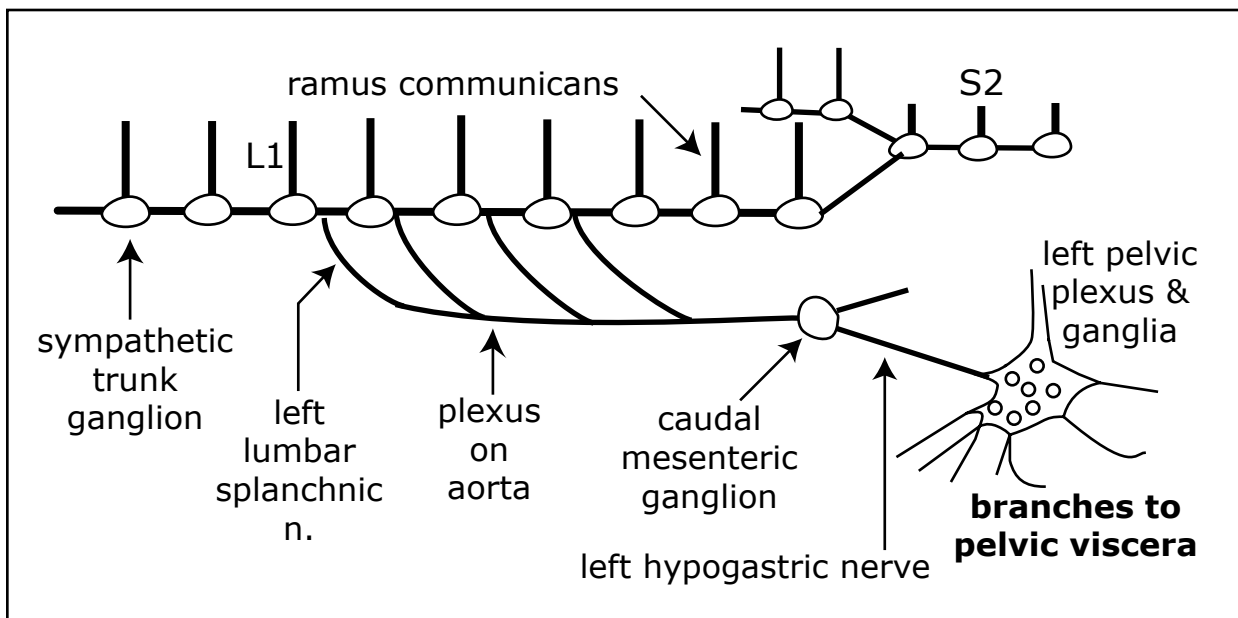


Pelvic Viscera

Presynaptic path: ventral root; spinal n.; ramus communicans; sympathetic trunk;
lumbar splanchnic nn.; caudal mesenteric plexus

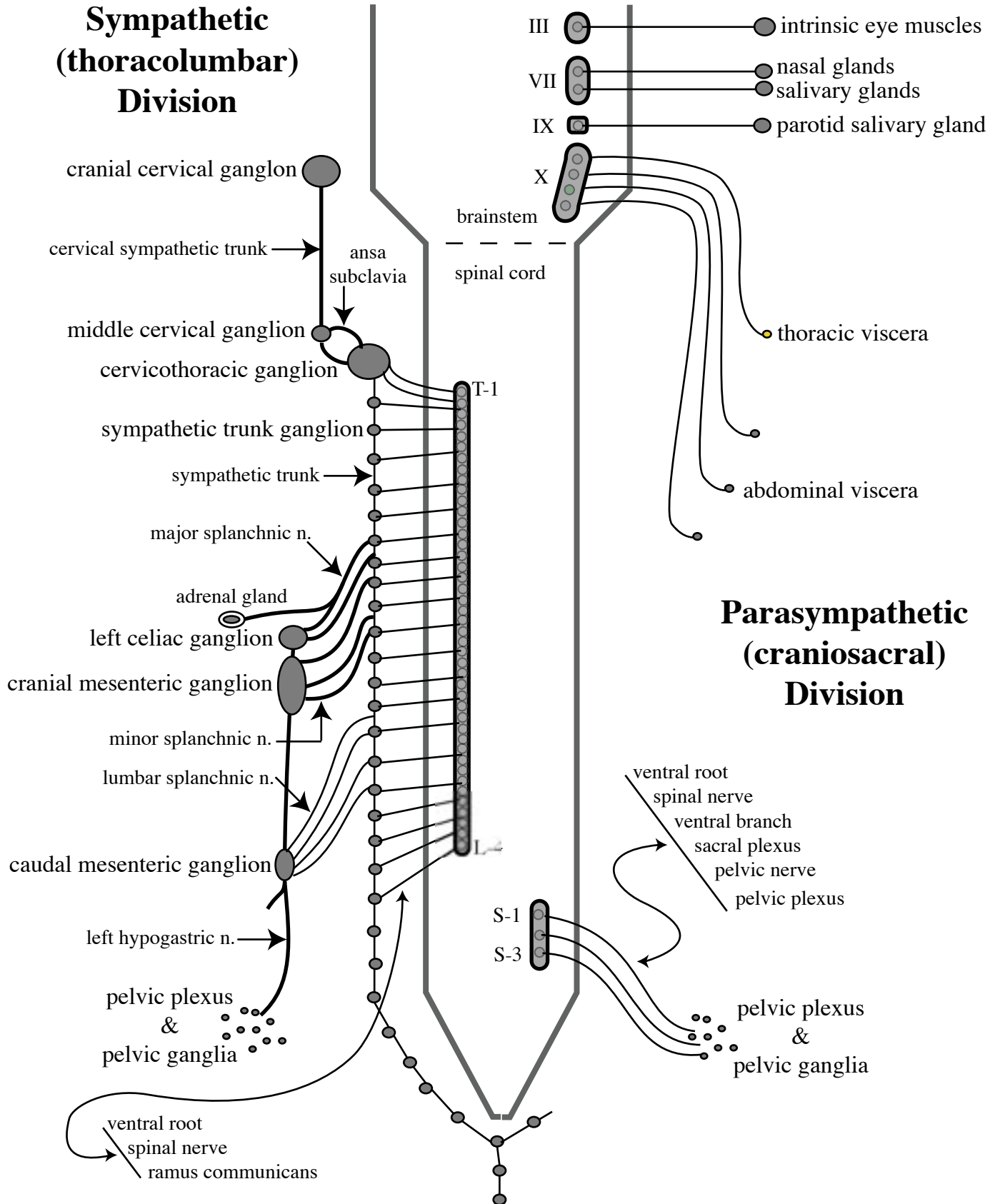
Synapse: caudal mesenteric ganglion (also, synapses in pelvic ganglia)

Postsynaptic path: hypogastric n.; pelvic plexus; branches directly to pelvic viscera (left/right)



Autonomic Preganglionic Pathways

Sympathetic (thoracolumbar) Division



Abdominal Viscera

Note: The digestive system consists of the digestive tube (mouth, pharynx, & alimentary canal) plus the liver, pancreas, & salivary glands.

Alimentary Canal (esophagus, stomach, intestines)

A. Esophagus — cervical, thoracic, abdominal regions
[all striated in dog; proximal 2/3's striated in cat]

B. Stomach:

- sphincters: 1] cardiac (at cardia) and
2] pyloric (at pylorus)
- regions: a] cardiac (surrounding cardia)
b] fundic (fundus = blind end)
c] body
d] pyloric (antrum & canal)
- also, lesser curvature — LESSER OMENTUM
greater curvature — GREATER OMENTUM

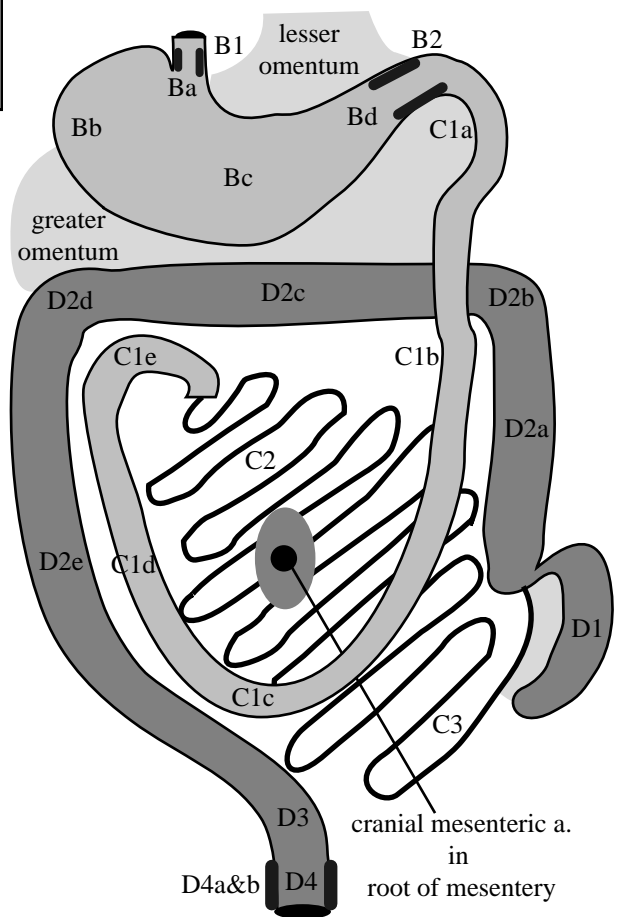
C. Small Intestines:

- 1) **Duodenum** — MESODUODENUM
regions: a] cranial flexure
b] descending duodenum
c] caudal flexure
d] ascending duodenum
e] duodenal-jejunal flexure
 - 2) **Jejunum** — MESOJEJUNUM
 - 3) **Ileum** — MESOILEUM
- } MESENTERY
- antimesenteric vessel; ileocecal fold
ileal (ileocolic) orifice

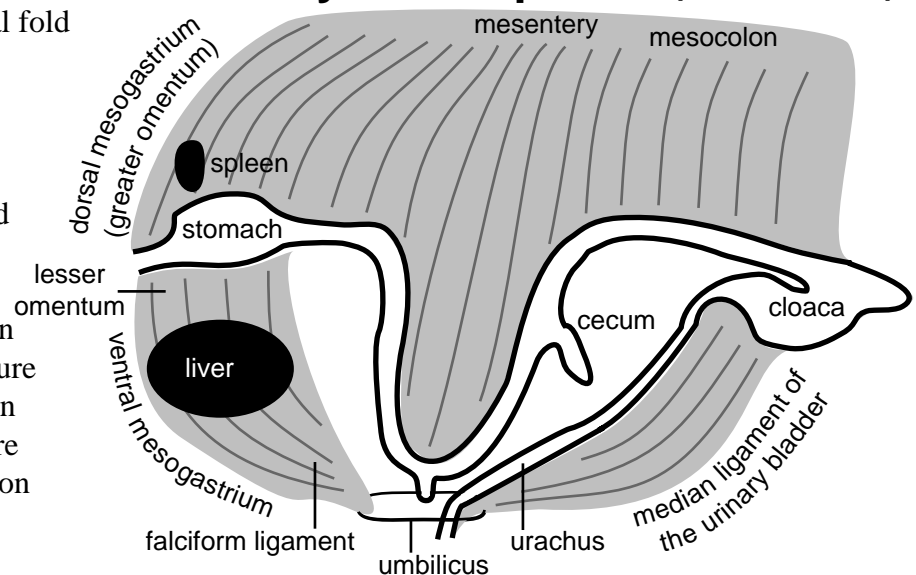
D. Large Intestines:

- 1) **Cecum** (blind end; no appendix)
cecocolic orifice; ileocecal fold
ileal (ileocolic) orifice
- 2) **Colon** — MESOCOLON
regions: a] ascending colon
b] right colic flexure
c] transverse colon
d] left colic flexure
e] descending colon
- 3) **Rectum** — MESORECTUM
- 4) **Anal canal** (retroperitoneal)
anus = external opening
sphincters — a] internal anal sphincter (smooth m.), and
b] external anal sphincter (striated m.);

Alimentary Canal (dorsal view)



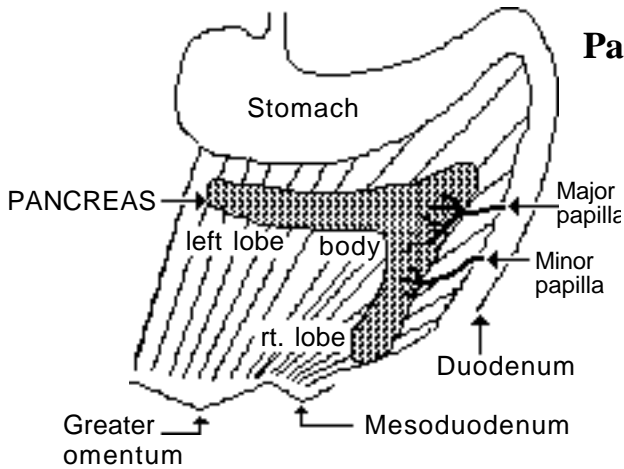
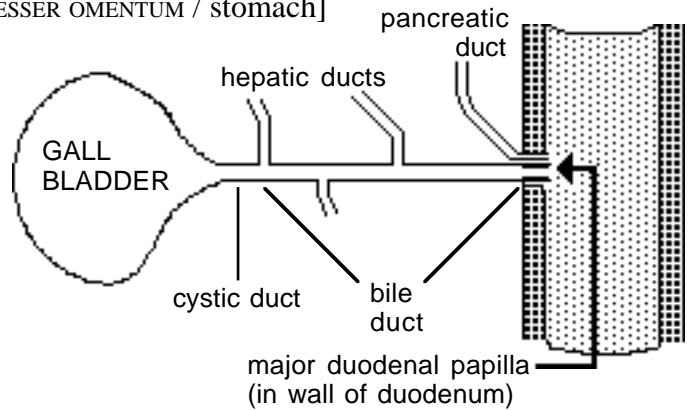
Mesentery Development (lateral view)



Liver — secretes bile salts which emulsify ingested fat; bile is stored in the gallbladder
 develops in ventral mesogastrium:

[diaphragm / LIGAMENTS / **LIVER** / LESSER OMENTUM / stomach]

Six lobes: right lateral lobe
 right medial lobe
 ————— *gall bladder*
 quadrate lobe
 left medial lobe
 left lateral lobe
 caudate lobe
 — papillary process &
 — caudate process



Pancreas — secretes proteolytic enzymes into duodenum;
 also, endocrine secretions (insulin, etc.)

Structure:

left lobe + body + right lobe;
 located in GREATER OMENTUM & MESODUODENUM

Ducts:

Pancreatic duct (smaller) empties with
 bile duct —> major duodenal papilla
 Accessory pancreatic duct (larger) empties
 —> minor duodenal papilla

Kidney:

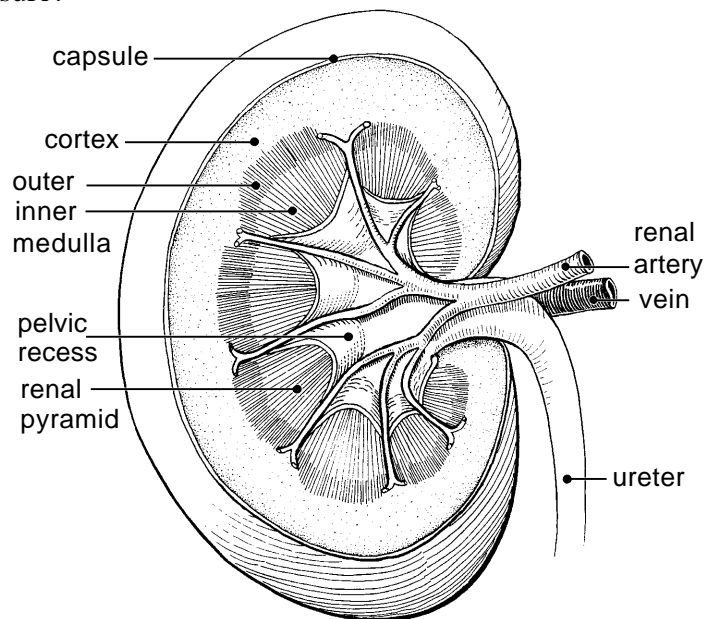
— removes waste products from blood (urine);
 — regulates fluid/salt balance (blood osmotic pressure)

Topography —

right kidney is more cranial than the left;
 cranial pole of right kidney is cupped by liver;
 left kidney is more loosely attached;
 feline kidneys are positioned more caudal.

Surface features —

cranial / caudal poles
 dorsal / ventral surfaces
 medial / lateral borders:
 medial border has a hilus (where vessels
 and the ureter enter) that leads to a
 space (renal sinus) where the renal
 pelvis is located.



Kidney structure —

a fibrous *capsule* surrounds the kidney (capsular veins are prominent in the cat)

renal *cortex* = superficial tissue that contains vascular glomeruli

renal *medulla* = deep tissue (an outer part and a less vascular inner part can be distinguished)

renal pyramid = the medulla between interlobar vessels (belonging to a renal lobe)

renal papilla = the free tip of a renal pyramid (not present as such in carnivores)

renal crest = median ridge produced by fusion of renal papillae in the carnivore

Note: During development distinct lobation is present in all kidneys. Lobes fuse to a greater or lesser extent in different species. Carnivore kidneys appear unilobar, lobation is only evident where interlobar arteries separate renal pyramids.

Ureter — (forms branches and calyces in multilobar kidneys)

conveys urine from kidney to urinary bladder

renal pelvis = expanded proximal end of ureter (located within renal sinus of unilobar kidney)

pelvic recess = lateral expansion of renal pelvis between interlobar vessels

Spleen:

Structure

— develops in dorsal mesogastrium;

— becomes enlarged when capsular & trabecular smooth muscle relax (e.g., under barbiturate anesthesia)

Function

— serves as a reservoir for blood cells (blood storage)

— filters particles from blood, particularly over-aged erythrocytes

Abdominal Vessels

Aorta:

A. Branches to the abdominal wall:

1) **lumbar** aa. — supply vertebral column, spinal cord, epaxial m., & skin over the back.

2) common trunk — supplies abdominal wall & adrenal gland. via **cranial abdominal a.** and diaphragm (caudal phrenic a.)

3) **deep circumflex iliac** aa. — supply abdominal wall (caudally)

B. Branches to paired organs:

1) **renal** a. — supplies kidney

2) **ovarian** a. or **testicular** a. — supplies gonad

Note: The above arterial branches are accompanied by satellite veins named the same as the arteries. The veins empty into the caudal vena cava.
In contrast, satellite veins which drain the digestive tract empty into the portal vein rather than the caudal vena cava

C. Branches to unpaired organs (digestive system & spleen):

1) **celiac a.**

- supplies cranial abdominal viscera (esophagus, stomach, duodenum, liver & gall bladder, pancreas, spleen)
- the stomach has a quadrant blood supply (right/left & gastric/gastroepiploic aa.)

2) **cranial mesenteric a.**

- supplies duodenum to descending colon also pancreas

3) **caudal mesenteric a.**

- supplies descending colon & rectum

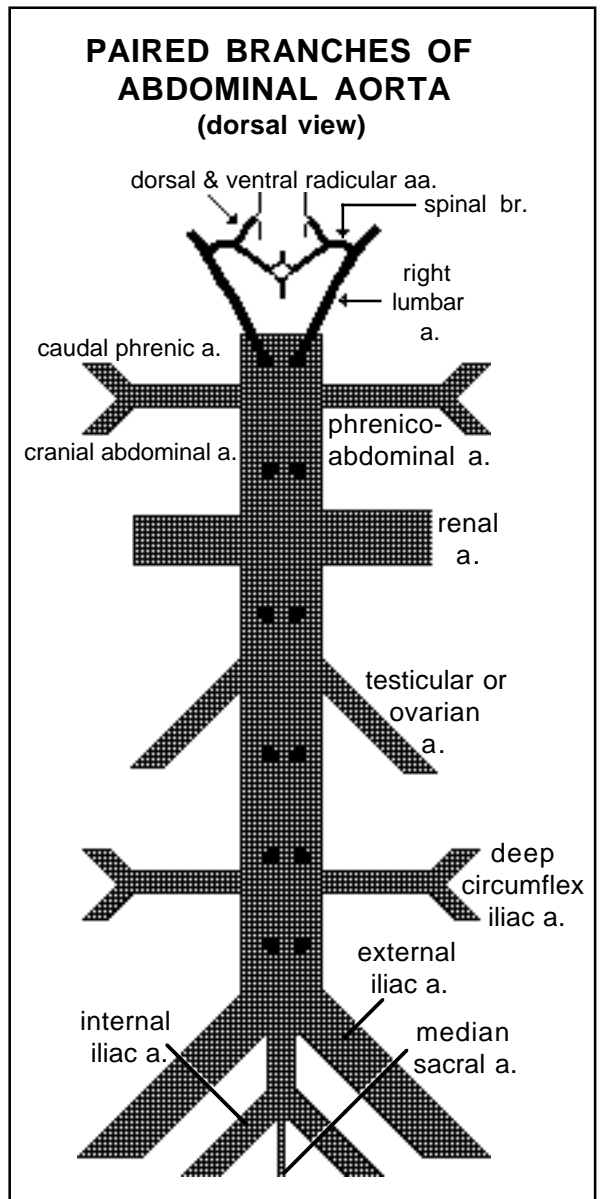
D. Terminal branches of the aorta: (within pelvic cavity)

1) **external iliac a.** (paired) — pelvic limbs

2) **internal iliac a.** (paired) — pelvis (wall & viscera)

3) **median sacral a.** (unpaired)

- becomes **median caudal a.** of the tail



Portal Vein:

The portal vein conveys blood between two capillary beds (between alimentary tract capillaries and liver sinusoids).

Cranial and caudal mesenteric veins anastomose to form the portal vein which receives a splenic vein (left side) and the gastroduodenal vein (right side) before entering the liver.

The circulation sequence is . . .

Celiac and cranial and caudal mesenteric arteries and their branches

- > alimentary, etc. capillaries
- > satellite veins
- > *portal vein*
- > hepatic sinusoids
- > hepatic veins
- > caudal vena cava

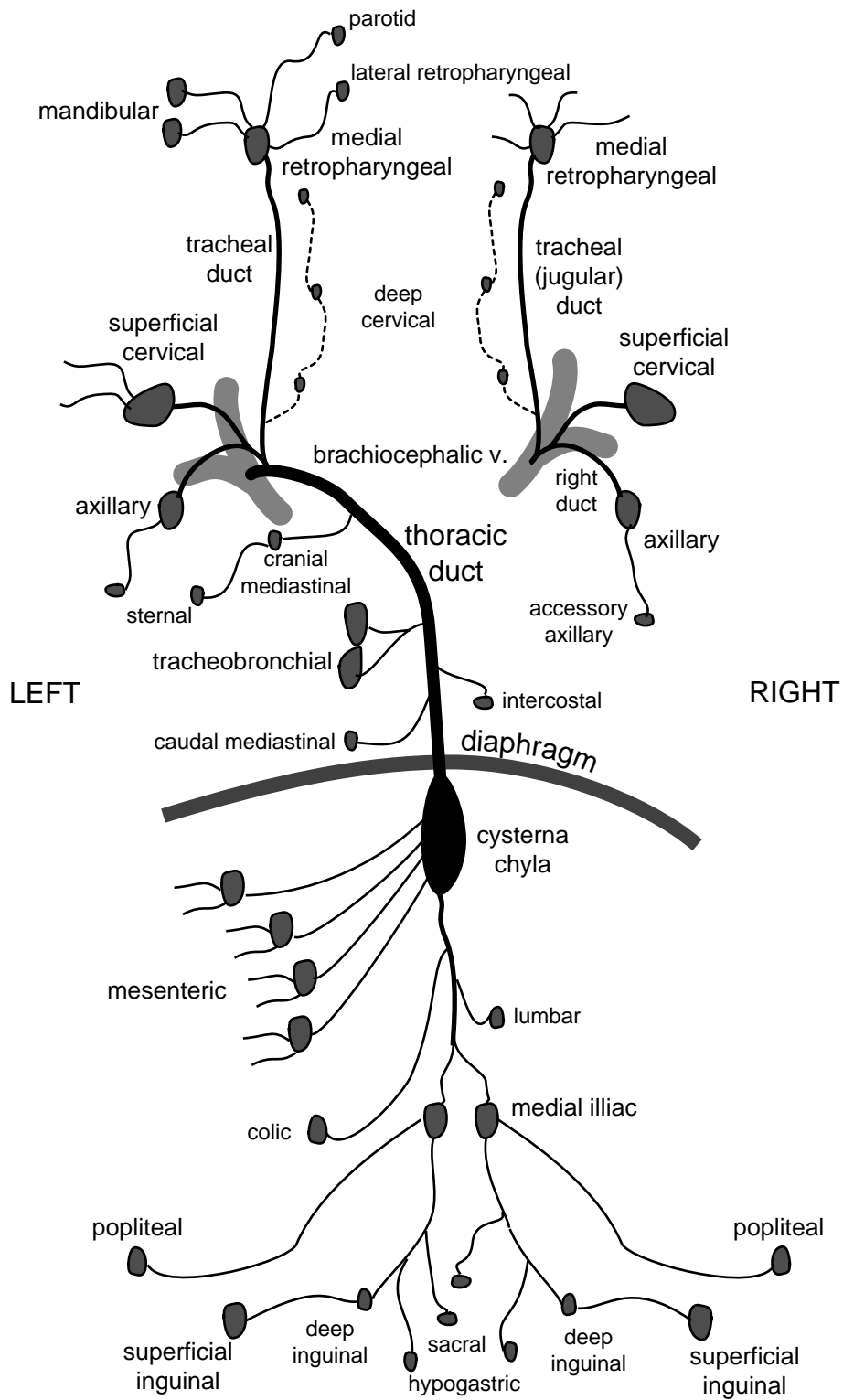
Lymphatics: (the attached diagram is included as a reference source)

Mesenteric lymph ducts converge to form a lymph "lake" (cysterna chyli)

Note: Chyle = lymph that has a milky appearance because it contains ingested fat.

Carnivore Lymphatic System

(Dorsal View)



Pelvis and Perineum

Pelvis = caudal region of trunk

The pelvis consists of pelvic viscera within a pelvic cavity that is bounded on five sides.

Note: **osseous pelvis** = sacrum + os coxae of each side (pelvic girdle)

Pelvic Viscera: rectum & anal canal; distal ureters, urinary bladder & urethra;
male or female genitalia; blood vessels, lymphatics & nerves

Pelvic Cavity Boundaries:

cranial opening— **pelvic inlet**, bounded by sacrum, ilium & pubis (rigid boundary)

cavity walls — osseous pelvis + obturator & gluteal mm. & sacrotuberous ligament (dog)

caudal boundary — perineum

Perineum = both a region & a wall

As topographic region . . .

from tail to scrotal attachment or entire vulva;
between ischiatic tuberosities.

As caudal wall of trunk . . .

muscles, fascia & skin surrounding anal canal and urogenital tract; *includes*

1. Pelvic diaphragm = levator ani & coccygeus mm. + associated deep fascia

2. Urogenital diaphragm = external urethral sphincter (urethralis m.) + associated deep fascia

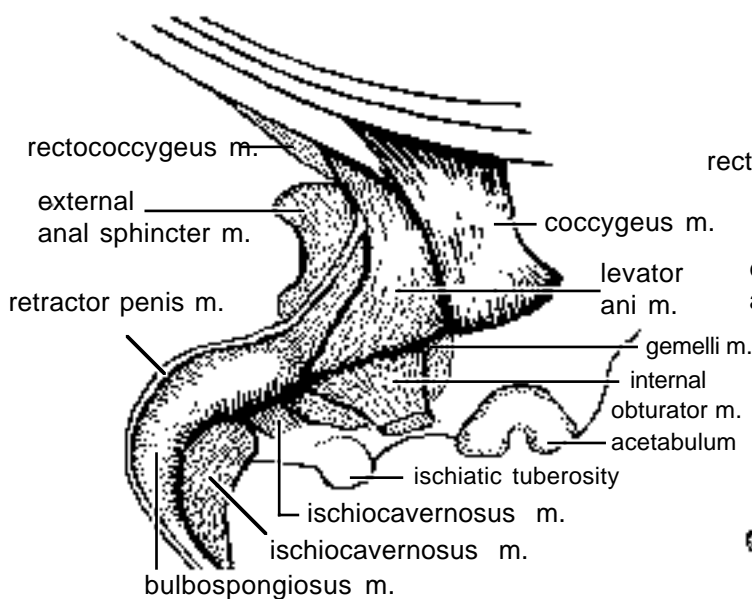
3. External anal sphincter m.

4. Genital striated mm. :

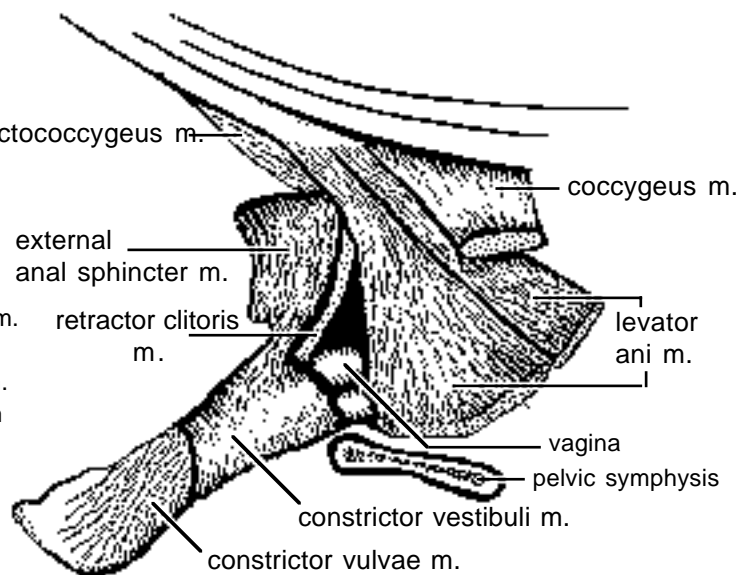
male — bulbospongiosus m. & paired ischiocavernosus mm.

female — constrictor vestibuli, constrictor vulvae & ischiocavernosus mm.

5. Smooth mm.: rectococcygeus m. (anchors rectum) & retractor penis m.



Lateral View — Male



Lateral View — Female

Micturition

Anatomy:

Urinary Bladder — apex ; body; neck (trigone = region of neck demarcated by ureters & urethra).
 Urethra — *female* : terminates in vestibule;
 male : pelvic urethra [preprostatic (cat); prostatic; & postprostatic regions] & penile urethra

Musculature:

Detrusor m. = smooth muscle coat of apex & body; innervated by pelvic n. (S2 + S1 & S3)

Internal urethral sphincter = smooth m.; innervated by hypogastric n. (L2 , L3 , L4)

female — vesical neck & cranial half of urethra

male — neck (dog); neck & preprostatic urethra (cat)

External urethral sphincter = urethralis m. (striated); innervated by pudendal n. (S2 & S3 + S1)

female — caudal half of urethra

male — postprostatic urethra

Urine Storage:

Sphincters active via spinal reflexes and detrusor m. inhibited

- internal sphincter exerts tonic activity after bladder is half full

- external sphincter is activated voluntarily or reflexly during phasic pressure increase

Micturition:

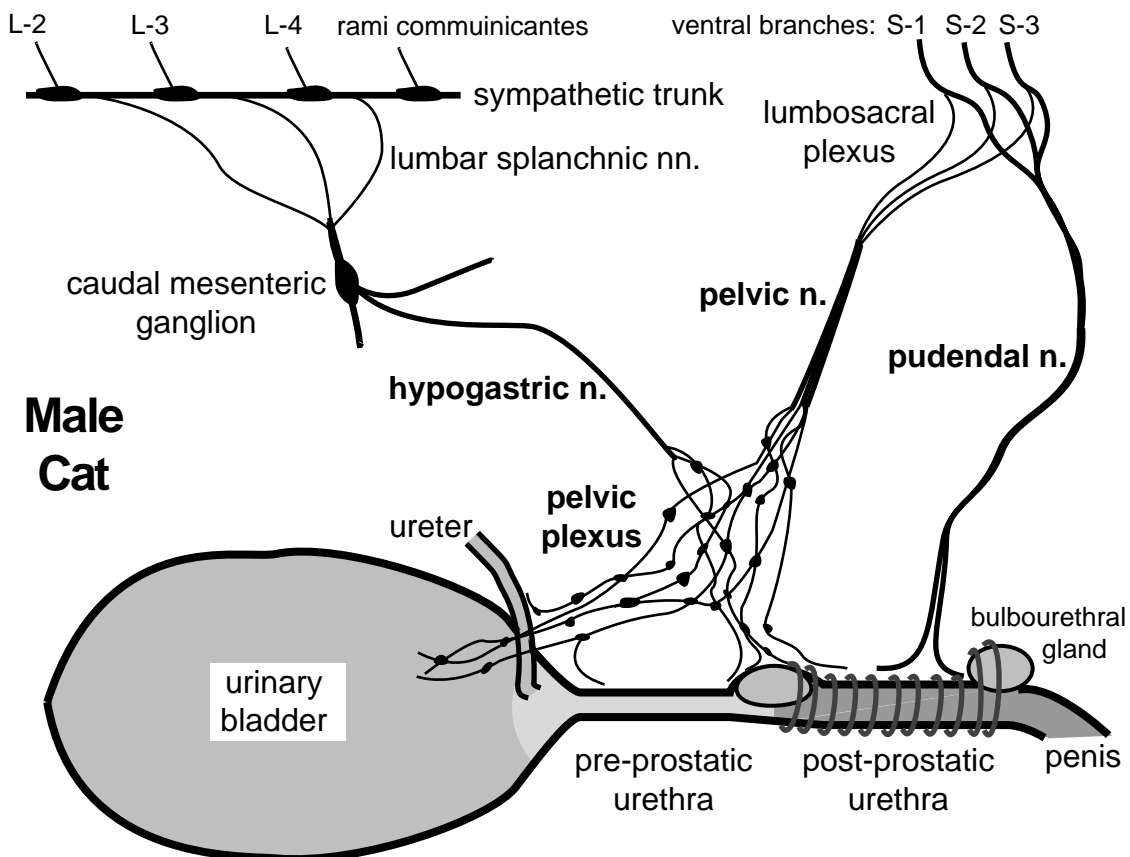
Requires prolonged detrusor contraction and sphincter inhibition

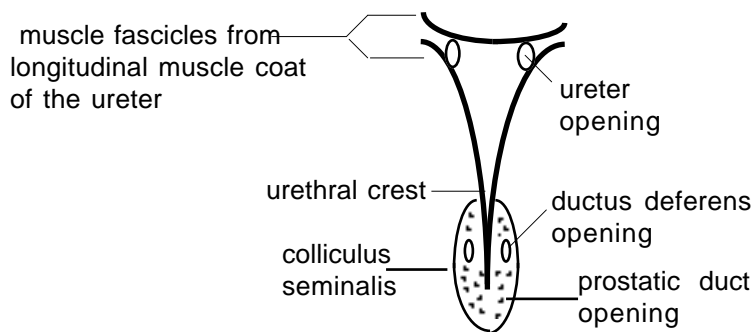
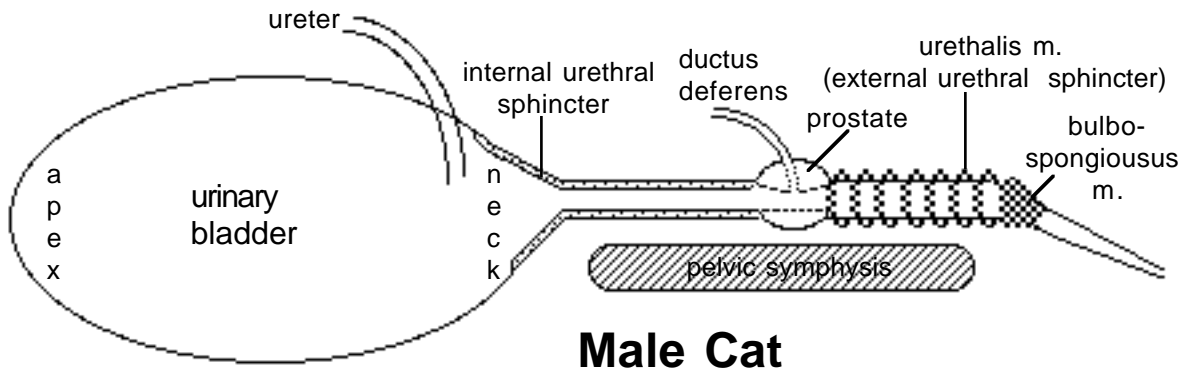
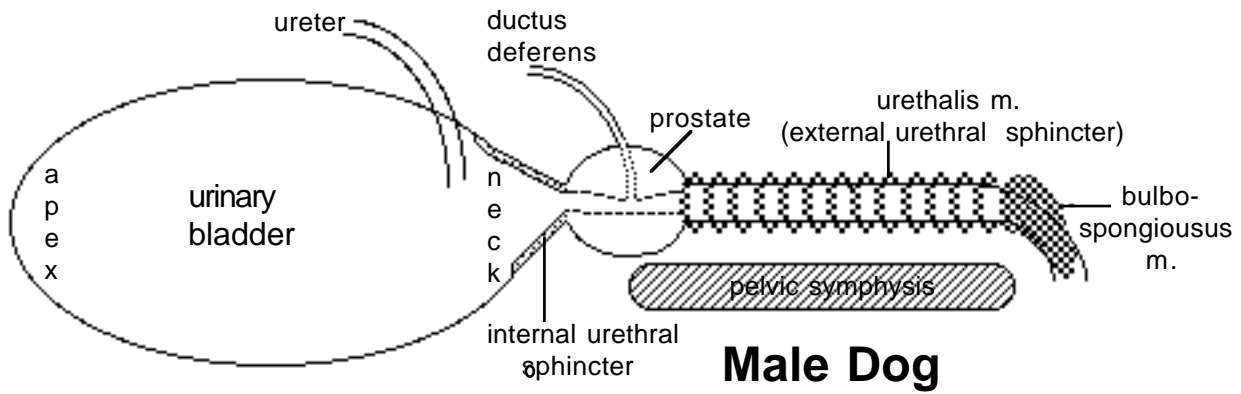
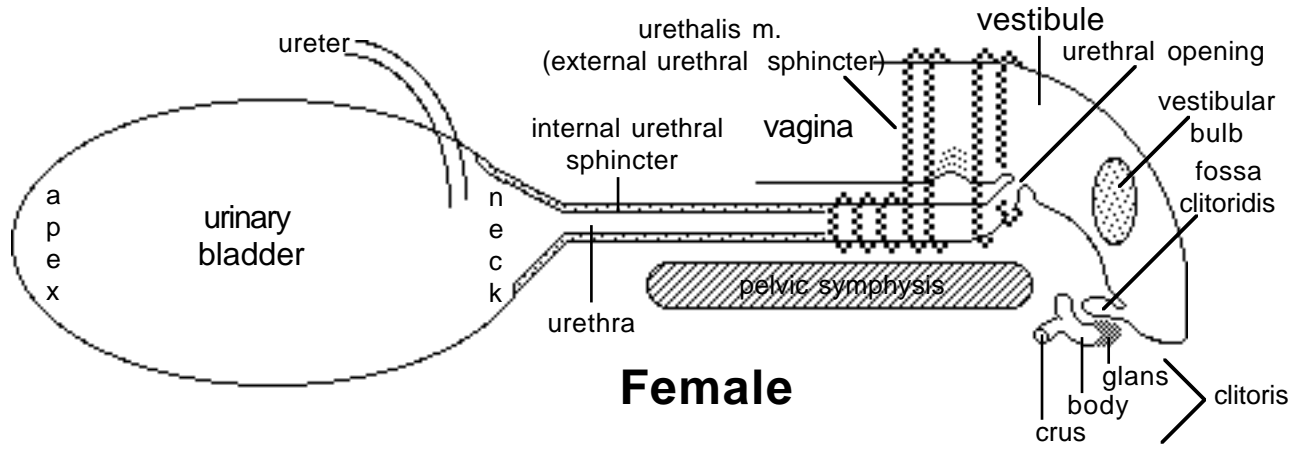
- free nerve endings (receptors) —> GVA fibers in pelvic n. —> ascending pathways

—> pons —> descending spinal pathways —> activate detrusor & inhibit sphincters

Pain:

GVA pain fibers travel through the hypogastric nerve to reach the spinal cord and brain.



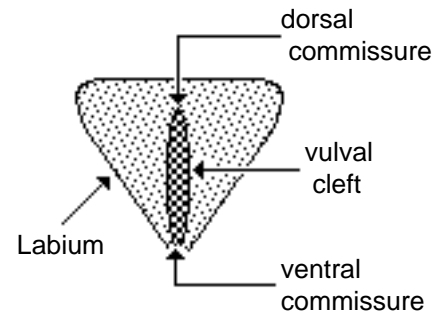


Trigone
 (internal surface of dorsal wall of urinary bladder neck of male dog)

Female Genital Tract

Vulva:*

- is composed of left & right labia which bound a vulval cleft
- constrictor vulvae m. (striated) is in the wall of each labium
- an indentation, the fossa of the clitoris, is present ventrally



Clitoris: *homologue of the penis*

- located deep (cranial) to the fossa of the clitoris
- composed of:
 - glans = erectile tissue
 - body = fat in a connective tissue capsule
 - crus = scant erectile tissue enclosed in fibrous c.t. (right & left crura)

Note : The crus attaches to the ischial arch and an ischiocavernosus m. covers the crus

Vestibule: (vestibule of the vagina)

- extends from vulval cleft to the transverse fold (hymen) that marks the vestibulo-vaginal junction
- receives the external urethral opening, on a tubercle (dog) or in a slit (cat)
- constrictor vestibuli m. (striated) is in the wall of the vestibule
- the wall contains vestibular glands (mucous) — a major vestibular gland in the cat
- in the dog, the wall contains an accumulation of erectile tissue = vestibular bulb

Vagina:

- extends from the vestibule to a fornix at the level of the cervix
- displays longitudinal folds when not expanded

Uterus:

1. Cervix — short, thick muscular wall & narrow canal
2. Body — relatively short in carnivores
3. Uterine horns — paired, relatively long

Uterine tube: (Oviduct; “Fallopian tube”)

- exits laterally from uterine horn (extends cranially, arcs ventrally, runs caudally, hooks dorsomedially)
- terminates medial to ovary in a funnel-shaped infundibulum that has fimbriae (villi)

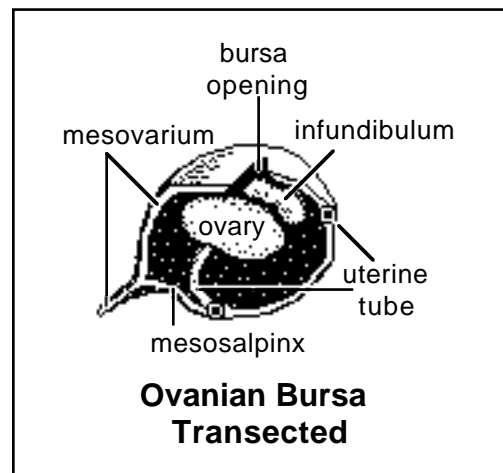
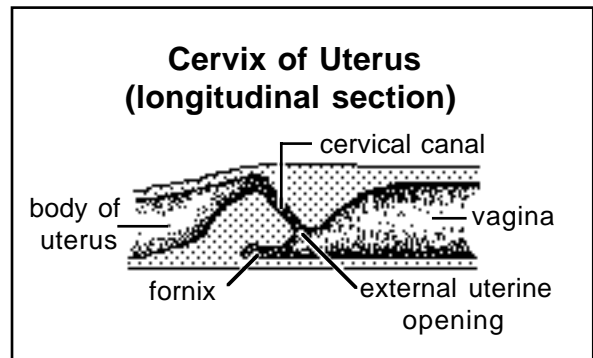
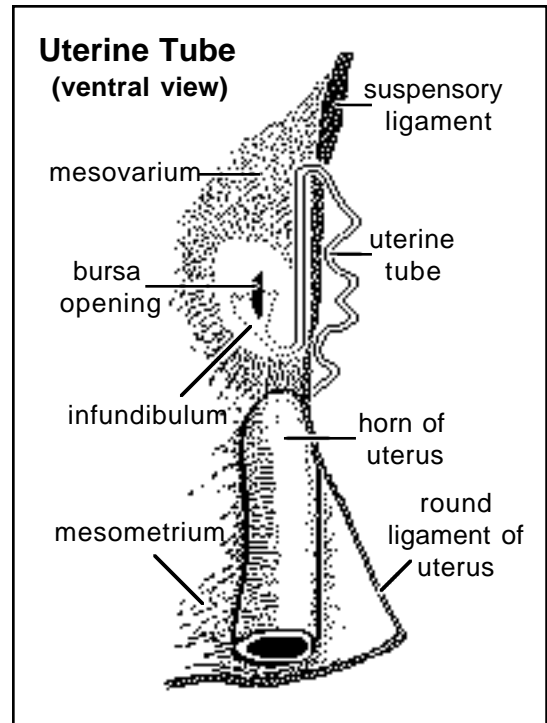
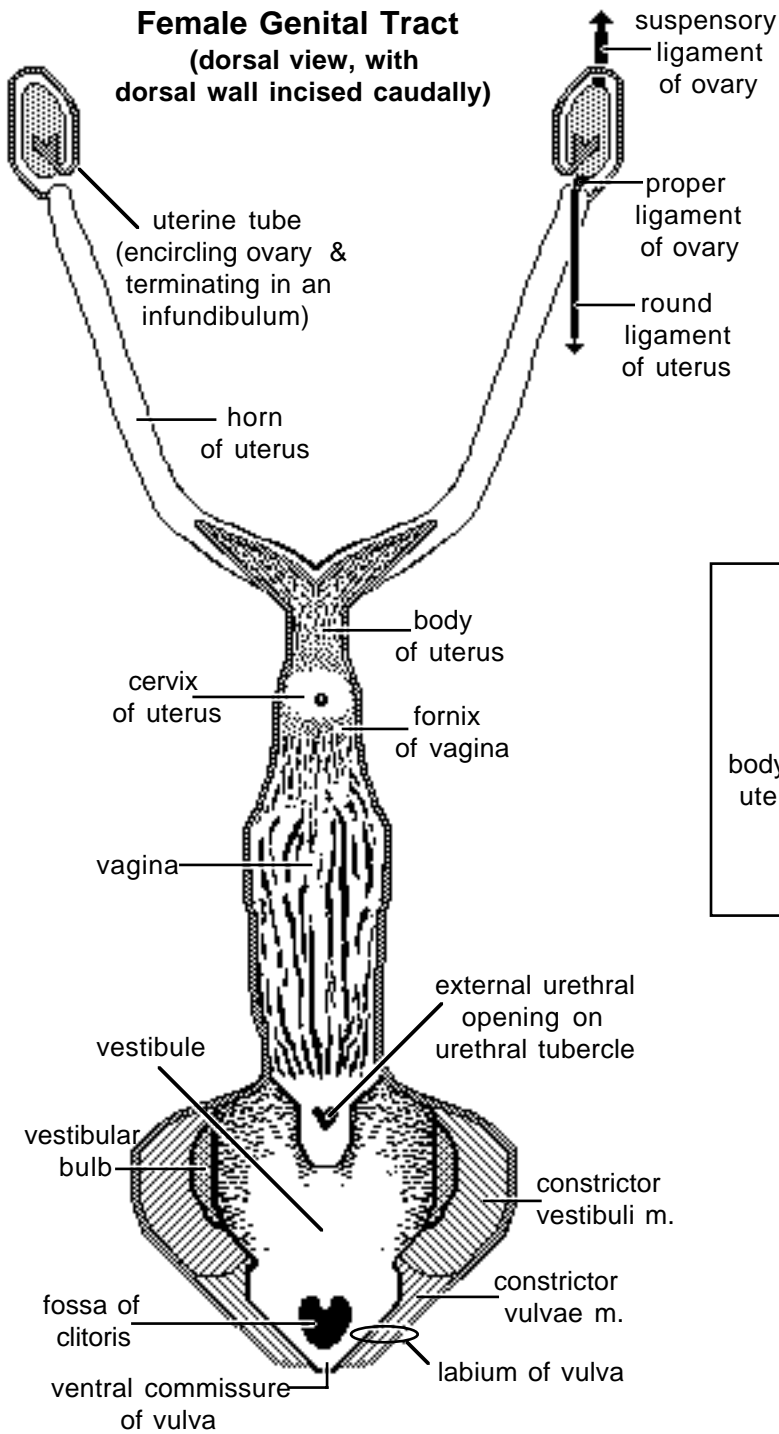
Ovary — source of ova & hormones (estrogen and during a pregnancy progesterone (CL))

Ligaments associated with the female genital tract:

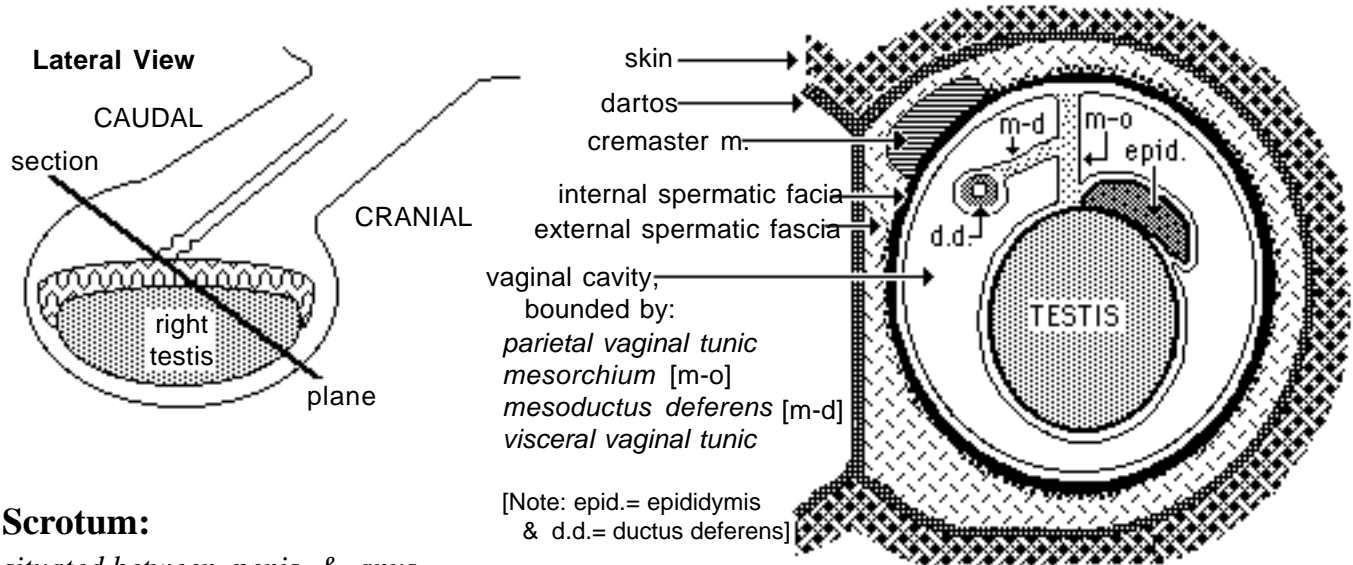
- 1) suspensory ligament of the ovary — extends from ovary to dorsal body wall
- 2) proper ligament of the ovary — extends between ovary & cranial end of uterine horn
- 3) round ligament of the uterus — extends from cranial end of uterine horn thru inguinal canal
- 4) broad ligament (lateral ligament of uterus), which has the following subdivisions:
 - a) mesometrium;
 - b) mesovarium;
 - c) mesosalpinx (forms ovarian bursa)

* The term vulva refers to female external genitalia. In human anatomy, the term vulva includes labia, clitoris & vestibule, which is appropriate in woman because the vestibule is compressed. In domestic mammals, the vestibule is elongated and the term vulva is typically restricted to just the labia.

Note: Women have major & minor labia, but domestic mammals have only one labium on each side.



Male Genitalia



Scrotum:

situated between penis & anus

cutaneous pouch; scrotal septum formed by dartos = “smooth cutaneous muscle”

spermatic fascia: internal = a fibrous membrane (fibrous tunic) bound to parietal vaginal tunic

external = areolar connective tissue within dartos

cremaster muscle— from internal abdominal oblique m.; attaches to internal spermatic fascia (not developed in the cat — where a levator scroti m. attaches to the scrotal septum)

Testis: *pl. = testes*

produces spermatozoa and testosterone;

coated by tunica albuginea (thick, white, c.t. capsule) & enveloped by visceral vaginal tunic

blood vessels are tortuous & highly branched for counter-current heat exchange;

histologically, seminiferous tubules connect to a rete testis which connects to efferent ductules

which converge at the cranial pole of the testis to form epididymis.

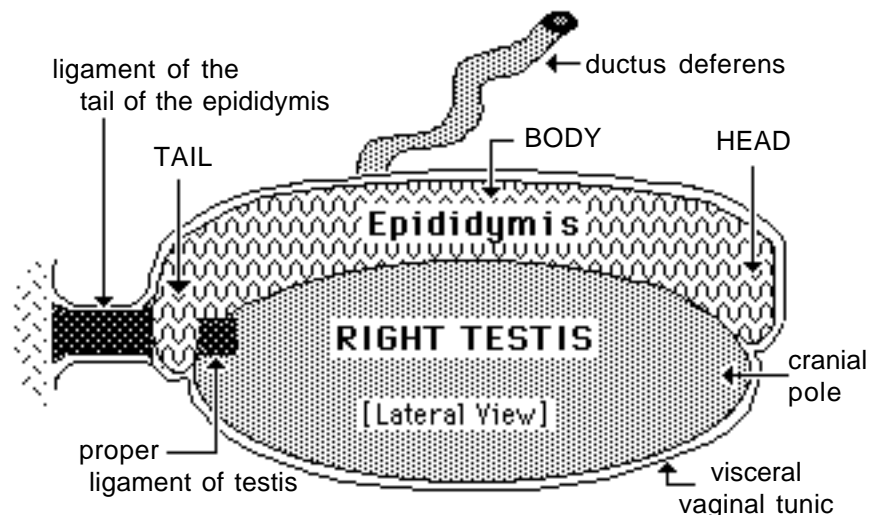
Epididymis:

spermatozoa storage & maturation occurs within the epididymis;

single coiled duct: head → body → tail → ductus deferens

proper ligament of the testis — homologous with proper ligament of ovary

ligament of the tail of epididymis — (embryonic gubernaculum) homologous with round ligament of uterus



Ductus Deferens: *pl. = ducti deferentes*

enveloped by visceral vaginal tunic connected to mesoductus deferens;
traverses inguinal canal, penetrates prostate, & empties into urethra at the colliculus seminalis;
terminal end of the ductus deferens features an ampulla (except in cat & pig) that has glands in its wall

Spermatic cord = ductus deferens + testicular vessels + vaginal tunics & spermatic fascia

Accessory Genital Glands: *contribute seminal fluid to the ejaculate*

prostate (body + disseminated components) — *all males*
bulbourethral glands (paired, at ischial arch) — *not dog*
(vesicular glands [seminal vesicles] — *neither dog nor cat*)
glands in wall of terminal segment of ductus deferens — *all males*

Penis:

three regions: *root* (contains bulb of penis & crus of penis), *body*, and *free part*
the penis is composed of: 1) penile urethra, 2) erectile tissue & 3) extrinsic muscles

Three bodies of erectile tissue:

corpus spongiosum penis: unpaired; surrounds urethra; begins as bulb of penis at root of penis

corpus cavernosum penis: paired; main erectile organ (fibroelastic tunica albuginea)

forms crus of penis at the root of the penis — attaches to ischial arch; covered by the ischiocavernosus m.; replaced by os penis within free portion (carnivores)

corpus spongiosum glandis or glans

dog : pars longa glandis & pars bulbus glandis (covers whole free portion)

cat : glans thin and distal [note: proximal skin has penile spines (cornified papillae)]

Extrinsic penile muscles:

bulbospongiosus m. (unpaired) — covers the bulb of the penis;

ischiocavernosus mm. (paired) — covers the crus of the penis;

ischiourethralis mm. (paired) — small, inserts on ring around dorsal vein of penis;

retractor penis mm. (paired but together at midline) — smooth muscle;

Prepuce:

cutaneous sheath which contains free part of penis (domestic mammals)

fascicles of cutaneous trunci m. encircling preputial orifice (*dog*) = (retractor) preputial m.

Process of Erection: *dog*

—parasympathetic effect — arterial vasodilation and venous constriction;

inflow to penis exceeds outflow and blood accumulates in penis;

pressure increases within fibroelastic capsules of erectile bodies;

—pressure mechanically compresses internal veins to further impede outflow;

—contraction of extrinsic penile mm. pumps blood in against the increasing pressure;

—ischiourethralis m. occludes dorsal vein of penis to expand pressure within glans;

—following intromission, the superficially located dorsal veins of penis, which drain the glans, are mechanically constricted. In the dog, the bulbus glandis expands following intromission and this explains “hung up” copulation.

Ejaculation:

- sympathetic pathway — contraction of ductus deferens, smooth m. in prostate & other glands, and internal urethral sphincter (to prevent reflux into bladder)
- also, contraction of urethralis m. & extrinsic penile mm. propels ejaculate along urethra.

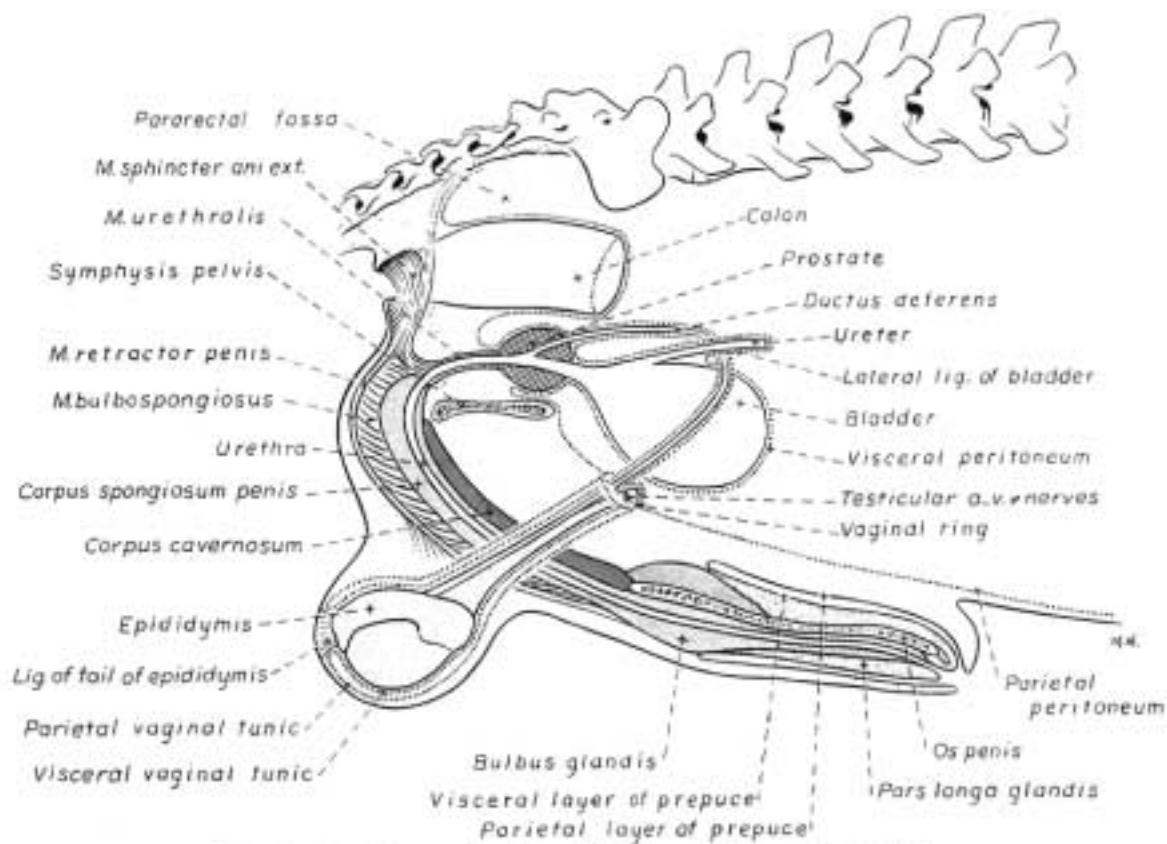
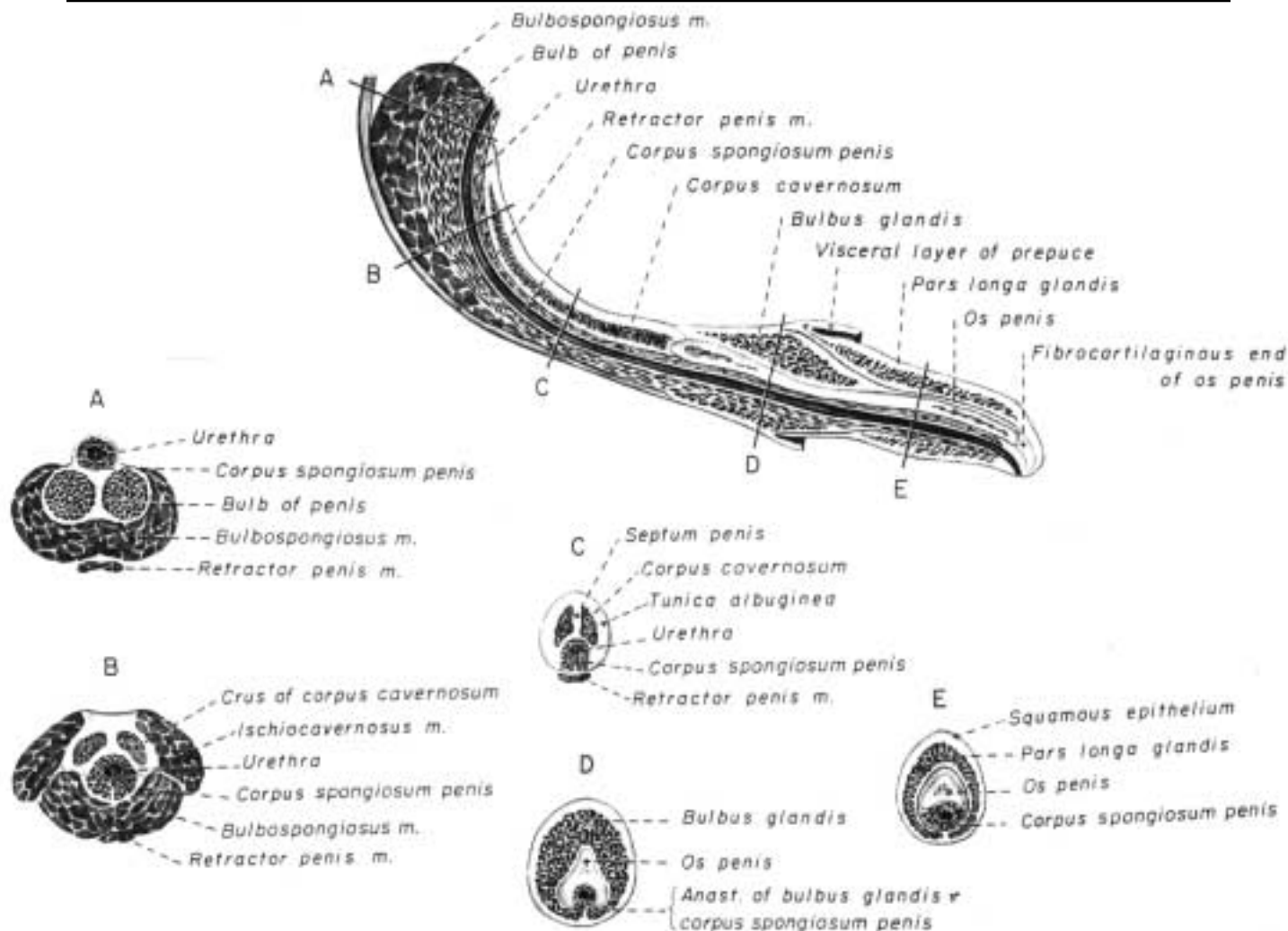


Figure 9-11. Diagram of peritoneal reflections and the male genitalia.



Head Features

Skull = bones of cranium (enclose cranial cavity) + bones of face (includes the mandible)

Notes: calvaria = roof of cranial cavity (intramembranous bones, e.g., frontal, parietal, etc.)

middle ear & inner ear are situated within the temporal bone (petrous part)

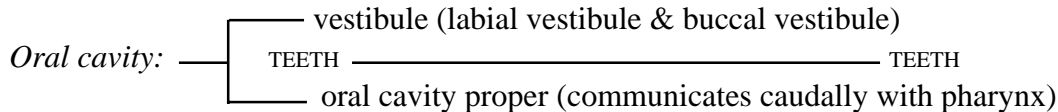
dorsal & ventral *conchae* subdivide nasal cavity, into dorsal, middle, ventral & common nasal meati

Joints: joints of the skull are fibrous for the most part; the calvaria has *suture* joints
mandibular symphysis = fibrocartilaginous joint uniting right & left mandibles
temporomandibular joint = a synovial that contains a meniscus
 also: atlanto-occipital synovial joint ("yes" motion)
 axio-atlantal synovial joint — features dens ("no" motion)

Paranasal sinuses = diverticula of nasal cavity lined by nasal mucosa
 (named for the bone that contains them; more prominent in herbivores)
frontal sinus (lateral, medial, & rostral compartments)
maxillary recess (sinus) — contains lateral nasal gland

Hyoid apparatus = chain of bones attached to the skull
 — provides muscle attachment sites for movement of the tongue & larynx
 — anchored by geniohyoideus m. (cranially) and sternohyoideus m. (caudally)

Mouth = oral cavity + accessory structures (tongue & teeth); the term *mouth* may also mean just oral cleft



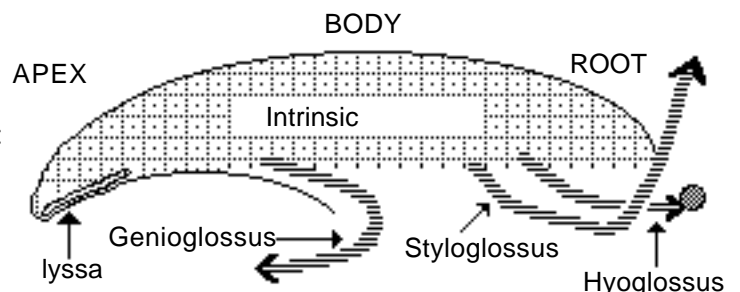
Teeth: *dental formula:* dog = (I3/3 C1/1 P4/4 M2/3) x 2 = 42;
 cat = (I3/3 C1/1 P3/2 M1/1) x 2 = 30
 incisors — adapted for grasping, pinching, scratching, nipping [3 vs. 2 in primates]
 canines — “weapons” for tearing flesh during hunting & fighting
 cheek teeth — for shearing [esp. upper P4 & lower M1]; grinding molars relatively reduced
 surfaces per tooth = vestibular/buccal, lingual, contact, & occlusal (masticatory)

Tongue = striated muscle; covered by mucosa, featuring papillae & taste buds
papillae :

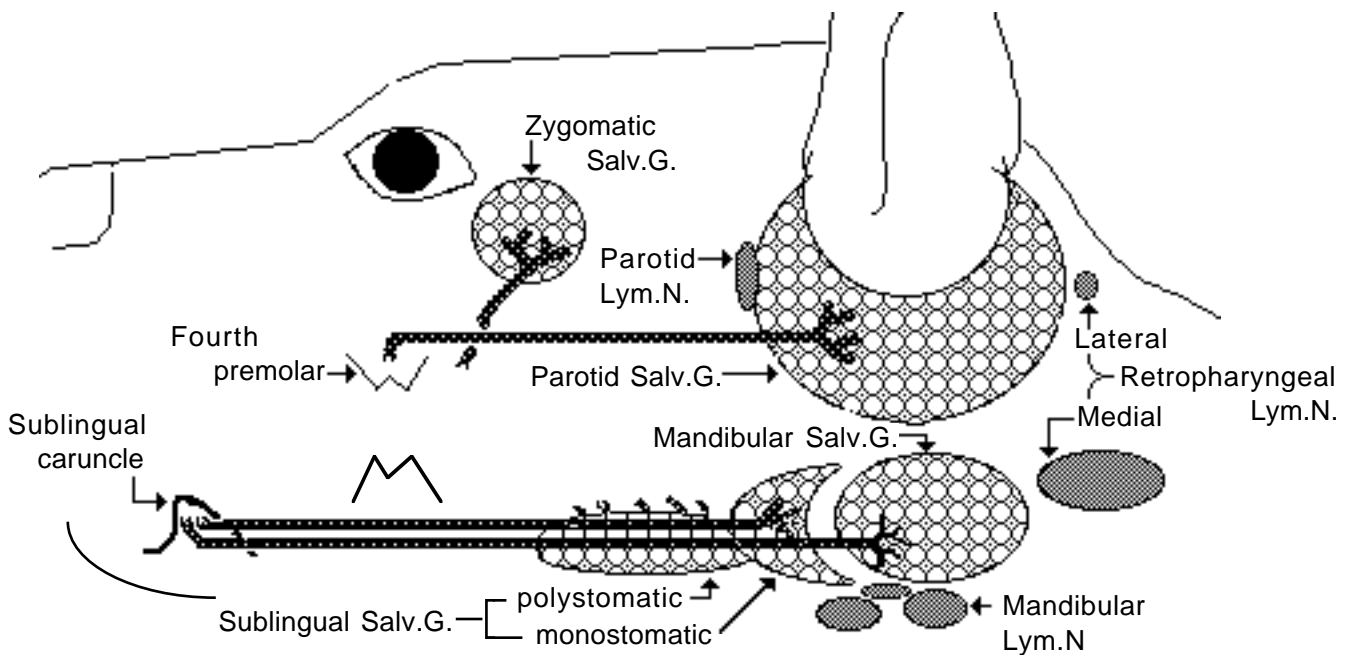
fungiform, vallate, & foliate — have taste buds
 filiform, conical, — are mechanical (cat tongue has spines)

tongue muscles :

intrinsic — forms tongue proper (curl, groove, bend, etc. the tongue)
 extrinsic — move tongue relative to bone:
genioglossus — protracts tongue
hyoglossus — retracts tongue
styloglossus — retracts tongue



lyssa = cylindrical fibrous tissue enveloping fat & muscle (located ventrally at apex in carnivores).



Salivary Glands:

saliva moistens food to facilitate swallowing & contains amylase to disassemble starch;
secretion is regulated by the autonomic nervous system (parasympathetic & sympathetic)

glands :

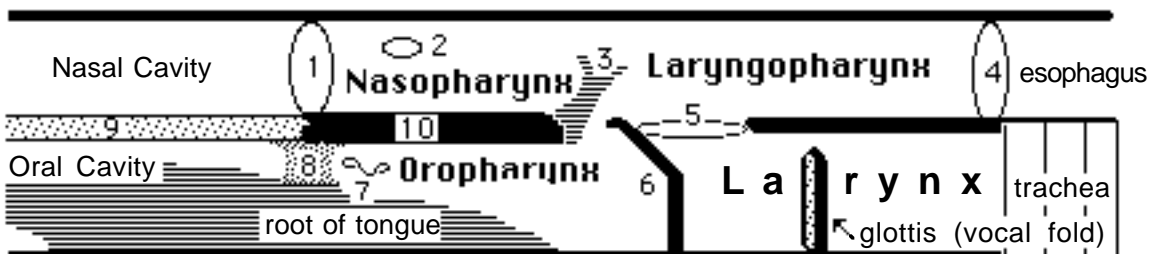
- 1) parotid — duct goes to upper buccal vestibule (beside upper 4th premolar)
- 2) zygomatic [carnivores] — ducts go to upper buccal vestibule (beside last upper tooth)
- 3) mandibular — duct goes to sublingual caruncle
- 4) sublingual: a) monostomatic gland — duct goes to sublingual caruncle
b) polystomatic gland — multiple ducts into oral cavity proper
- 5) buccal — prominent in the cat, caudal to last lower molar
- 6) diffuse glandular tissue in cheeks, lips, tongue, & soft palate

Pharynx = common digestive-respiratory chamber (the wall of the pharynx is striated muscle)
Subdivided into 3 compartments (nasopharynx; oropharynx; & laryngopharynx);

Note: Crossing of the air & ingesta pathways is potentially dangerous; strong physiological reflexes are required to overcome the “poor” anatomical design.

Swallowing: (deglutition) 2 stages

- 1) voluntary initiation — tongue acts as plunger to force bolus into oropharynx
- 2) mechanical-reflex completion — bolus displaces soft palate; stimulates reflexes:
 - palatopharyngeal arch shortens & closes access to nasopharynx;
 - larynx is pulled forward allowing epiglottis to close laryngeal opening;
 - pharyngeal wall contracts to accelerate bolus into a relaxed esophagus.



- 1 = choane; 2 = auditory tube; 3 = palatopharyngeal arch; 4 = esophageal opening;
5 = laryngeal opening; 6 = epiglottis; 7 = palatine tonsil; 8 = palatoglossal fold;
9 = hard plate; 10 = soft palate.

Regurgitation (vomition) and *eructation* (belching):

- increased intra-abdominal pressure & stomach contraction;
- chest expansion with closed glottis;
- esophageal reverse peristalsis & reflex laryngeal closure (regurgitation).

Esophagus:

extends from pharynx (pharyngoesophageal ridge) to stomach entirely striated in dog; only cranial 2/3's striated in cat

Larynx:

composed of: paired mobile cartilages [right & left *arytenoid*] & three wall cartilages [*epiglottis*, *thyroid*, & *cricoid*]

intrinsic and extrinsic skeletal muscles are innervated by vagus n. (vagus is sensory as well) glottis = vocal folds & the intervening cleft (closes to seal the opening into the trachea)

Note: the dog has a true vocal fold (a laryngeal ventricle); the cat has only a vocal ridge

Lymphatics:

A) Lymph nodes — mandibular (several); parotid; medial & lateral retropharyngeal.

Nodes & tonsils drain into the medial retropharyngeal lymph node which is drained by a tracheal (jugular) lymph duct (which terminates in the brachiocephalic vein).

B) Tonsils — lymphatic tissue in mucosa; tonsils lack afferent lymphatics

palatine tonsil — compact, within fossa in the wall of the oropharynx (tonsillectomy)

lingual tonsil — diffuse, in root of tongue

pharyngeal tonsil — diffuse, in dorsal wall of pharynx

tonsil of soft palate — diffuse, in soft palate

Major Skeletal Muscle Groups:

1] mm. of mastication — operate temporomandibular joint (MANDIBULAR N. FROM TRIGEMINAL N.)

• close jaw: temporal m.; masseter m.; medial & lateral pterygoid mm.

• open jaw: digastricus m. (also gravity)

2] mm. of facial expression — move nose, lips, eyelids, ears, skin (FACIAL N.)

3] mm. of pharynx, larynx & esophagus (VAGUS & GLOSSOPHARYNGEAL NN.)

4] tongue mm. — intrinsic & extrinsic (HYPOGLOSSAL N.)

5] extrinsic eye mm. — seven muscles:

OCULOMOTOR N.

dorsal rectus m.

medial rectus m.

ventral rectus m.

ventral oblique m.

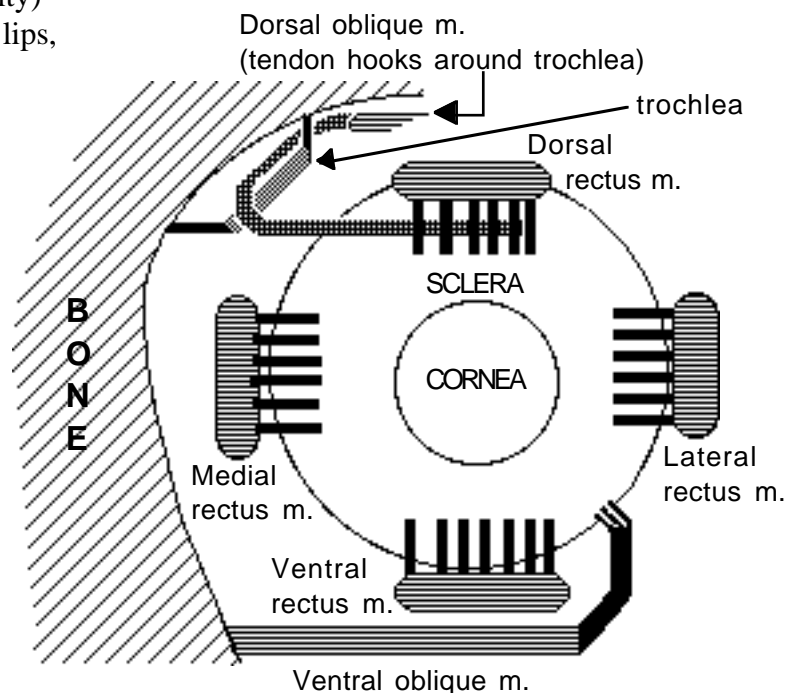
TROCHLEAR N.

dorsal oblique m

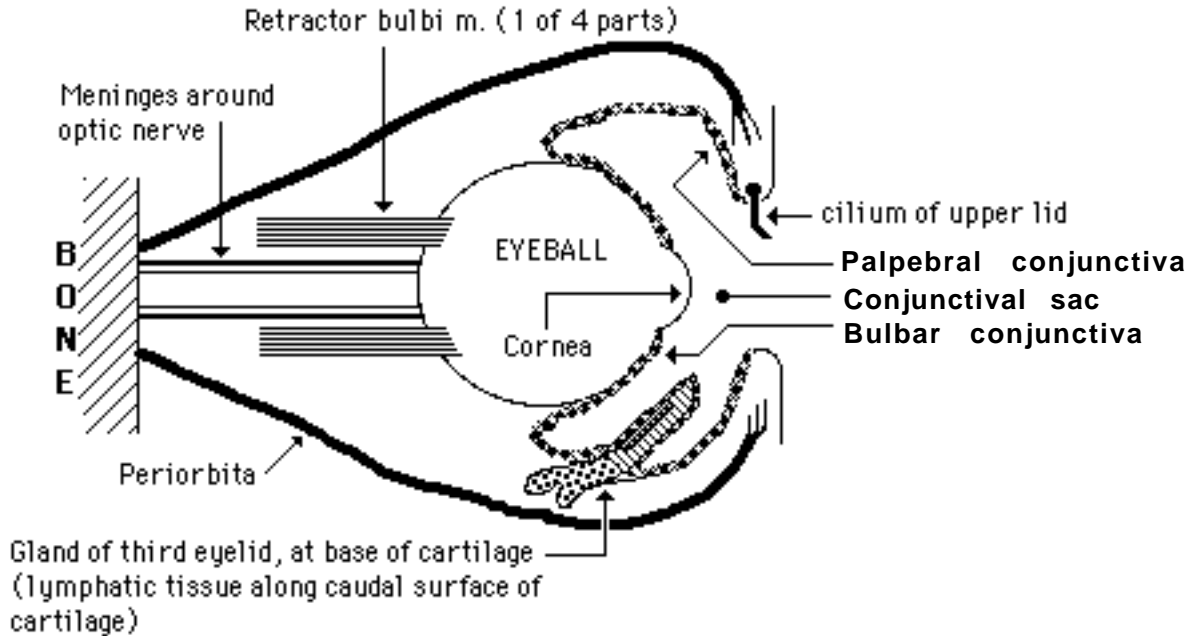
ABDUCENT N.

lateral rectus m.

retractor bulbi m.



Conjunctival sac: lined by palpebral & bulbar conjunctiva (mucosa of eyelids & sclera, respectively)

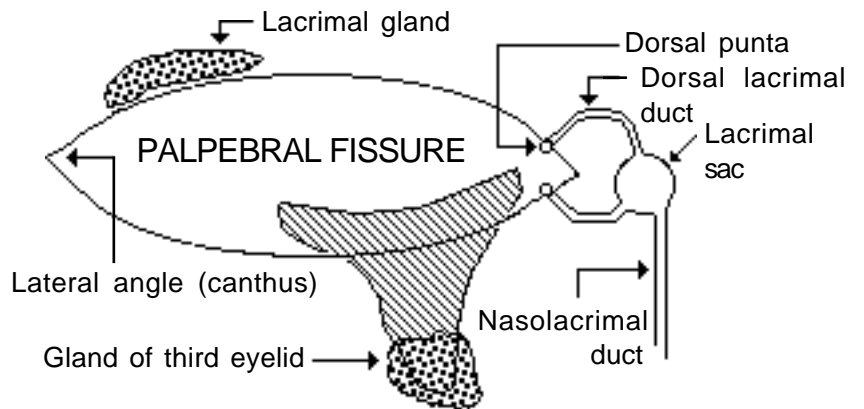


Note: Officially the third eyelid is called the *semilunar conjunctival fold*; it is also called *nictitating membrane*

Lacrimal Apparatus:

tear production: lacrimal gland, gland of 3rd eyelid, & diffuse gland tissue.

tear drainage: lacrimal puncta
to
lacrimal ducts
to
lacrimal sac
to
nasolacrimal duct
(ends at nose)



Arterial considerations:

Common carotid a. divides into
internal carotid a. — traverses the middle ear to supply the brain via an arterial circle, and
external carotid a. — supplies the rest of the head

In the cat, the extra-cranial internal carotid a. atrophies & the ascending pharyngeal a. supplies brain.

Carotid sinus = enlargement at the origin of the internal carotid a. (occipital a. in cat) that contains baroreceptors which reflexly regulate blood pressure (glossopharyngeal nerve).

Carotid body = chemoreceptors within arterial wall in the vicinity of the carotid sinus.

Note: The brain also receives blood from the vertebral a., which supplies spinal branches to the cervical spinal cord. (The vertebral artery gives rise to a basilar a. that supplies the brainstem and then joins the arterial circle fed by the internal carotid a.)

Cranial Nerves

Cranial Nerves...

- 12 pair;
- emerge from the brain;
- exit through foramina in floor of cranial cavity.

In contrast to spinal nerves:

- individual cranial nerves differ in their fiber type composition
- regional overlap—multiple nerves innervate the same region or structure
- some cranial nerves lack a sensory ganglion
- cranial nerves have single roots

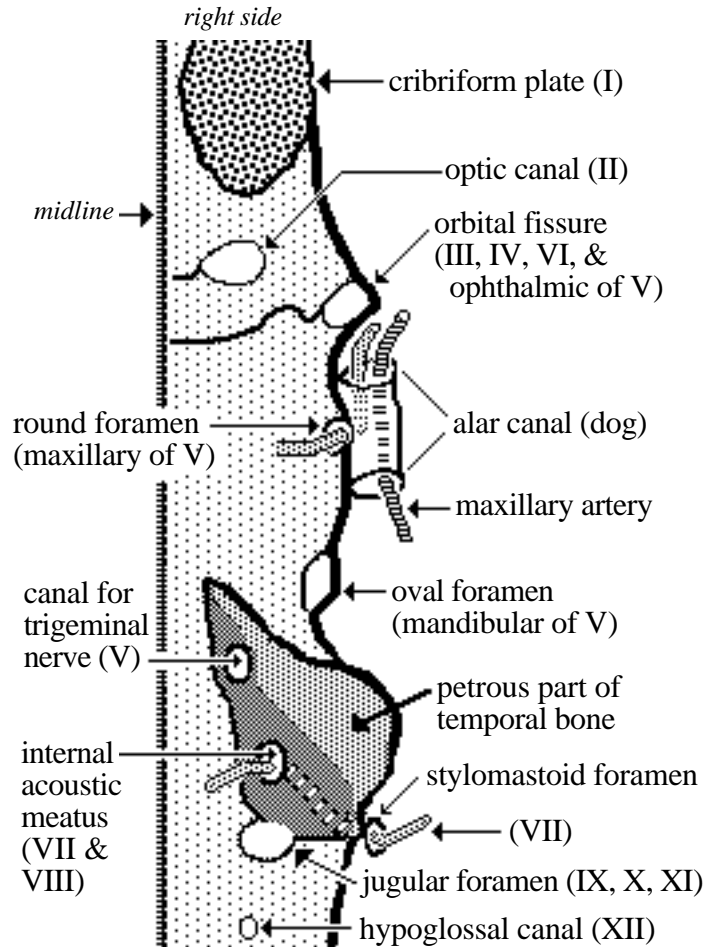
Cranial nerves collectively have two additional (special) fiber types:

Special Somatic Afferent — vision & hearing
 Special Visceral Afferent — olfaction & taste

in addition to:

General Somatic Afferent — face, mouth
 General Visceral Afferent — pharynx, larynx
 Somatic Efferent — skeletal mm.
 Visceral Efferent — parasympathetic

NOTE: Formerly, an additional fiber type was recognized; viz., Special visceral efferent (SVE) innervating skeletal m. derived from pharyngeal (branchial) arches. Thus, the current VE & SE types used to be designated "General Visceral Efferent" (GVE) and "General Somatic Efferent" (GSE).



"Twelve" cranial nerves:

Vomer nasal organ

"O" = Vomer nasal Nn.— Selective smell (pheromone detection) [cribriform plate]
 (SVA) nerve fibers from the vomer nasal organ traverse the nasal cavity and penetrate the cribriform plate to synapse in the accessory olfactory bulb. The vomer nasal organ detects pheromones (odors that elicit sexual behavior). The flehmen reaction (curled upper lip) is associated with vomer nasal organ activity.

I = Olfactory Nn. — Smell [cribriform plate]
 (SVA) neuron cell bodies located within olfactory epithelium on the ethmoidal labyrinth.

II = Optic N. — Vision [optic foramen]
 (SSA) cell bodies are in the retina (actually the "nerve" is a CNS tract enveloped by meninges)

III = Oculomotor N. — Eye movement & pupil constriction [orbital fissure]
 (SE) innervates 4 extrinsic eye mm.: dorsal, medial, & ventral rectus; ventral oblique
 (it also innervates the levator palpebrae superioris m.)
 (VE) intrinsic eye mm.: ciliary body {accommodation} & iris {constrict pupil}
 [postganglionic neurons are in the ciliary ganglion within orbit]

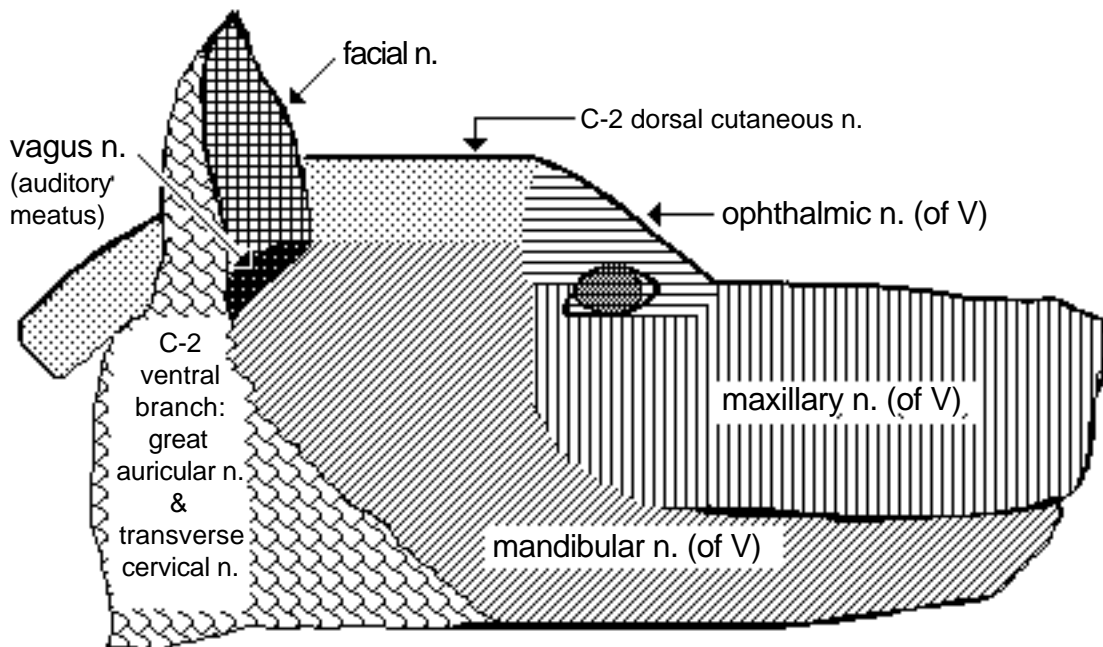
IV = Trochlear N. — *smallest, exits dorsally, decussates* [orbital fissure]
 (SE) Dorsal oblique m.

VI = Abducent N. — Lateral gaze & 3rd eyelid protrusion [orbital fissure]
 (SE) lateral rectus m. & retractor bulbi m.

V = Trigeminal N. — Sensory to face (GSA); Mm. of mastication (SE) [old SVE to branchial arch I]

Three Divisions :

ophthalmic n.:	orbit; cornea; eyelids; & skin medial to eye	[orbital fissure]
maxillary n.:	both lids laterally; upper jaw, teeth, lips; nose & nasal cavity	[round f. & alar canal]
mandibular n.:	lower jaw, teeth, tongue; temporal region skin; <i>also</i> , innervates muscles of mastication	[oval foramen]
	[plus mylohyoid & tensor tympani mm.]	



VII = Facial N. — Facial expression; taste; secretions (saliva, lacrimal, & nasal) [int. acoustic meatus—>stylomastoid f.]
 (SE) mm. of facial expression (ears, eye lids, nose, & lips) [old SVE to branchial arch II]
 (*also*, stapedius m. & caudal belly of the digastricus m.)
 (VE) nasal glands, lacrimal gland, & the two ventral salivary glands (sublingual & mandibular)
 [postganglionic neurons are in the pterygopalatine & submandibular ganglia]
 (SVA) taste buds of rostral two-thirds of tongue
 via chorda tympani n.(from middle ear) joining the lingual branch of the mandibular n.
 (GSA) rostral (concave) surface of pinna

VIII = Vestibulocochlear N. — Hearing; Head acceleration (SSA) [internal acoustic meatus]

Within petrous part of temporal bone::

hearing: axons from bipolar cell bodies in spiral ganglion of the cochlea

acceleration: bipolar cell bodies in vestibular ganglion, associated with the vestibular apparatus

IX = Glossopharyngeal N. — Taste; Pharyngeal sensation; Saliva [jugular foramen]

(GVA) receptors in pharynx, middle ear, and carotid sinus & carotid body

(SVA) taste buds at caudal 1/3rd of tongue

(VE) parotid & zygomatic salivary glands

[postganglionic neurons are in the otic ganglion]

(SE) one m. of pharynx [old SVE to branchial arch III]

X = Vagus N. — [jugular foramen]

(SE) mm. of larynx, pharynx & esophagus (voice; cough; swallow; regurgitate)

[old SVE to branchial arches IV, V, & VI]

(VE) thoracic & abdominal viscera — postganglionic neurons are in terminal ganglion

(GVA) receptors in viscera and in the larynx, also pharynx

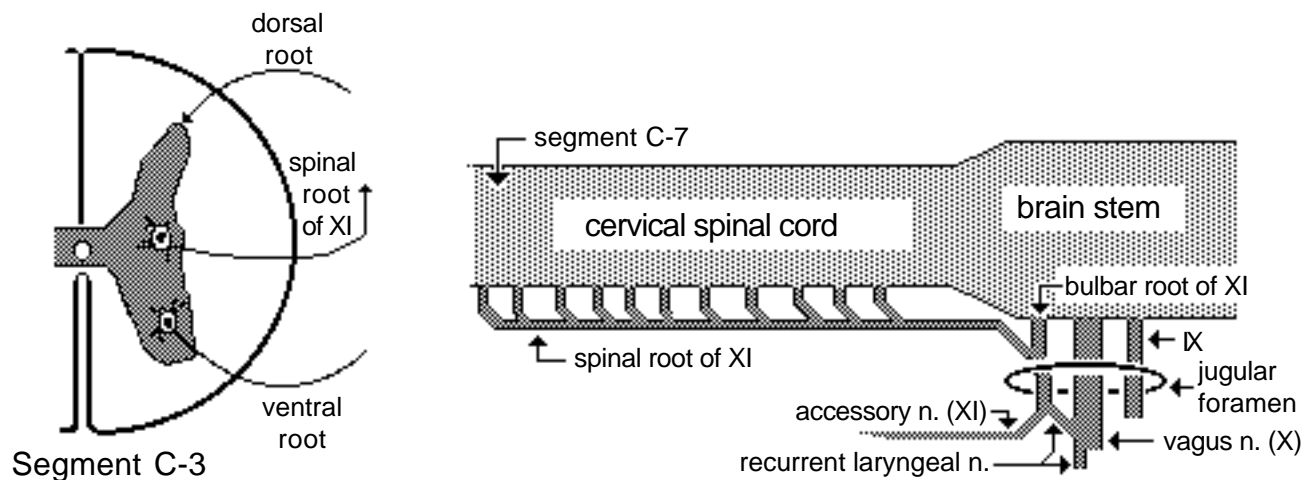
(SVA) taste in region of pharynx

(GSA) skin of external auditory meatus via branch to facial n.

XI = Accessory N. — Neck mm. [jugular foramen]

(SE) Four mm.: [cleidocervicalis; cleidomastoideus; omotransversarius; trapezius]

[old SVE to branchial arches IV, V, & VI]



XII = Hypoglossal N. — Tongue mm. [hypoglossal foramen]

(SE) styloglossus, hyoglossus, genioglossus & intrinsic musculature)

[also contributes to innervation of sternohyoid & sternothyroid mm.]

Distributions of Selected Nerve Branches to Head

