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CVM 6100
Veterinary Gross Anatomy

General Anatomy & Carnivore Anatomy Lecture Notes

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CONTENTS

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
- compartmentalize skeletal muscles & gives rise to aponeuroses
- forms several named structures, *viz.,*

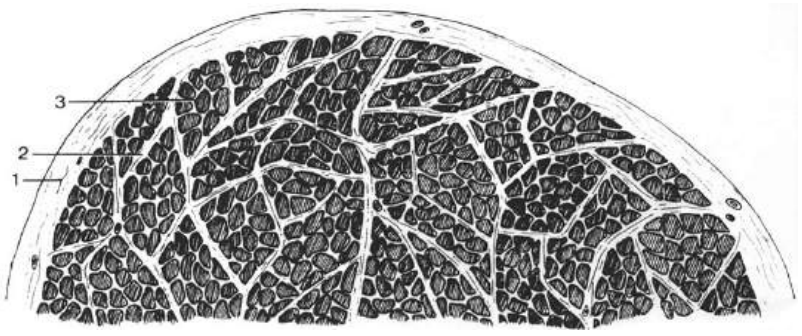
  • named regional fascia, e.g., thoraco-lumbar fascia, fascia lata, etc. (fascia is named where it is thick & distinct (i.e., dense c.t. vs. loose areolar c.t.)

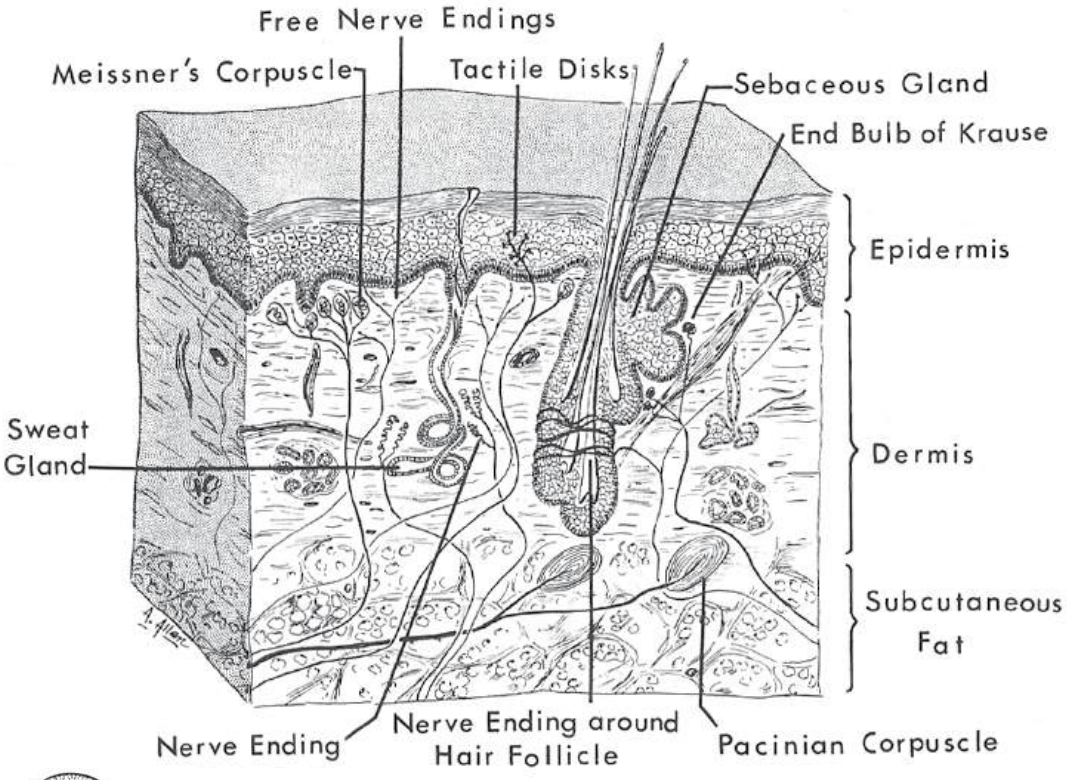
  • retinaculum [L. rope or cable] fascia that binds passing tendons to the surface of the carpus or tarsus (also, transverse humeral retinaculum)

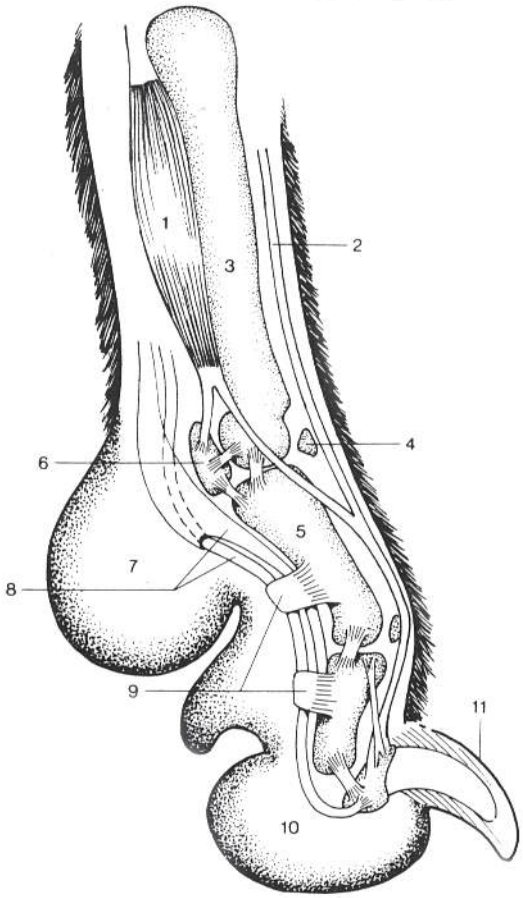
  • raphe [G. seam] fascia that joins right and left counterparts of a particular muscle at the midline (e.g., ventral abdomen = linea alba)

  • 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)

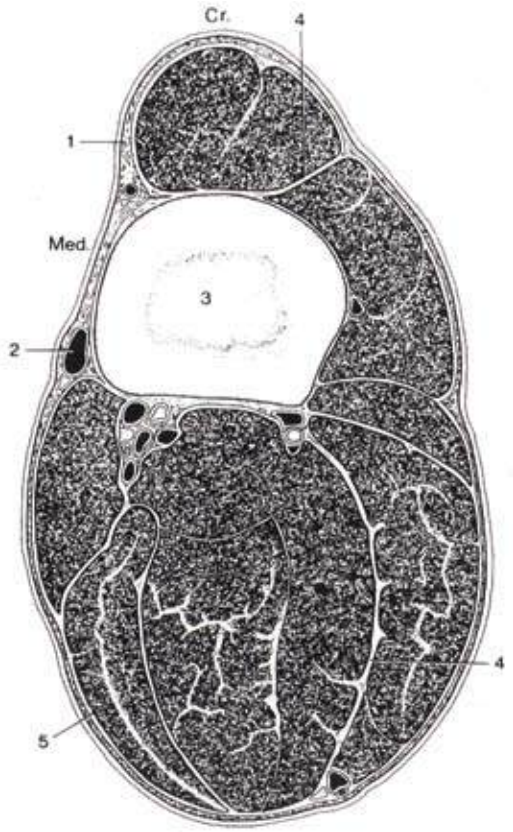
Transverse section through a skeletal muscle:
1 = epimysium;
2 = perimysium;
3 = endomysium







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

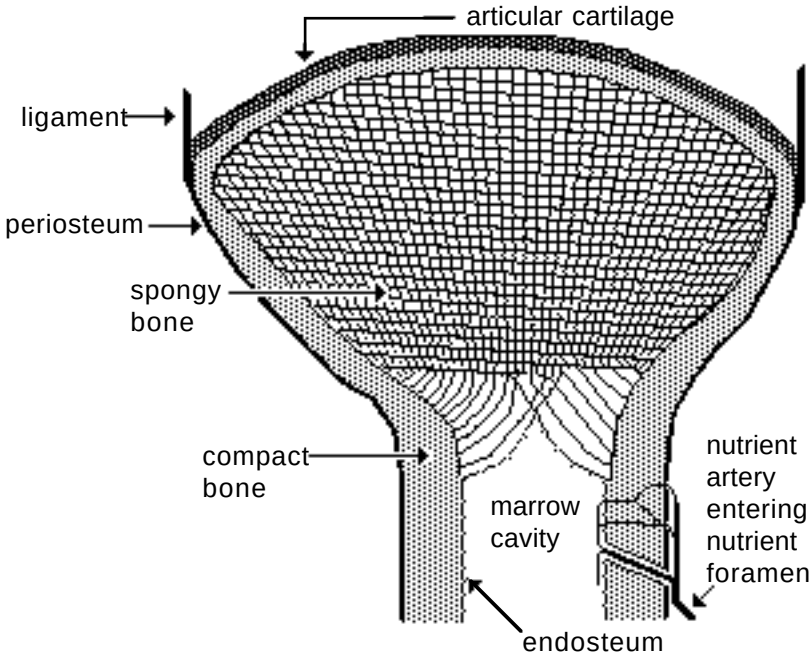
Bone Composition

Collagen fibers
by weight: 1/3 of bone
by volume: 1/2 of bone

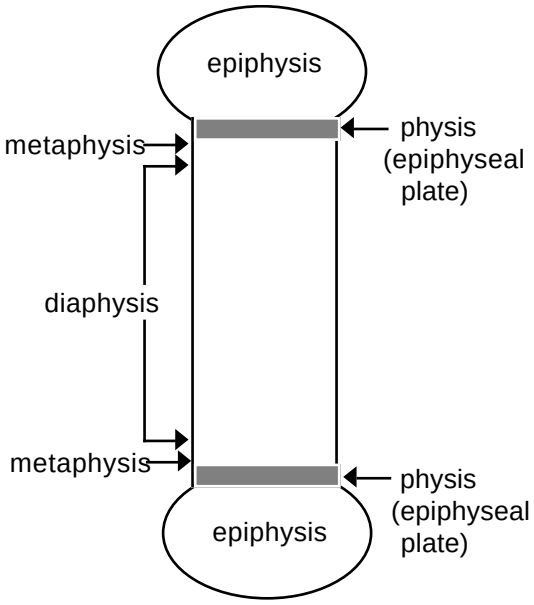
Hydroxyapatite crystals
(Ca)10(PO4)6(OH)2

95% solid (vs. water)
65% mineral; 35% organic

Structure of a Long Bone



Regions of a Long Bone



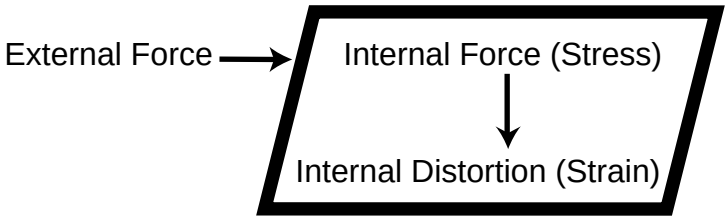
Mechanical Considerations

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

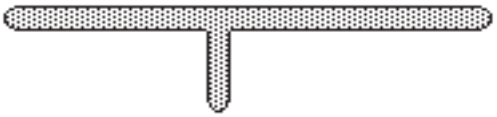


General Principle:

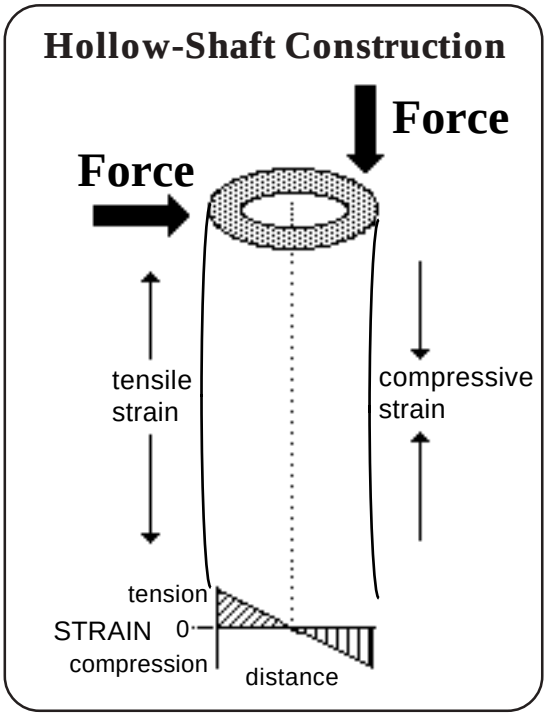
Bones are designed to provide adequate strength with minimal material (minimal mass or weight).

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

Flat Scapula Reinforced
(transverse section)

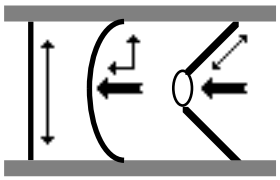


Scapula strengthened with only a spine

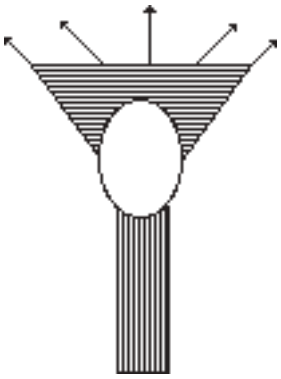


Sesamoid bone — Patella

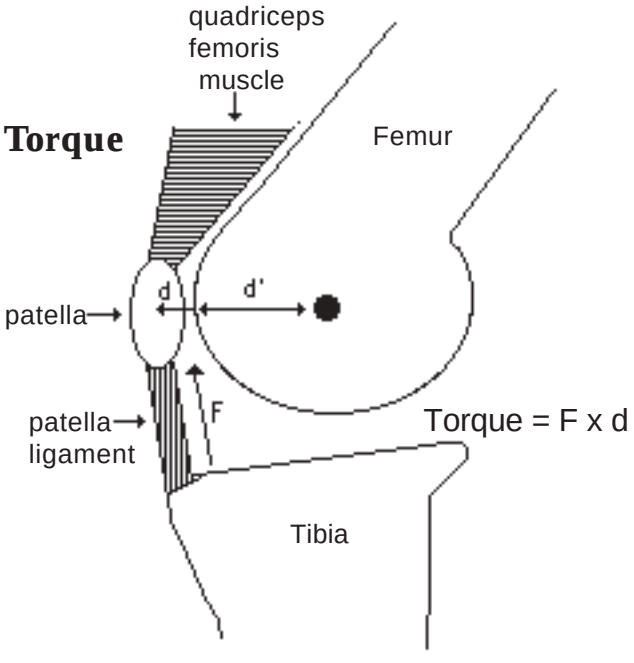
1] Eliminates tendon shear



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)]

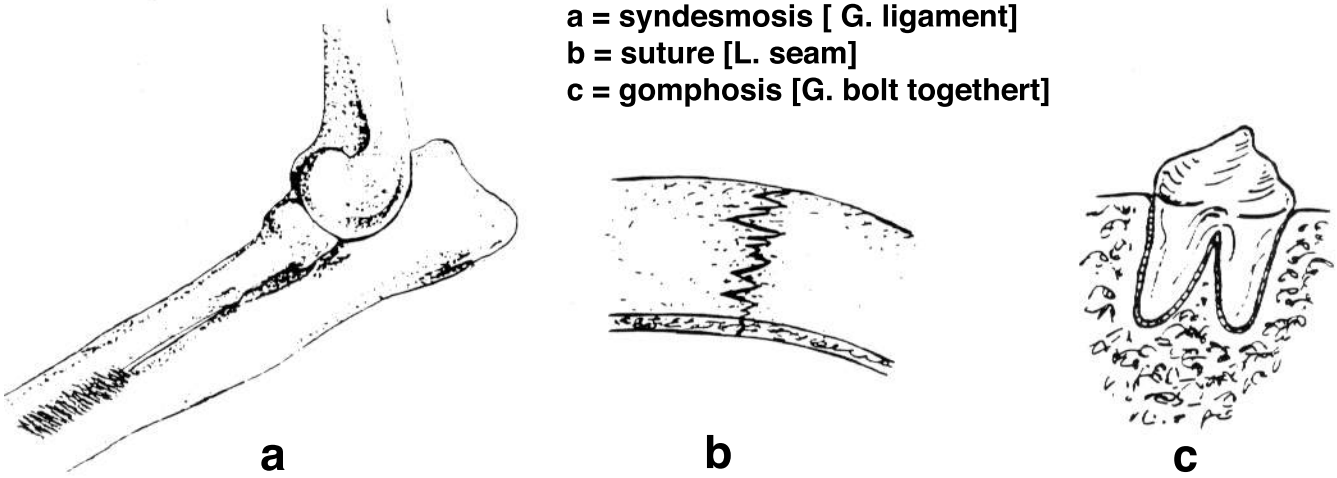
Joint features...
- articular (hyaline) cartilage covers the opposing surfaces of the bones
- synovial membrane lines a synovial cavity that separates the bones
  — the membrane secretes synovial fluid into the cavity
- fibrous (collagenous tissue) layer located external to synovial membrane
  — mechanically 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

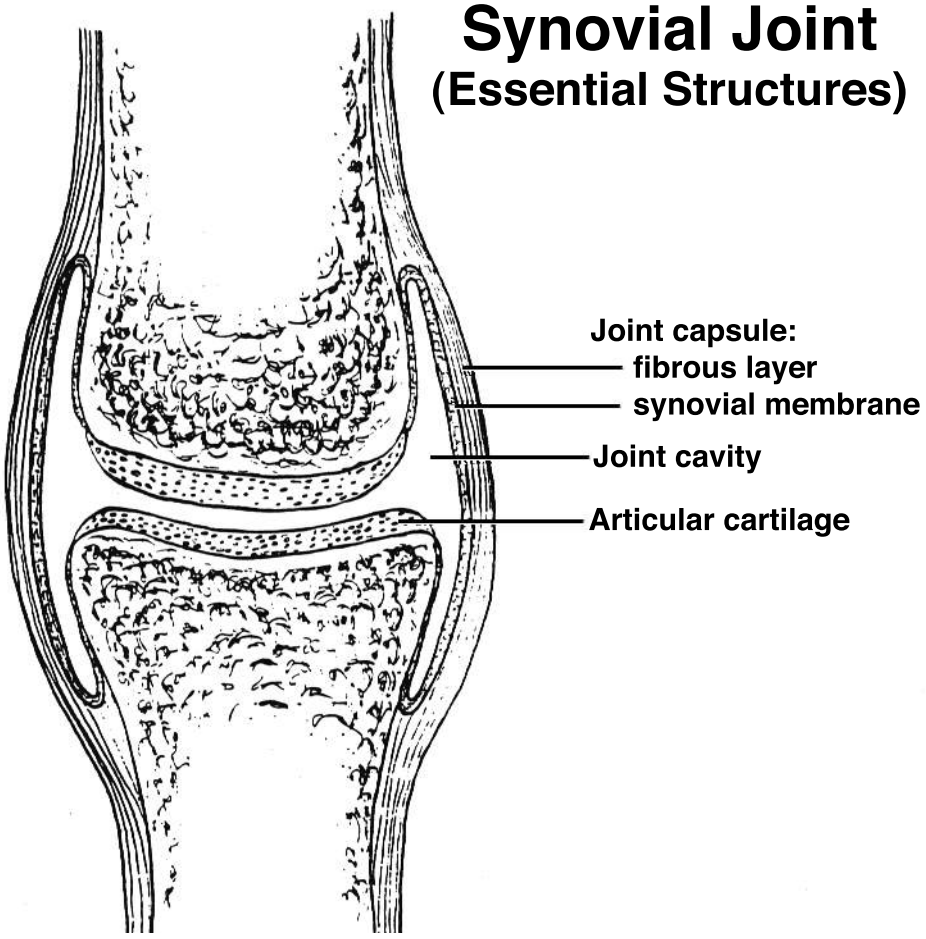
Types of Fibrous Joints

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



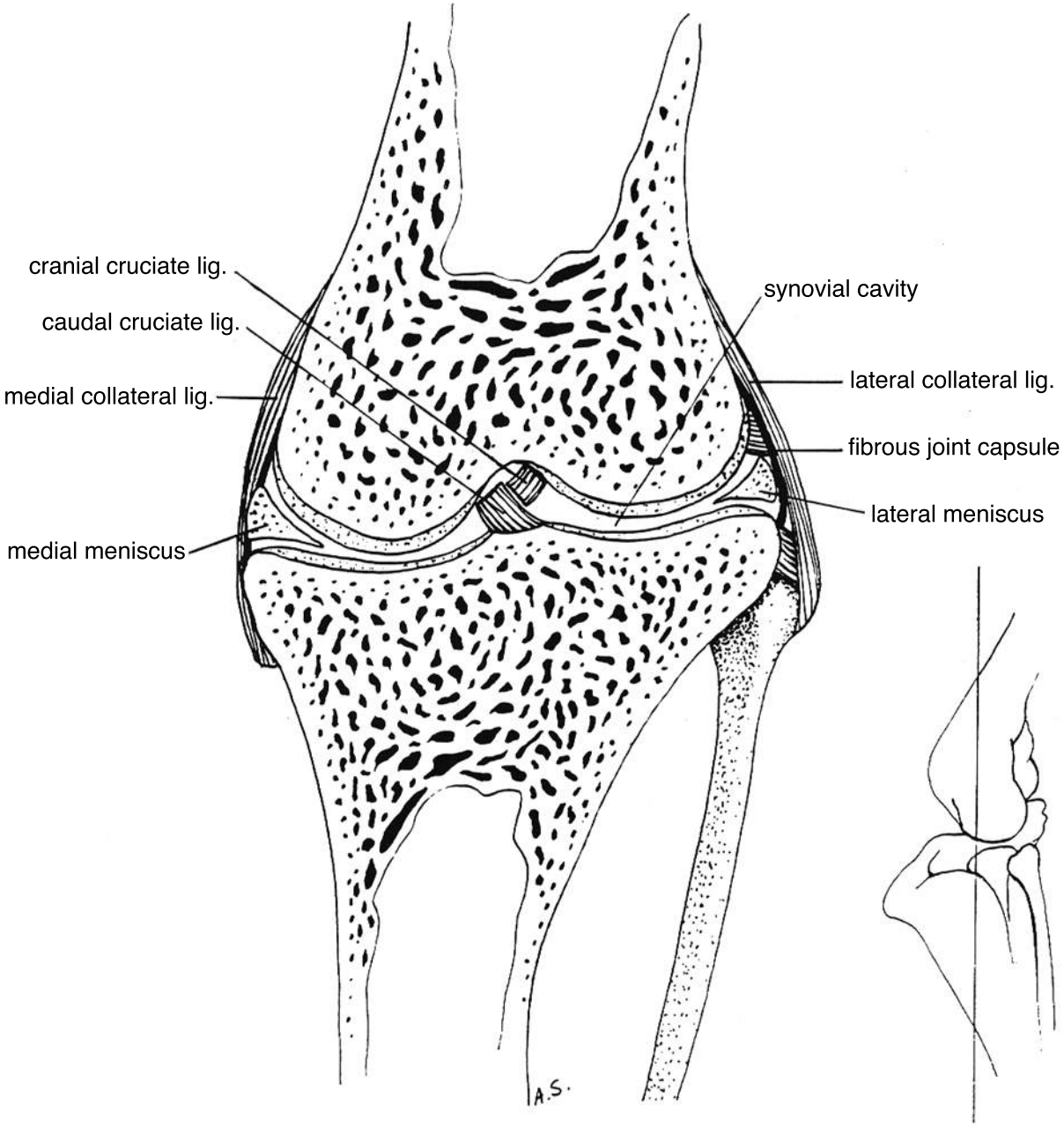
a b c

Synovial Joint
(Essential Structures)



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 various 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)

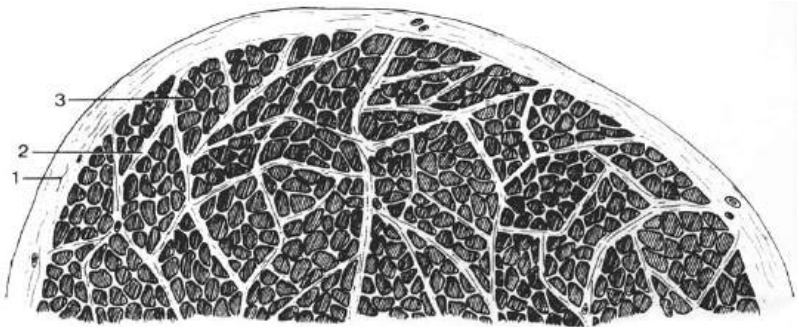
Note: Skeletal muscle will not contract in the absence of a functional nerve supply (denervation atropy occurs). One neuron innervates a variable number of muscle fibers. The neuron plus the muscle fibers it innervates constitute a **motor unit.** To produce a stronger contraction, the nervous system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

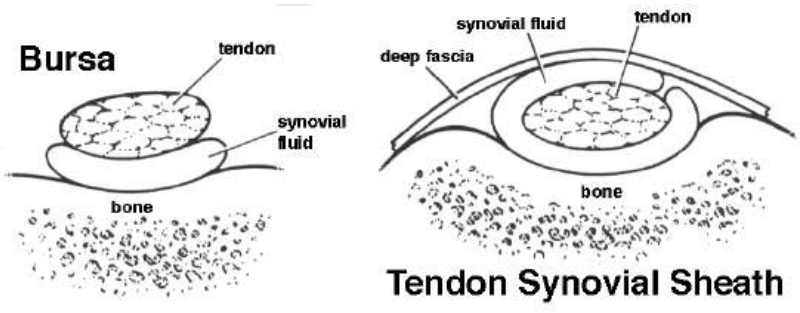
Muscle associated fascia:

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). Muscle are named (originally in the human) for their shape (deltoideus) or location (brachialis) or attachments (sternohyoideus) 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:

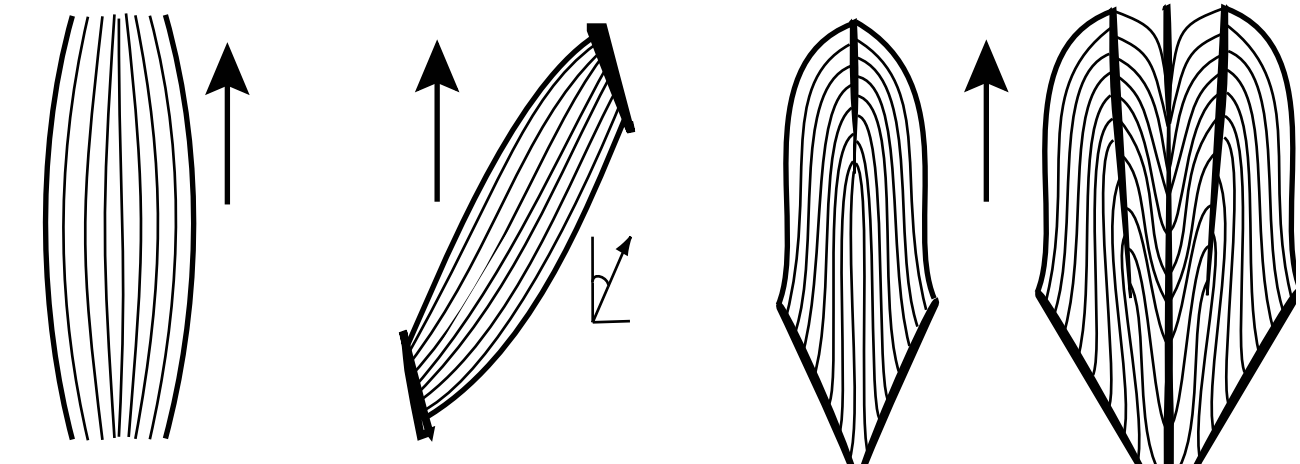
Parallel arrangement, e.g., strap or spindle arrangement, fibers/fascicles arranged parallel to the tendon of insertion. This results in a greater range of shortening and thus yields greater movement velocity (distance per time).

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.



Muscle & Body Biomechanics

Muscle Dynamics

MUSCLE FIBER ARRANGEMENT

EFFECT ON STRENGTH

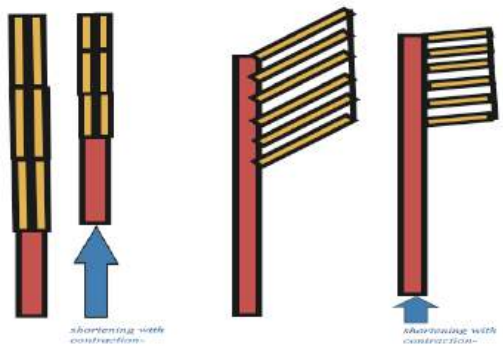
The amount of force that a muscle can generate is proportional to the cross-sectional area of muscle fibers (a.k.a. muscle cells) attaching to its tendon, i.e., the number of contractile proteins (actin and myosin) pulling on the tendon and contributing to muscle force.

- pennation design increases the number of muscle fibers (cross sectional area) attached to the tendon
- since force is a function of cross sectional area - a pennated muscle can generate more force than a comparable muscle with parallel fibers.

EFFECT ON SHORTENING

In this example, again consider two muscles - one with parallel fibers the other pennate

Assume each muscle fiber will contract to 50% of its resting length
Therefore:
- with parallel-arranged muscle fibers the entire muscle can contract by 50%
- with the pennate arrangement each individual muscle fiber is pulling at an angle, resulting in reduced overall shortening of the entire muscle belly.



Animals are subject to the same physical laws as inanimate objects.
An understanding of movement (e.g. motion of the joints and body) comes through an understanding of the forces acting upon the joint or the body that result in that movement. Forces can be simplified into **linear** and **rotational** components

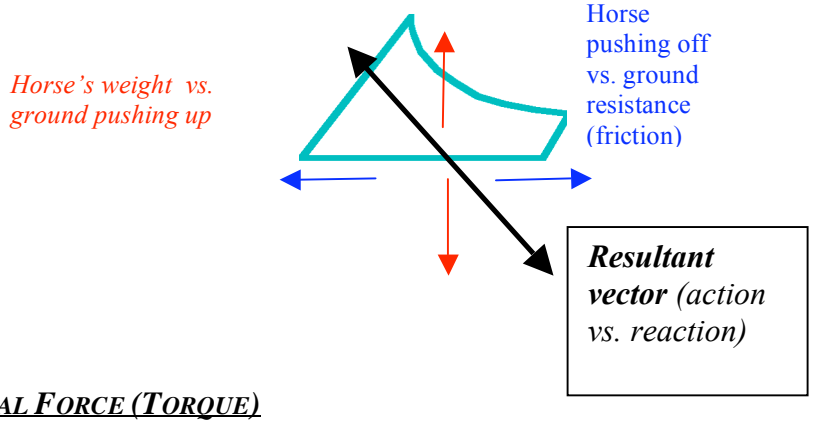
DEFINITIONS:

LINEAR FORCE:

Force can be broken down into various vectors.

- ∞ *Vertical vectors* (e.g. the downward forces due to body weight and the upward forces of the supporting surface)
- ∞ *Horizontal vectors* (e.g. forces exerted to propel forward and backward forces to brake forward motion)

With adequate force and friction (traction) the body can propel itself forward. (practical application dictates a need for good traction to allow this forward motion – whoa to those leading a horse on ice)



ROTATIONAL FORCE (TORQUE)

Rotational force = force (F) x distance from fulcrum (d)
Limb rotation = muscle force (F) x distance from joint (d)
Torque input (muscle generated) = torque output (limb movement)

Muscles generate forces which when applied to the skeleton will generate rotation about a joint.

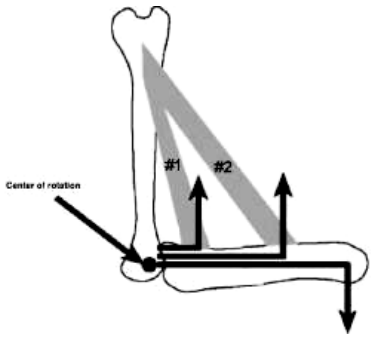
MUSCLE ATTACHMENT EFFECTS

The location of the muscle attachment (e.g. distance from joint) **influences the resultant movement of that joint**

MECHANICAL ADVANTAGE VERSUS VELOCITY ADVANTAGE

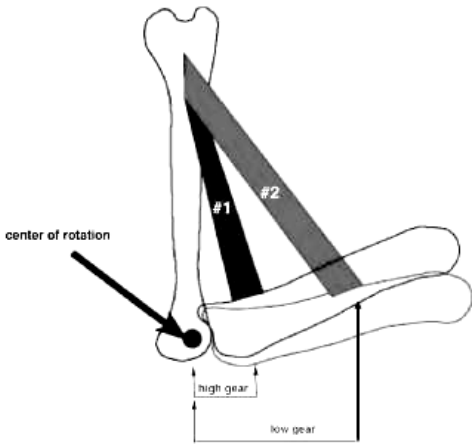
Muscles that attach further from the joint have a mechanical advantage over muscles attached closer to the joint

In the diagram below if muscles #1 and #2 were of equal strength (i.e., can generate the same force) then muscle #2 could produce a greater rotational force because its attachment is at a greater distance from the joint (rotational force = muscle force X distance from joint).



Conversely muscles that attach close to the point of rotation are able to produce faster movement of the lever arm than muscle that attach farther from the fulcrum.

In the diagram to the right if muscle #1 and muscle #2 both contract 10% during an identical time period - muscle #1's contraction would result in a larger movement of the lever arm during that same frame of time than muscle #2. In other words, muscle #1 will result in a more rapid rotation - it has a velocity advantage.



Muscles attaching close to the joint with their velocity advantage are termed "high gear" muscles and those with a more distal attachment resulting in a mechanical advantage are termed "low gear" muscles.

It may be helpful to consider a similar gear analogy as in a car or bike. At ***low gears*** the output force is relatively large – allowing the vehicle to climb up a steep hill. ***High gears*** on the other hand generates a lot of speed – as would be advantageous in passing a vehicle.

Note: the relationship between force and speed is inverse – one will increase at the same time the other decreases

JOINT POSITIONING EFFECTS

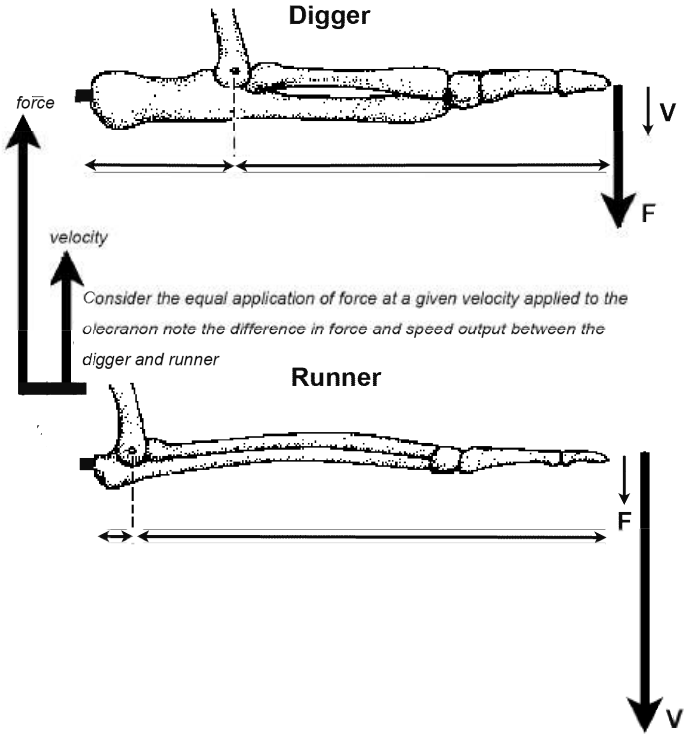
THE BODY'S LEVER SYSTEM

Unique skeletal features result from functional adaptations over time.

In the figure below - the upper diagram is an example of an animal that uses it's front limbs for digging; the muscles attached to the point of the elbow (olecranon) are positioned further from the elbow joint (fulcrum of movement) thereby generating large forces for digging.

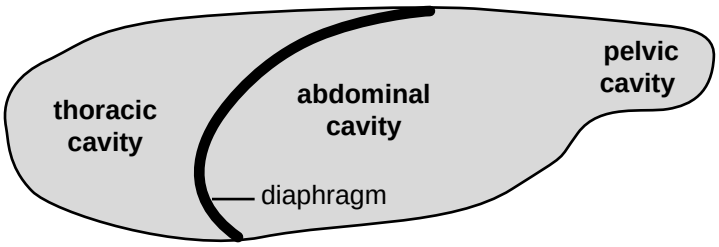
The lower diagram with muscles attaching closer to the elbow joint is an runner adaptation that can result in a rapid rotation with muscle contraction (velocity advantage.

For the same force and velocity input (left arrows), note the relative magnitude of bolded arrows to the right of the diagrams – a large downward force (F) is generated in upper diagram and rapid rotation (V; velocity) of movement is produced in the lower diagram.



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:

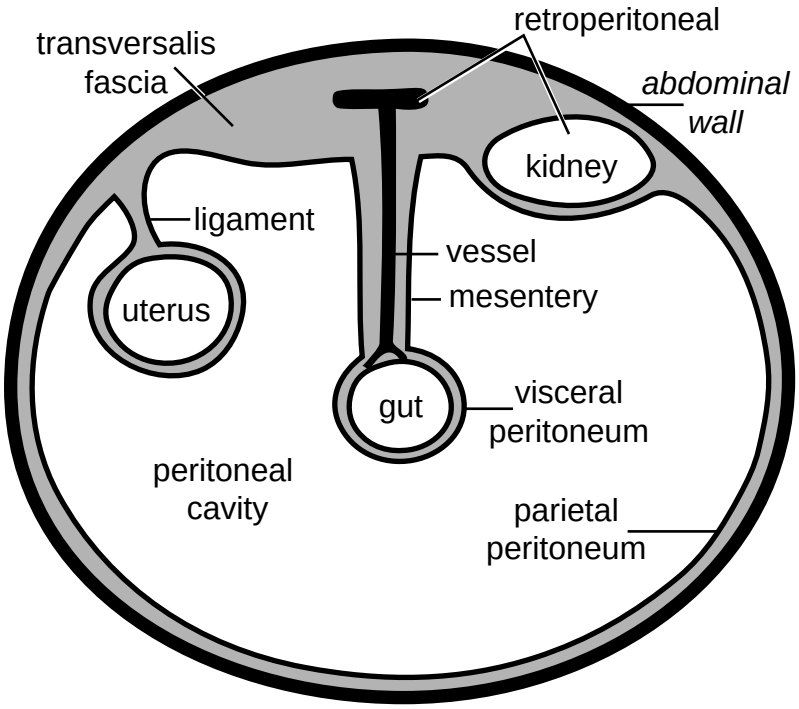
Peritoneum — the peritoneal cavity is found within the abdominal & pelvic body cavities.
Connecting peritoneum forms:
— mesentery
— ligament.

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*.

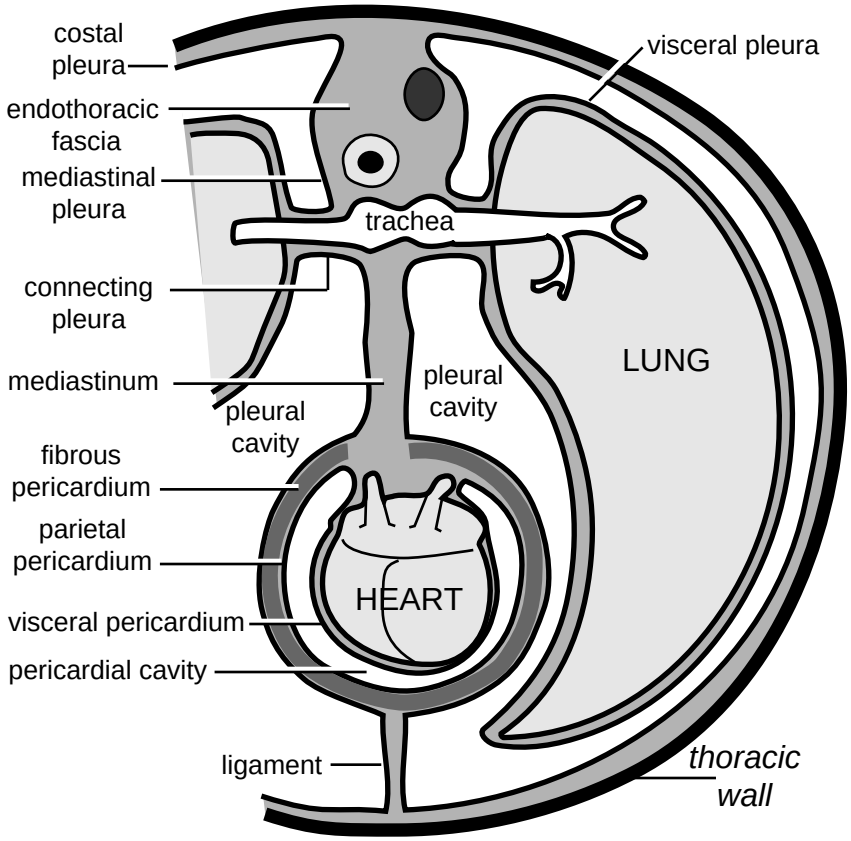
Pericardium — the pericardial cavity is found within the mediastinum of the thoracic cavity.
Visceral pericardium is also called *epicardium*.

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



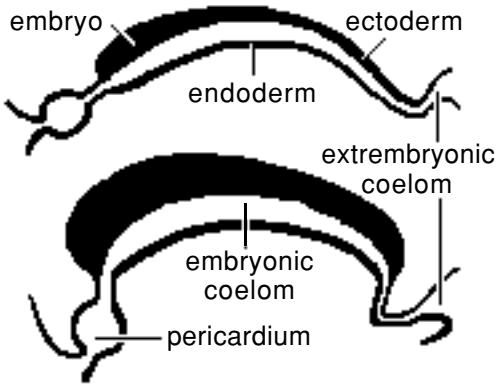
Formation of Body (Serous) Cavities

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:

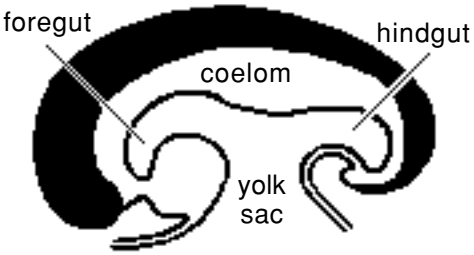
• all of the serous cavities develop from a common embryonic coelom and thus the cavities are continuous until partitions develop to separate them;

• 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:

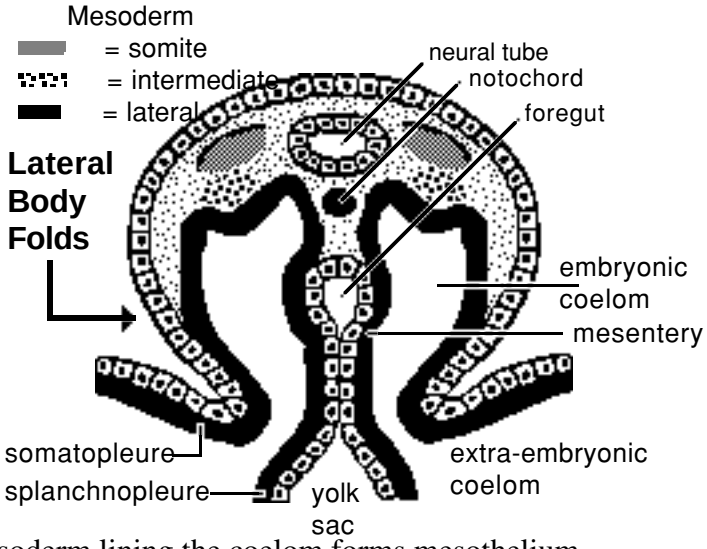
During gastrulation, the space between ectoderm and endoderm (and between trophoblast and hypoblast) is filled by inflow of primary mesenchyme that becomes mesoderm. Cavitation occurs in lateral mesoderm, establishing the **coelom** bounded by somatopleure and splanchnopleure.



Coelom (Longitudinal View)

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.

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.

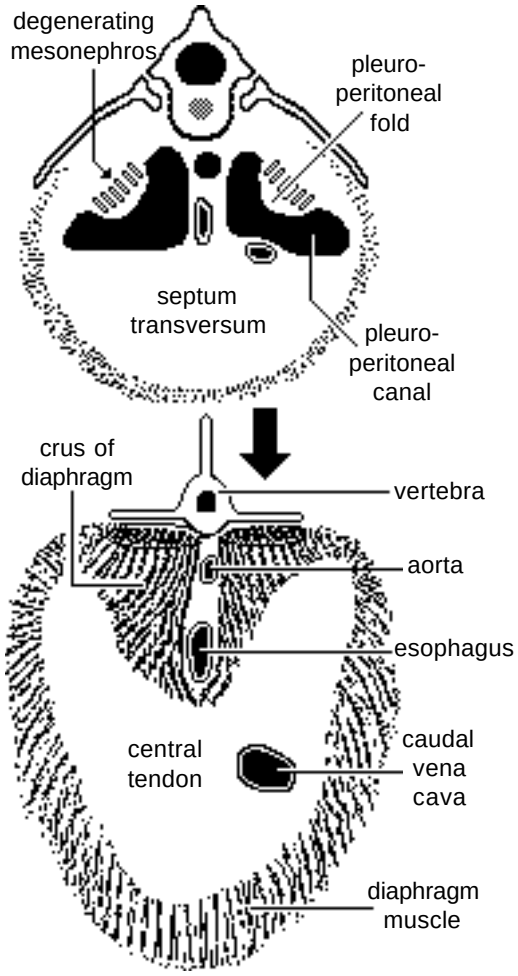
Originally in the embryo, the pericardial coelomic cavity communicated with two dorsally positioned pleural cavities (canals). Subsequently, the cavities become partitioned by paired *pleuropericardial folds* and then somatic mesoderm. Details of the separation include:

— 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.

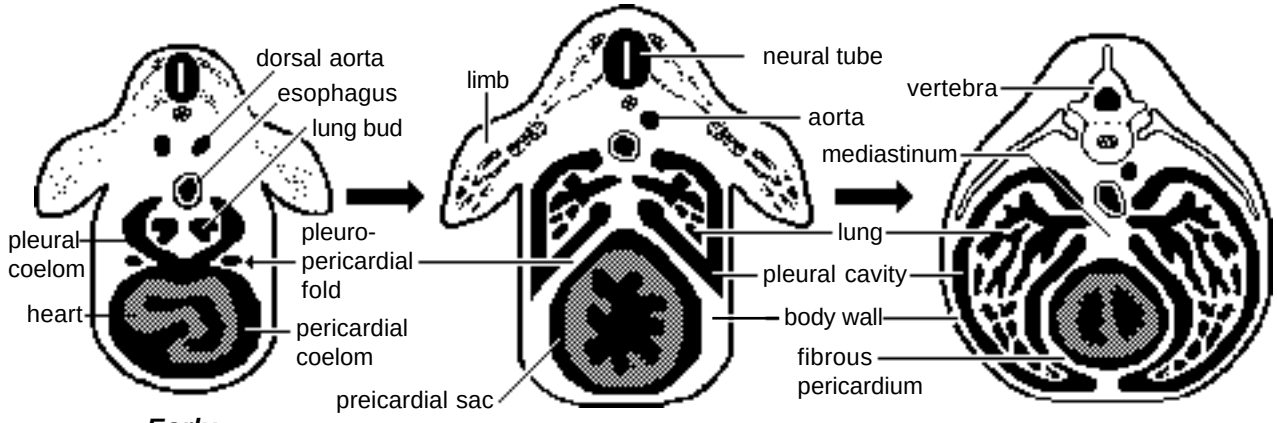
NOTE: Mediastinum is formed initially by dorsal and ventral mesenteries of the esophagus.

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.



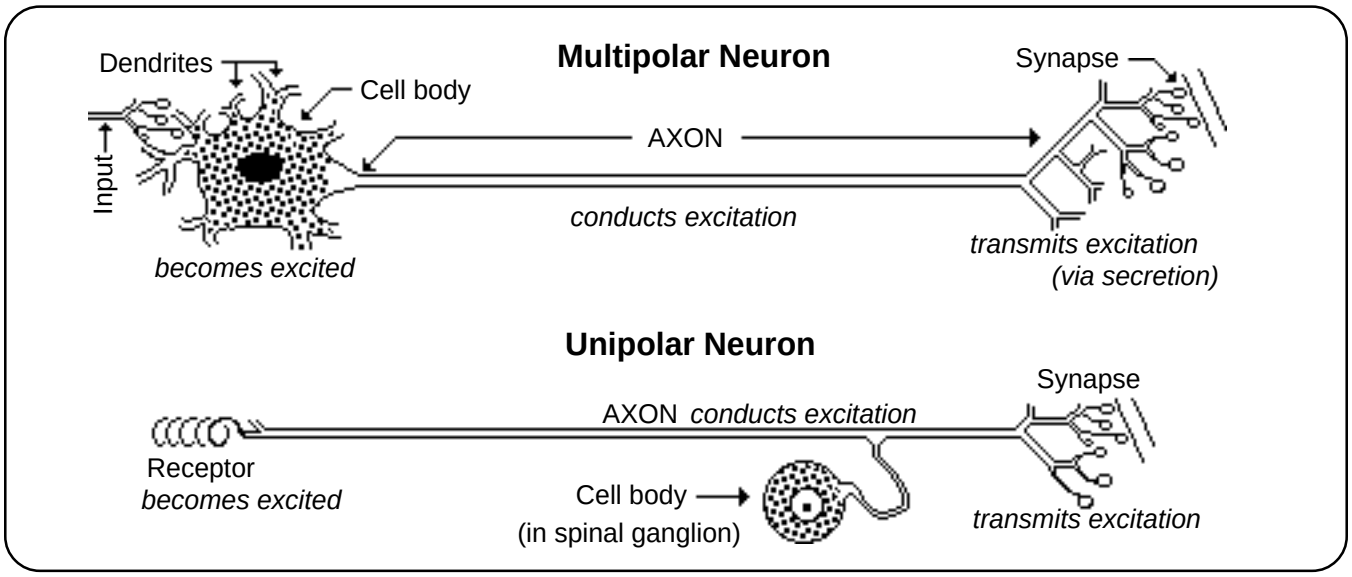
Pleural Cavity Formation

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)

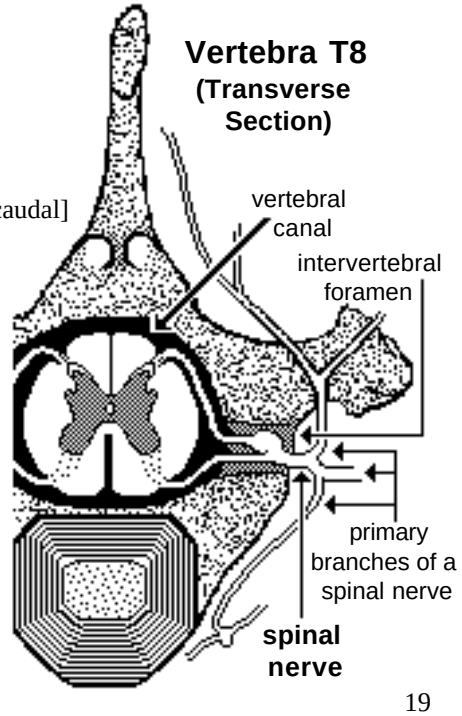


Definitions:

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

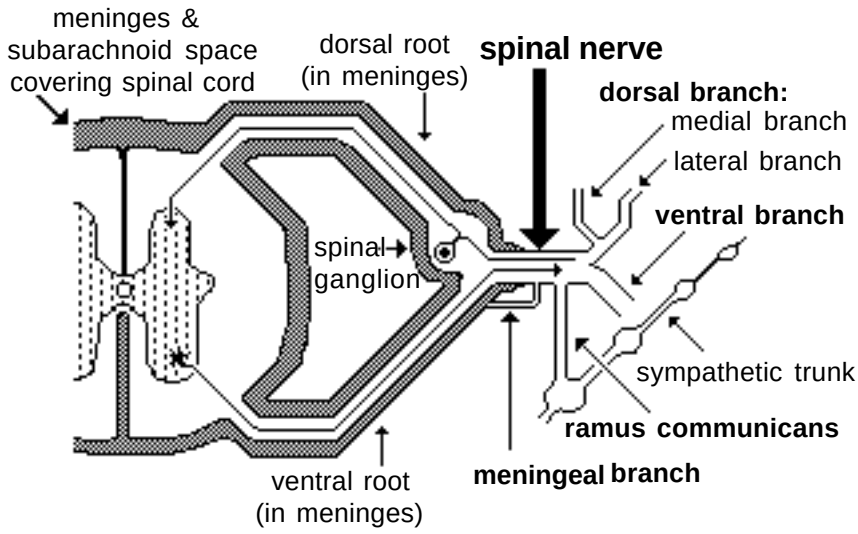
— divides into four primary branches:

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.



Four Primary Branches of a Spinal Nerve

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.

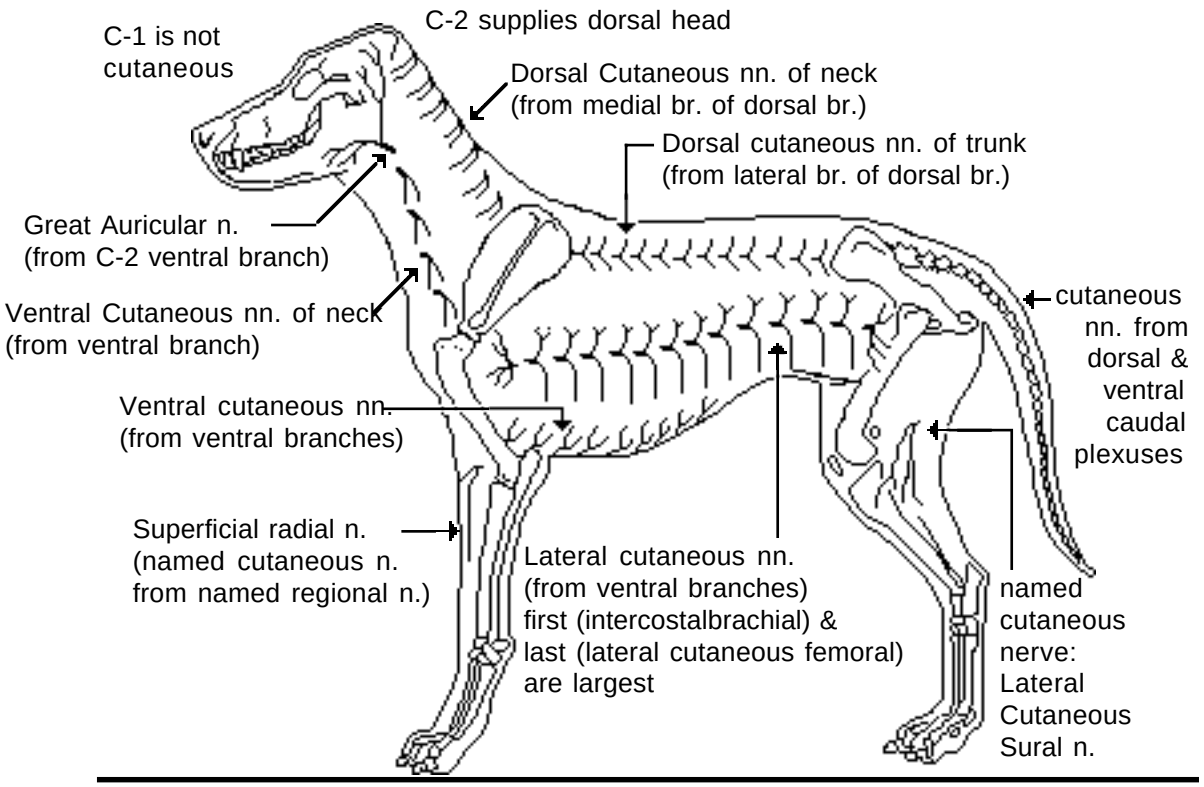
Autonomic Nervous System (ANS) = VE (sometimes the ANS includes GVA as well as VE fibers)

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.

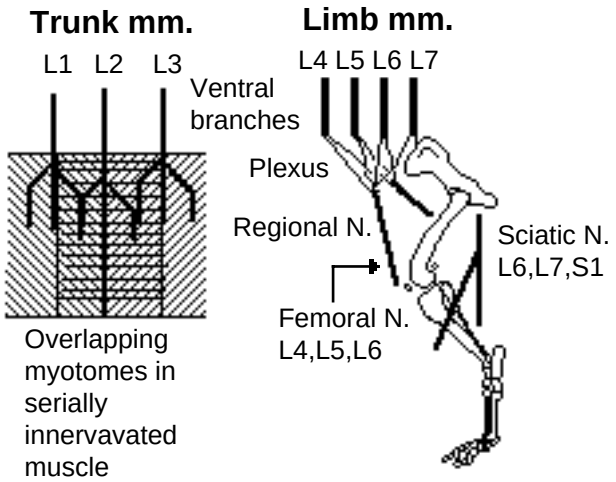


Brachial and Lumbosacral nerve plexuses:

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

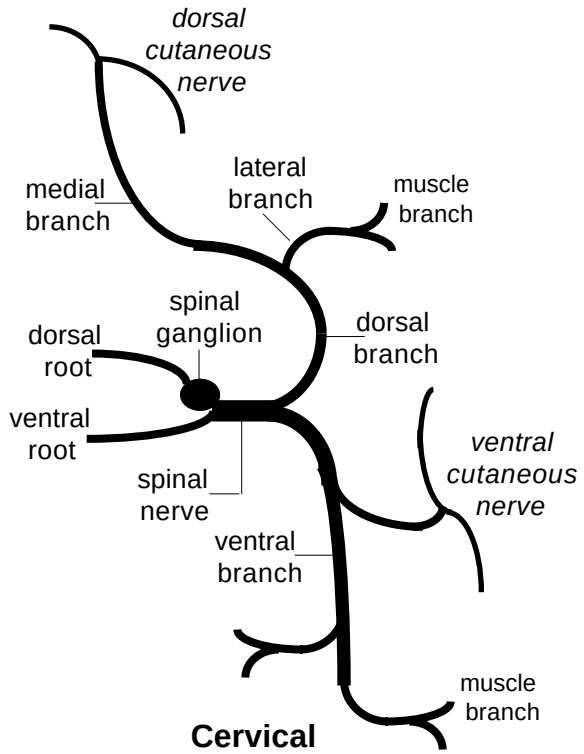
In the case of trunk muscles, which are generally broad, multiple dorsal or ventral branches of spinal nerves can be seen to serially innervate each individual muscle. The innervations overlap within the muscle because of myotome overlap.

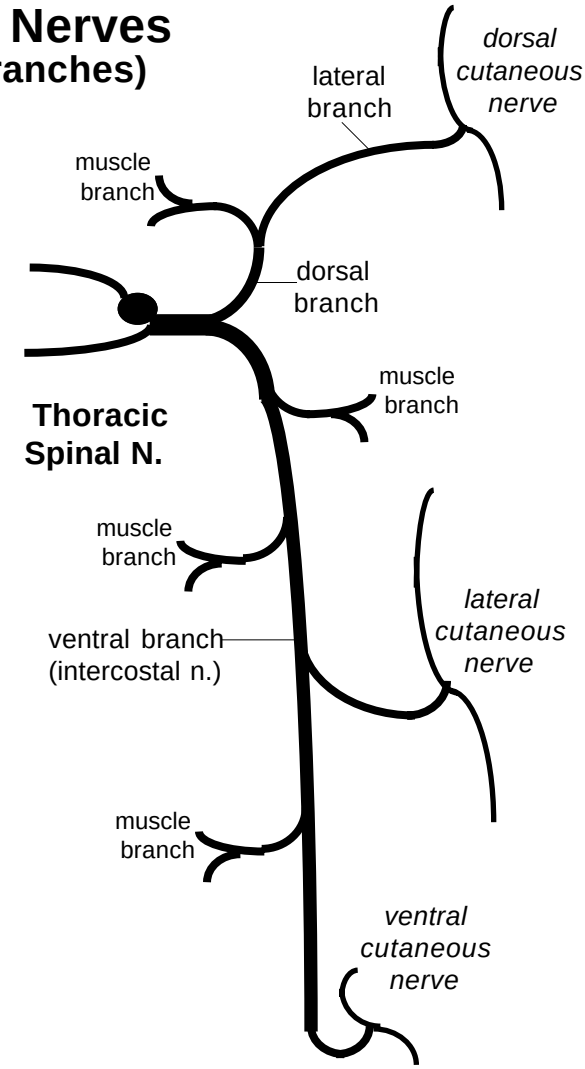
In the case of limb muscles, each muscle is innervated by the branch of a single regional nerve. Because of multiple myotomes per muscle, the regional nerves must contain axons from ventral branches of multiple spinal nerves. The exchange of axons among ventral branches as they form regional nerves produces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



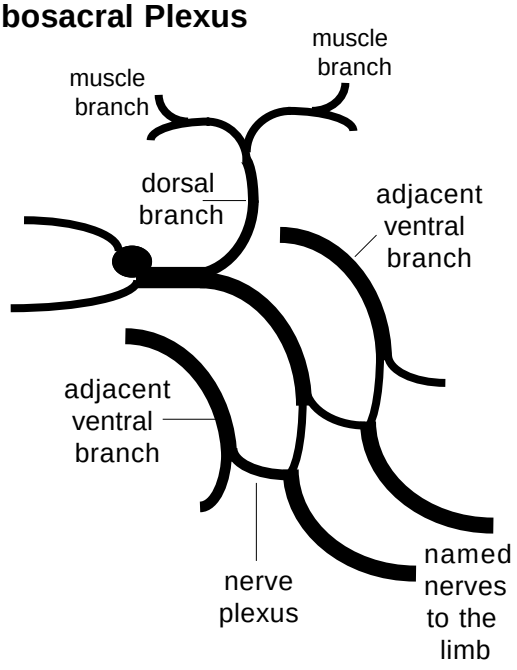
From a Gross Anatomy perspective ...
MYOTOME = muculature derived from one somite and thus innervated by a single spinal nerve per body half.
DERMATOME = skin derived from one somite and thus innervated by a single spinal nerve per body half.

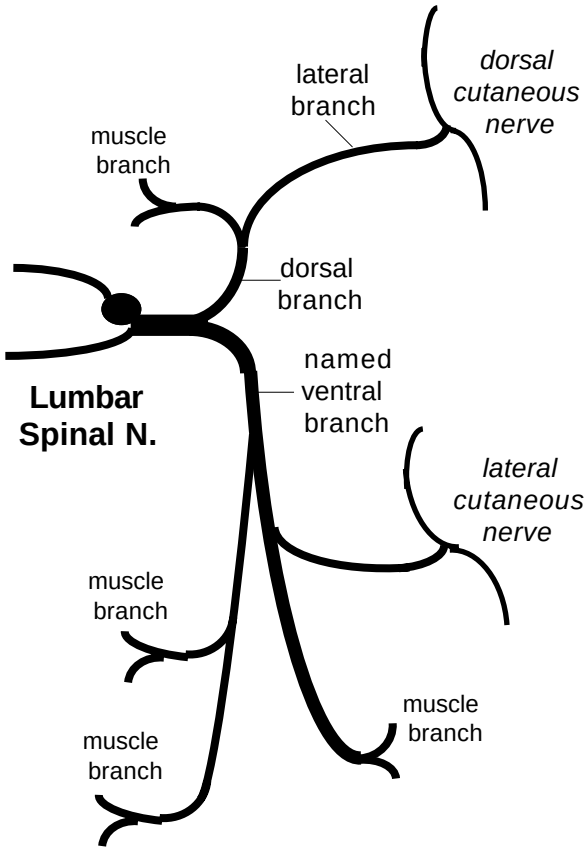
Regional Configurations of Spinal Nerves
(Showing Roots and Dorsal & Ventral Branches)





Spinal N. Contributing to the Brachial or Lumbosacral Plexus





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

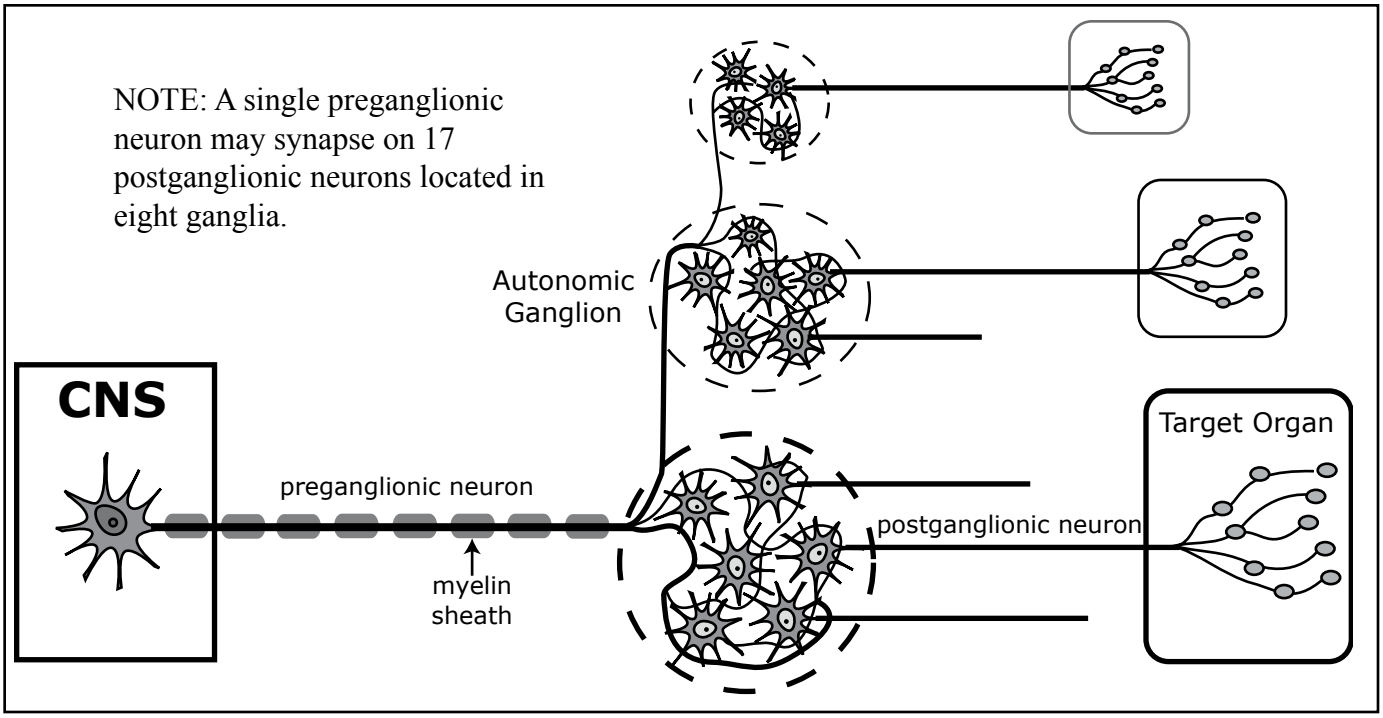
Autonomic Nervous System (ANS)

(Note: In addition to VE nerurons, GVA neuons (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

Feature	**Sympathetic**	**Parasympathetic**
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

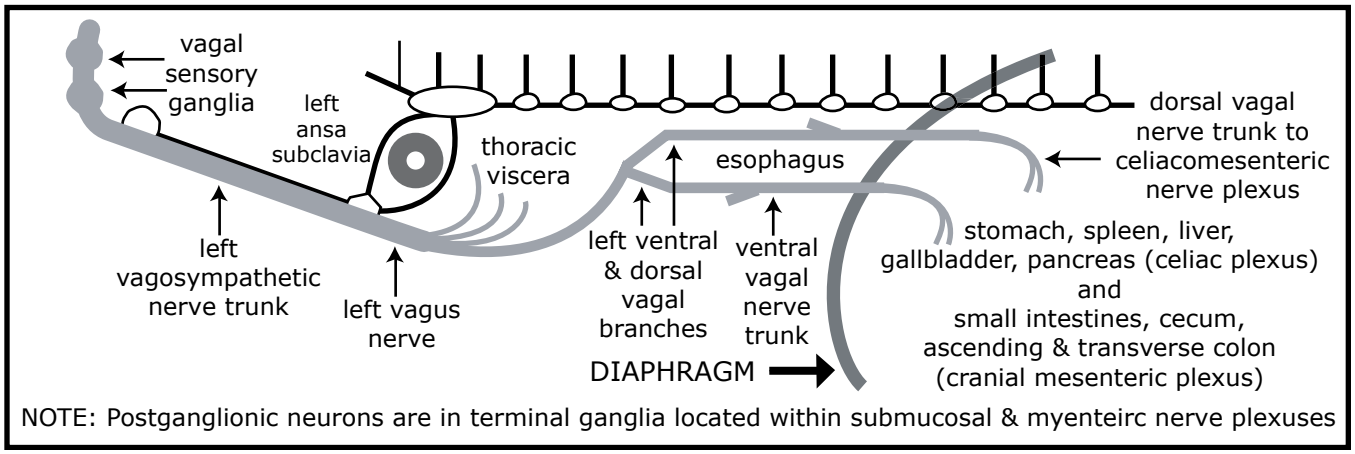
Functional Differences:

Structure	**Sympathetic**	**Parasympathetic**
iris (pupil)	dilate	constrict
heart	increase rate & force of contraction	decrease rate
bronchi	dilate	constrict
gut & bladder wall	inhibit motility	excite contraction
gut & bladder sphincters	contract	relax
cutaneous vessels	constrict	*doesn't innervate*
muscle vessels	dilate (cholinergic)	*doesn't innervate*
sweat glands	secrete	*doesn't innervate*
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

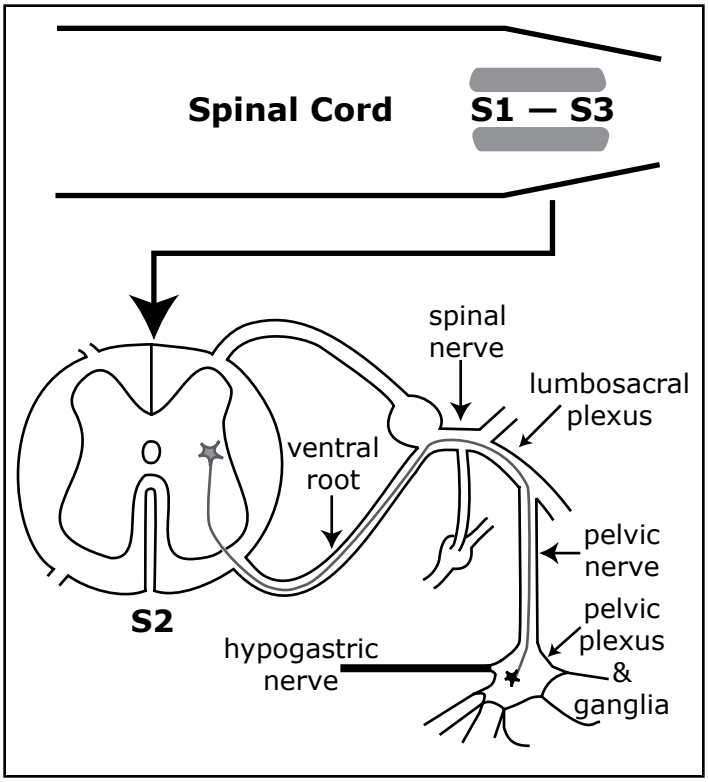


Parasympathetic pathways:

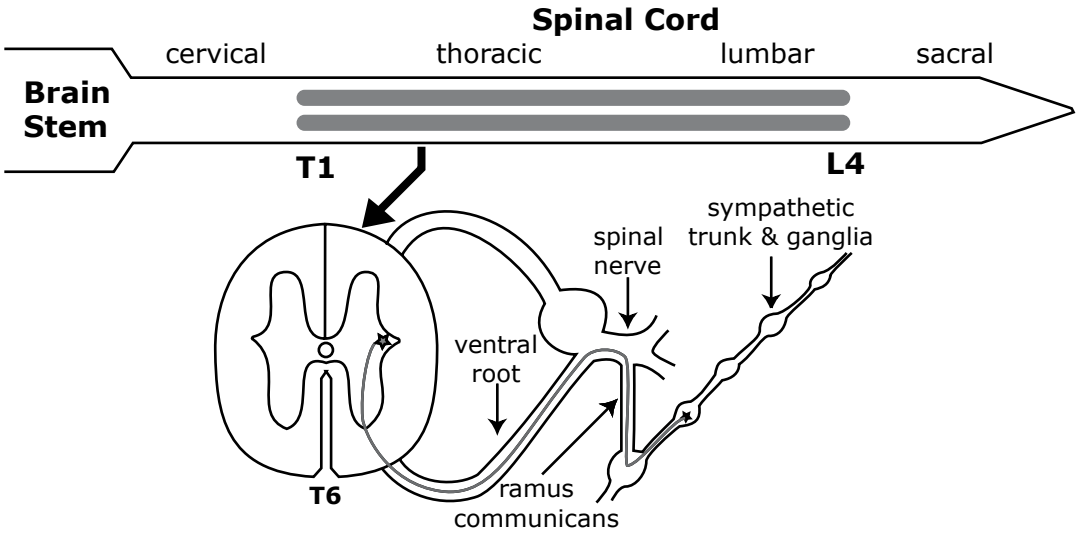
1] **Cranial nerves III, VII, and IX** .... *later in the course*.

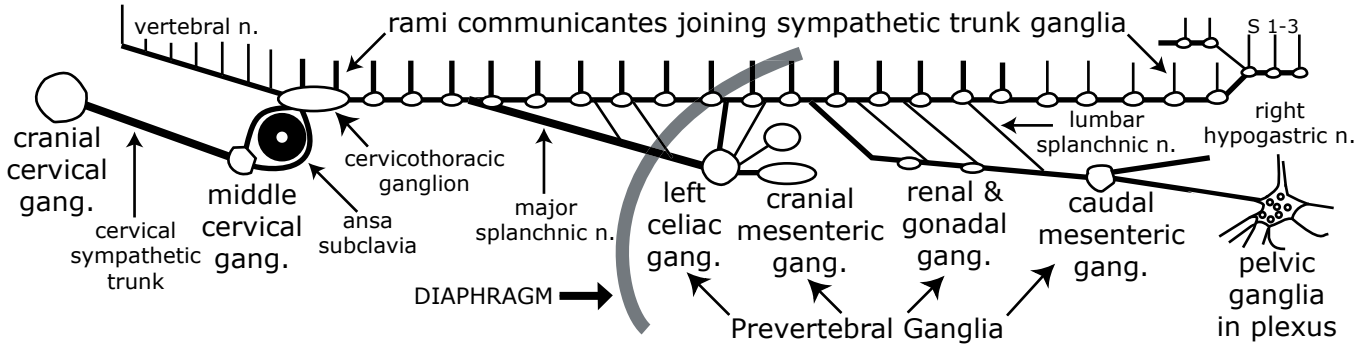
2] **Cranial nerve X** (vagus nerve) innervates thoracic and abdominal viscera:
Preganglionic pathway: the vagus n. branches travel to organs being innervated
Synapse: occurs within organs innervated, in microscopic terminal ganglia
Postganglionic pathway: axons course in submucosal or myenteric plexuses 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

Preganglionic path:

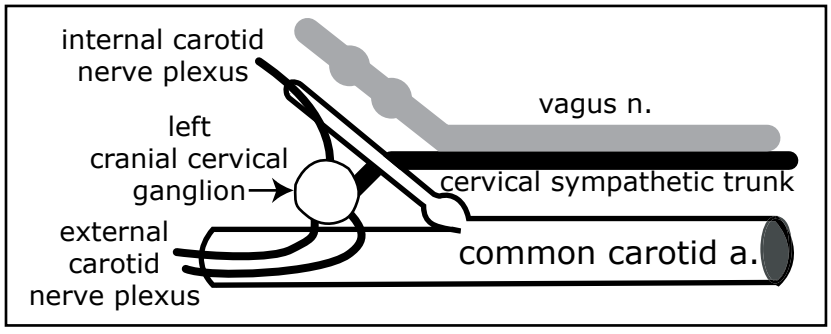
ventral root; spinal n.; ramus communicans; sympathetic trunk; ansa subclavia; and cervical sympathetic trunk

Synapse:

cranial cervical ganglion

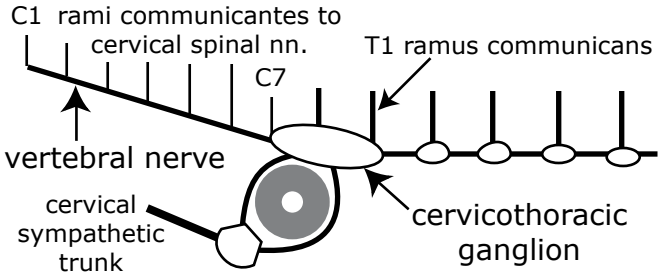
Postganglionic path:

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



Neck Region

Preganglionic path:
ventral root; spinal n.; ramus communicans; sympathetic trunk
Synapse:
cervicothoracic ganglion
Postganglionic path:
vertebral nerve; rami communicantes; cervical spinal nn.; dorsal or ventral branches to muscles & skin

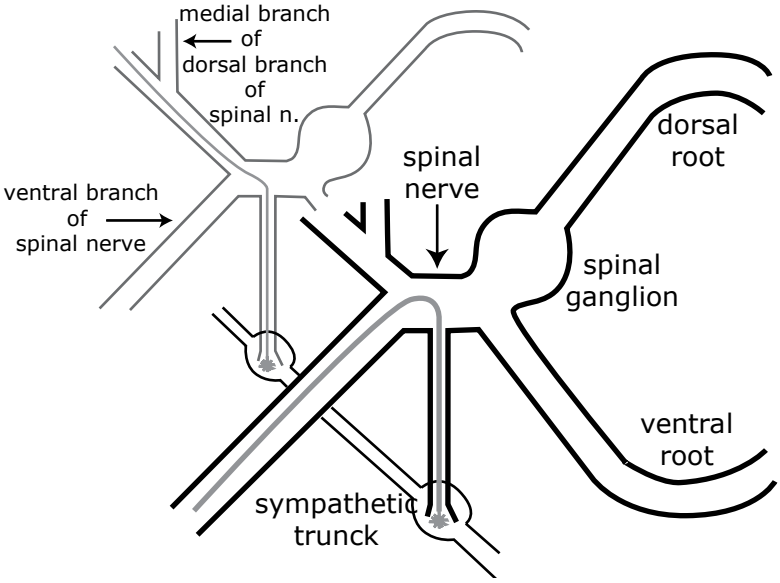


Body Wall and Limbs and Tail

Preganglionic path:
ventral root; spinal n.; ramus communicans; sympathetic trunk

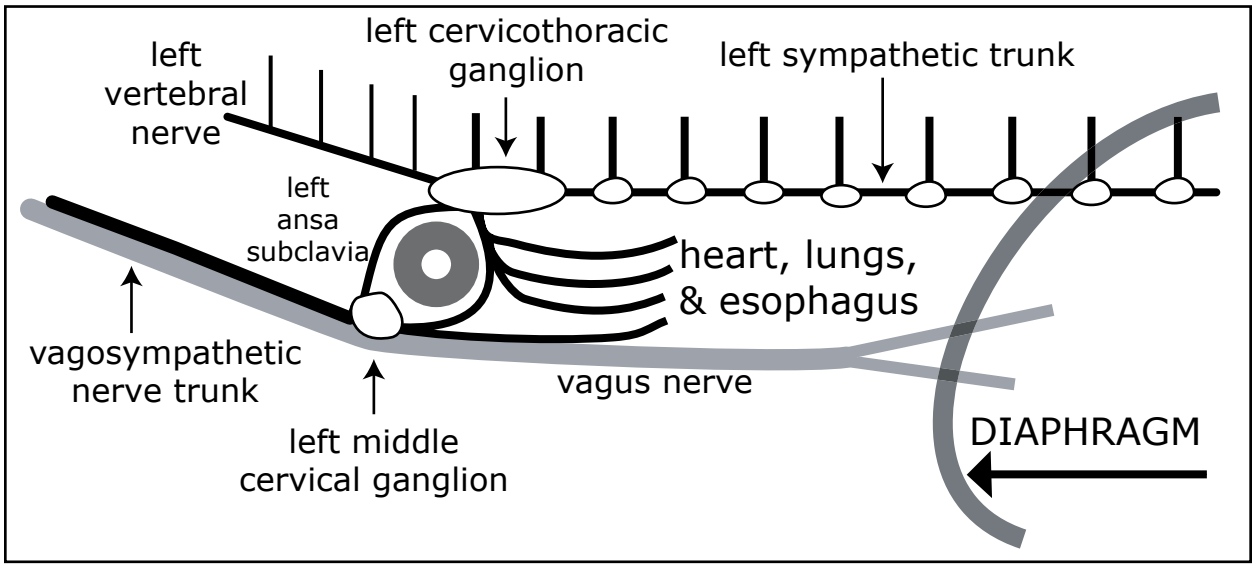
Synapse:
sympathetic trunk ganglia (paravertebral ganglia)

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



Thoracic Viscera

Preganglionic path: ventral root; spinal n.; ramus communicans; sympathetic trunk
Synapse: cervicothoracic & middle cervical ganglia
Postganglionic path: cardiosympathetic nn. branch from ansa subclavia (also, branches that run with vagus n.)

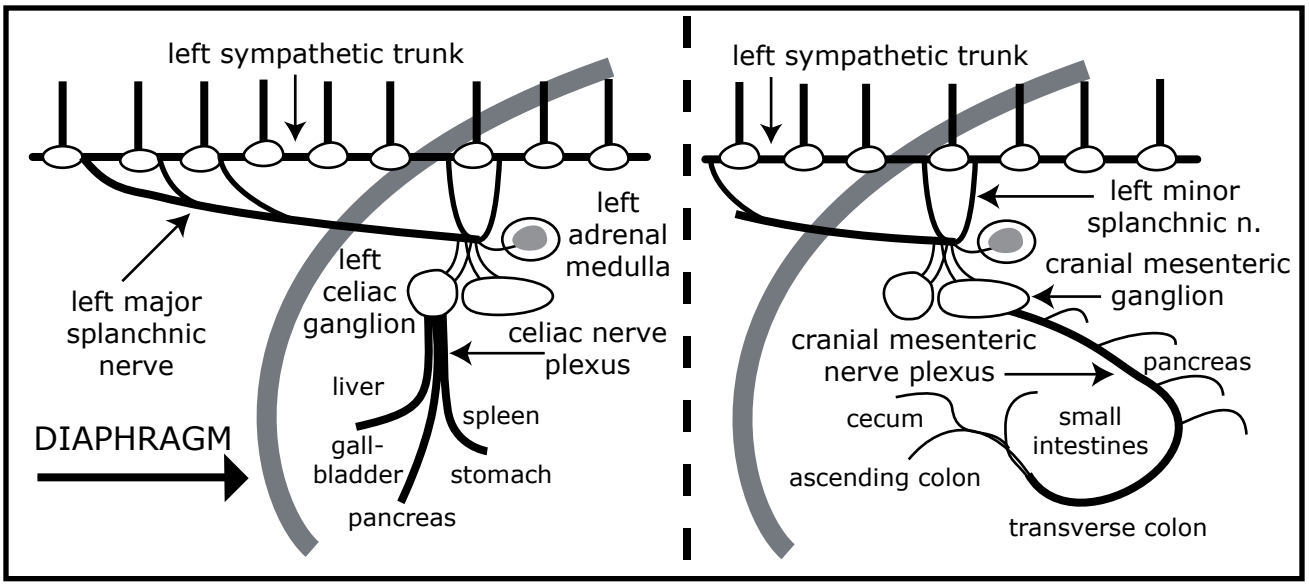


Abdominal Viscera

Preganglionic 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

Postganglionic path: nerve plexuses on abdominal arteries supplying particular organs

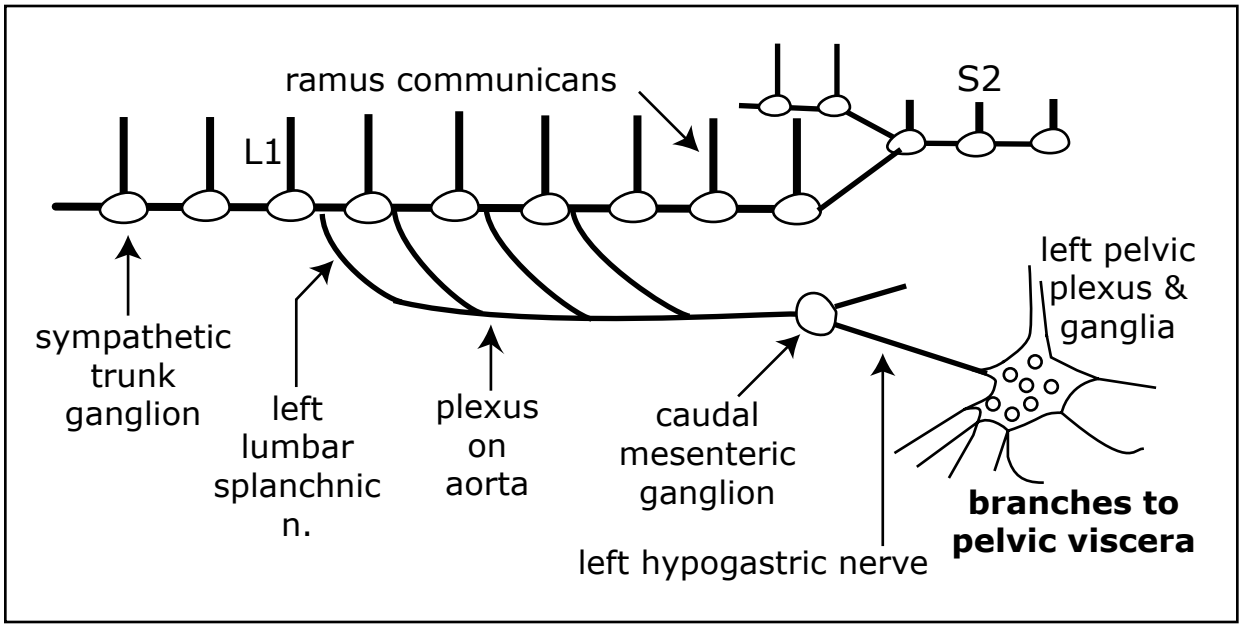


Pelvic Viscera

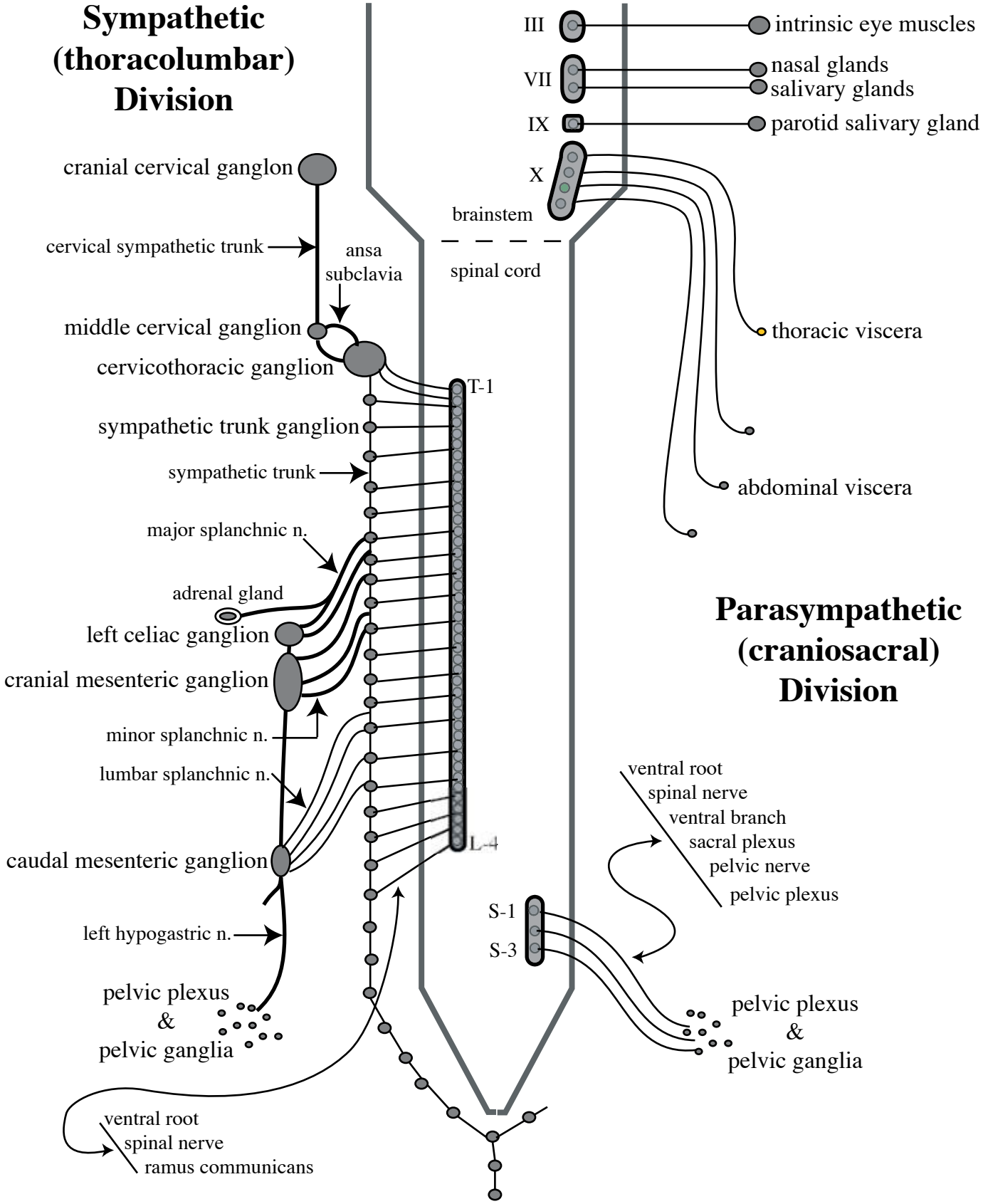
Preganglionic path: ventral root; spinal n.; ramus communicans; sympathetic trunk; lumbar splanchnic nn.; caudal mesenteric plexus

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

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



Autonomic Preganglionic Pathways



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, intestine)

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 Intestine:

1) **Duodenum** — MESODUODENUM
regions: a] cranial flexure
b] descending duodenum
c] caudal flexure
d] ascending duodenum
e] duodenal-jejunal flexure

2) **Jejunum** — MESOJEJUNUM } MESENTERY

3) **Ileum** — MESOILEUM

antimesenteric vessel; ileocecal fold
ileal (ileocolic) orifice

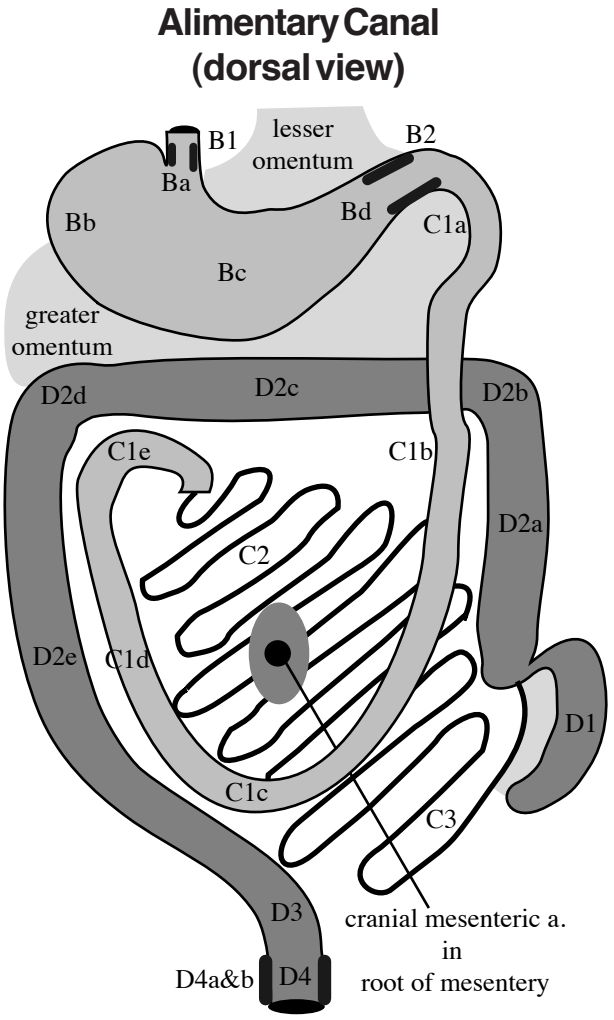
D. Large Intestine:

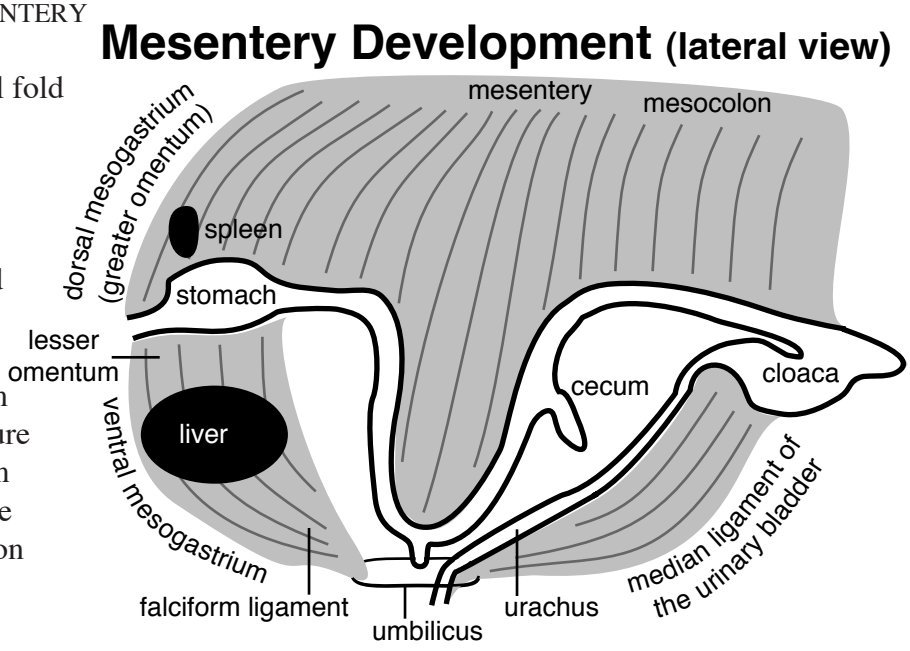
1) **Cecum** (blind end; no appendix)
cecocolic orifice; ileocecal fold

2) **Colon** — MESOCOLON
regions: a] ascending colon
b] right colic flexure
c] transverse colon
d] left colic flexure
e] descending colon

3) **Rectum** — MESORECTUM

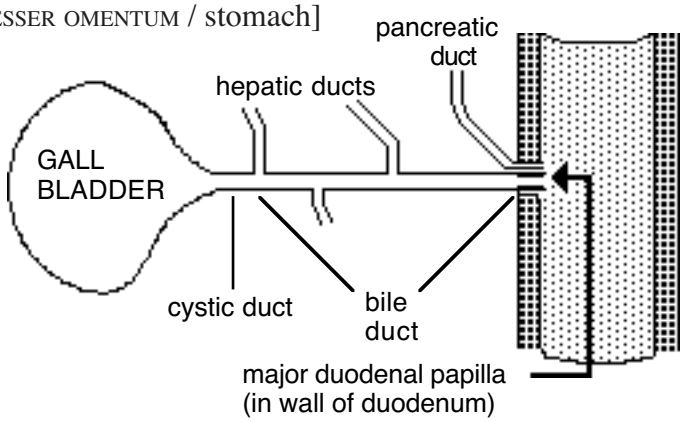
4) **Anal canal** (retroperitoneal)
anus = external opening
sphincters — a] internal anal sphincter (smooth m.), and
b] external anal sphincter (striated m.);

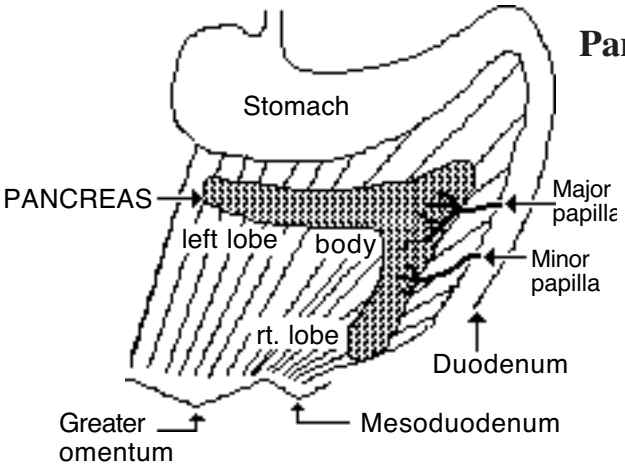




Liver — secretes bile salts which emulsify ingested fat; bile is stored in the gallbladder
develops in ventral mesogastrium:
[diaphragm / LIGAMENTS / **LIVER** / LESSER OMENTUM / stomach]

Six lobes: right lateral lobe
right medial lobe
— — — — — *gallbladder*
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

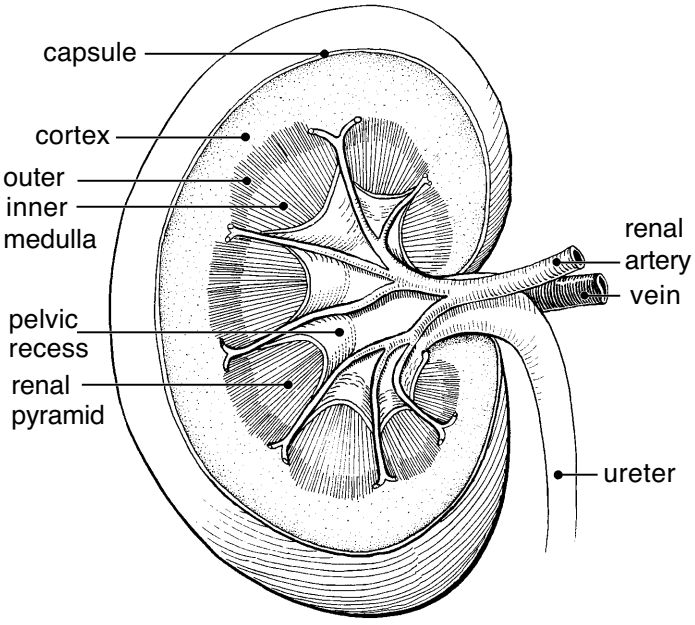
Ducts:
Pancreatic duct (smaller) empties with
bile duct —> major duodenal papilla
Accessory pancreatic duct (larger) empties
—> minor duodenal papilla

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 caudally.

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 (previously, phrenicoabdominal a.) — supplies abdominal wall & adrenal gland via **cranial abdominal a.** and diaphragm (via 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

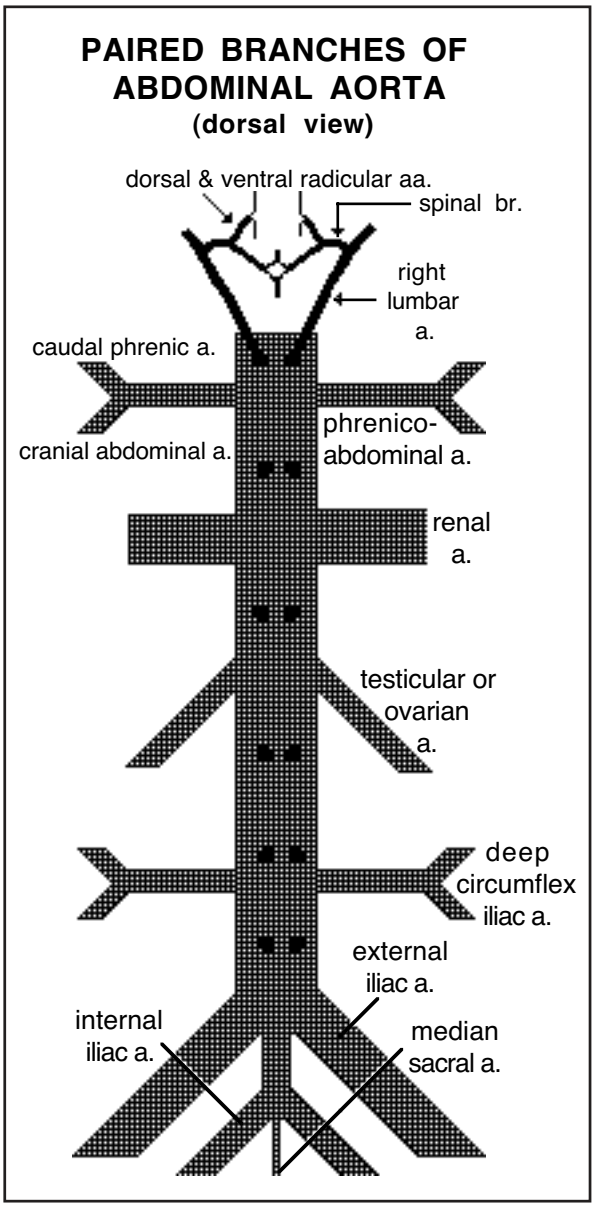
3) **caudal mesenteric** a.
— supplies descending colon & rectum

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 from 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

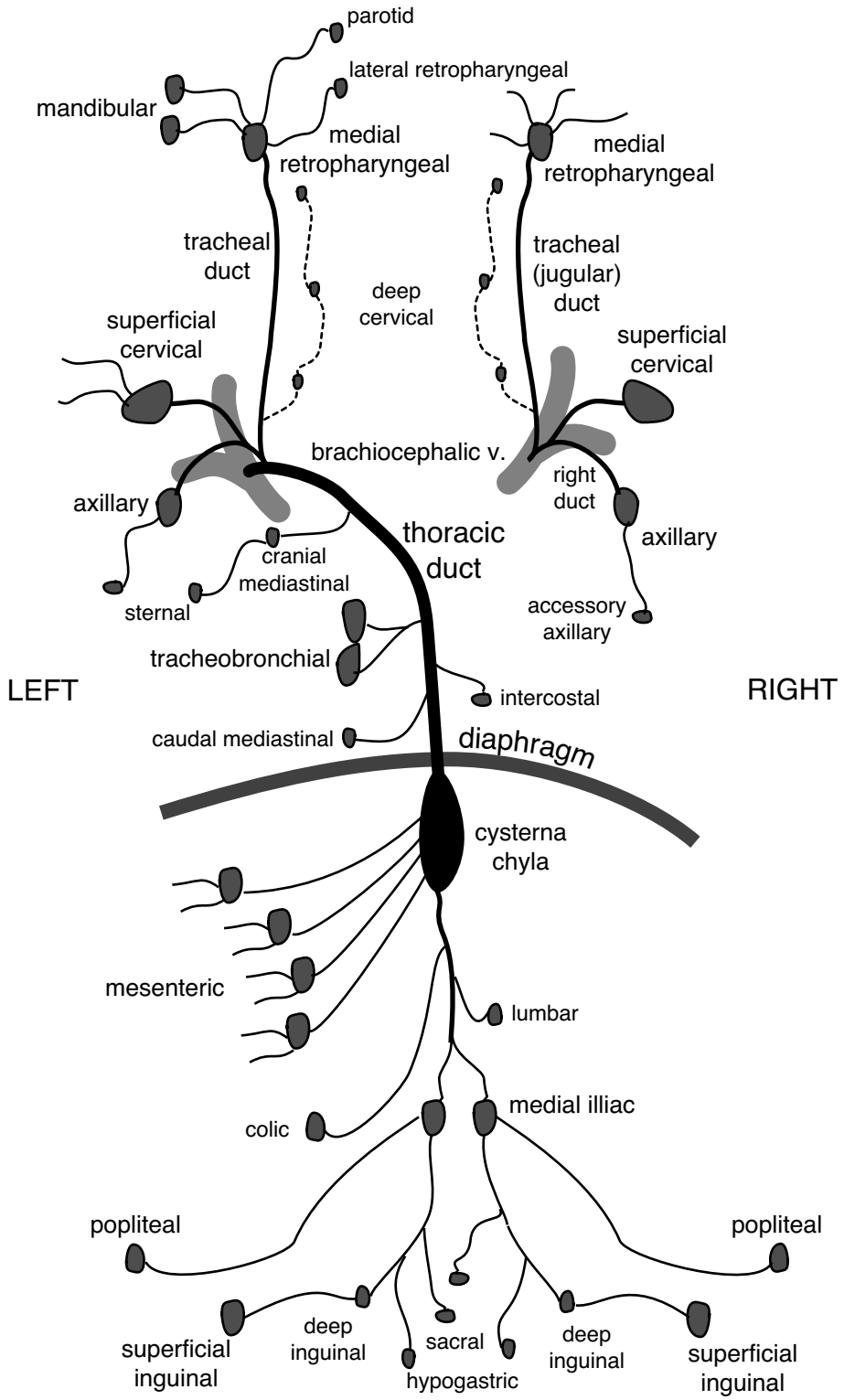
Lymphatics: (the attached diagram is included as a reference source)

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

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

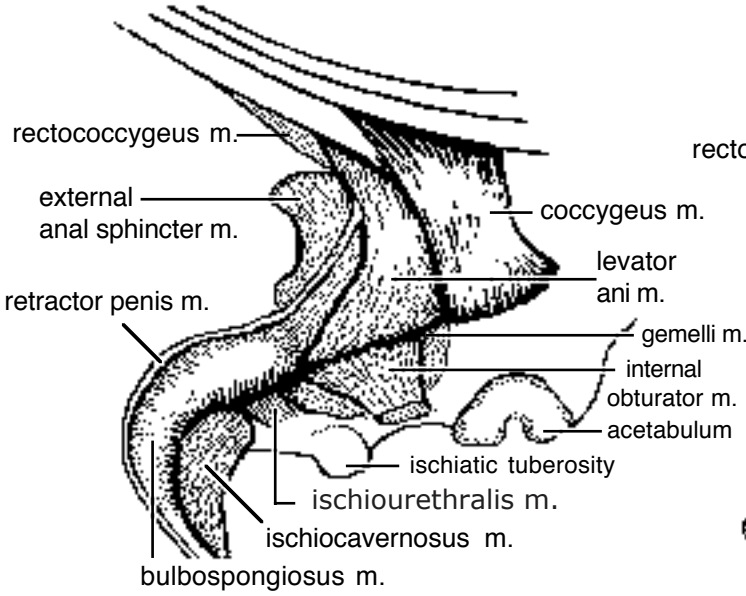
As topographic region . . .

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

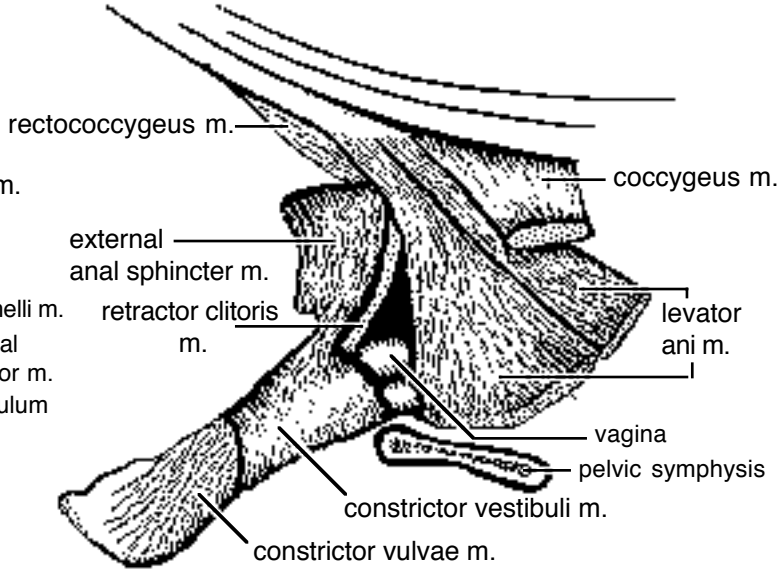
As caudal wall of trunk . . .

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. ($S_2 + S_1$ & S_3)

Internal urethral sphincter = smooth m.; innervated by hypogastric n. (L_2, L_3, L_4)

female — vesical neck & cranial half of urethra

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

External urethral sphincter = urethralis m. (striated); innervated by pudendal n. (S_2 & S_3 + S_1)

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

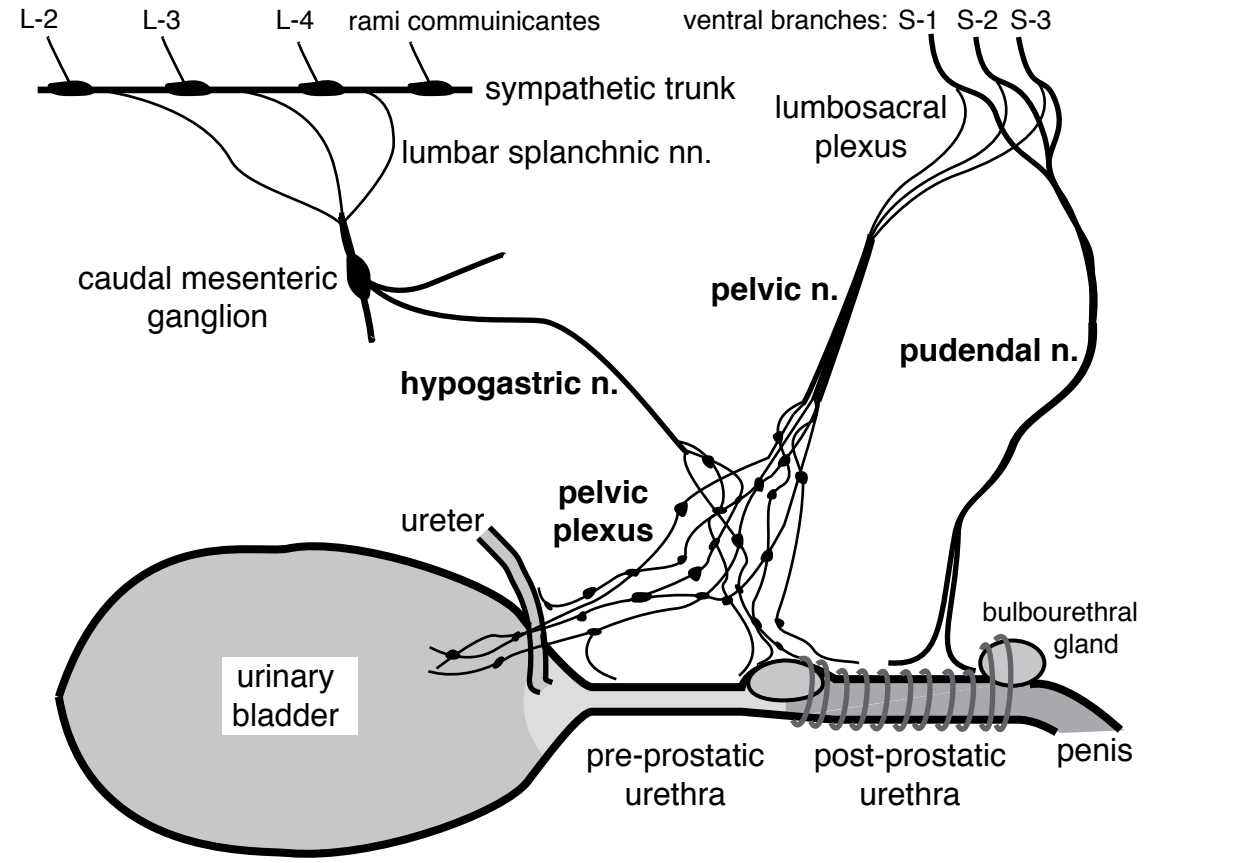
Micturition:

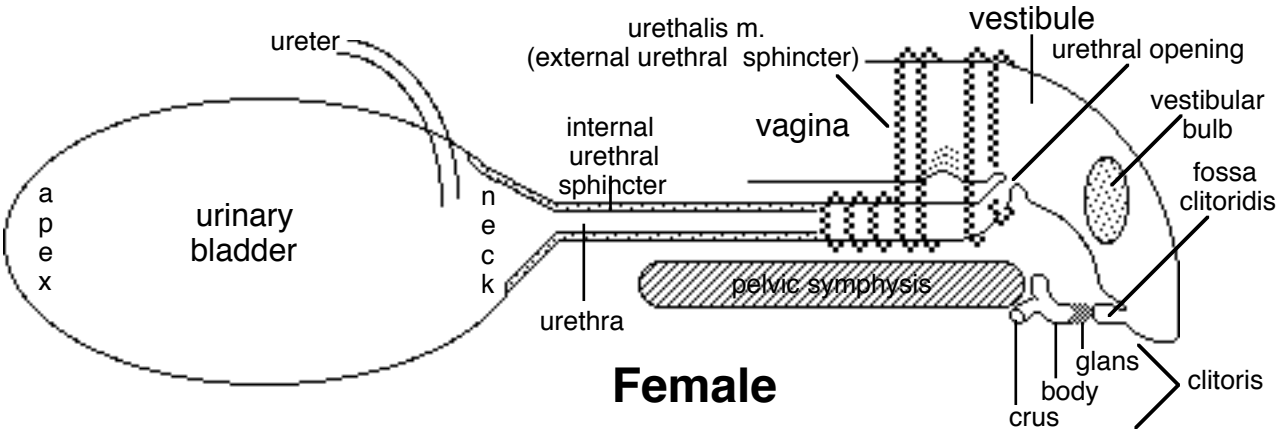
Requires prolonged detrusor contraction and sphincter inhibition

- free nerve endings (receptors) —> GVA fibers in pelvic n. —> ascending pathways —> pons —> descending spinal pathways —> activate detrusor & inhibit sphincters

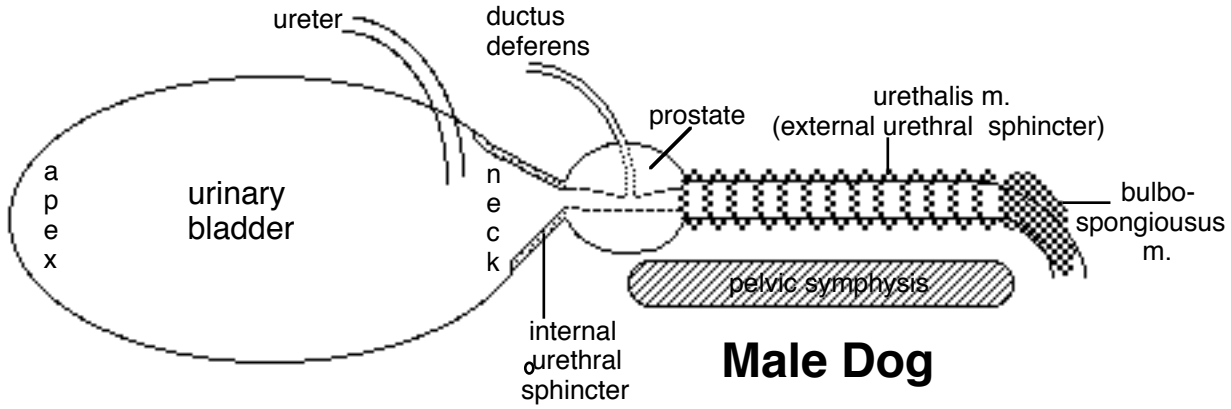
Pain:

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

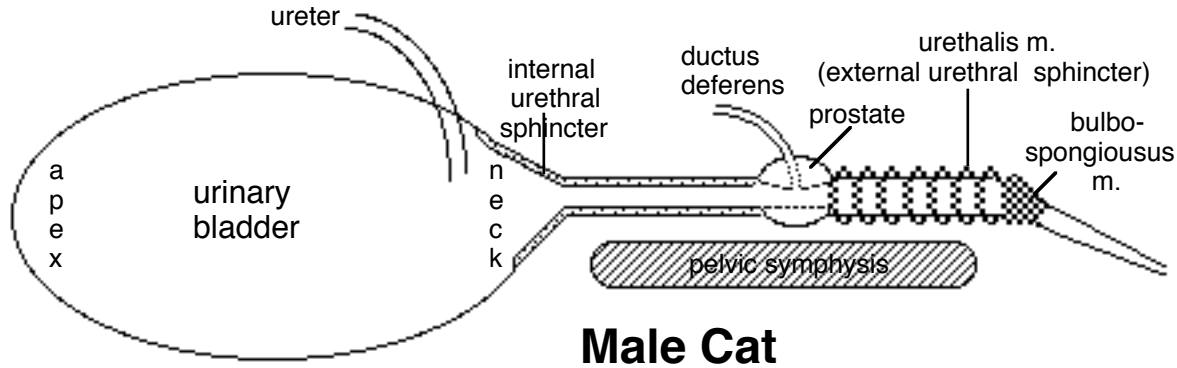




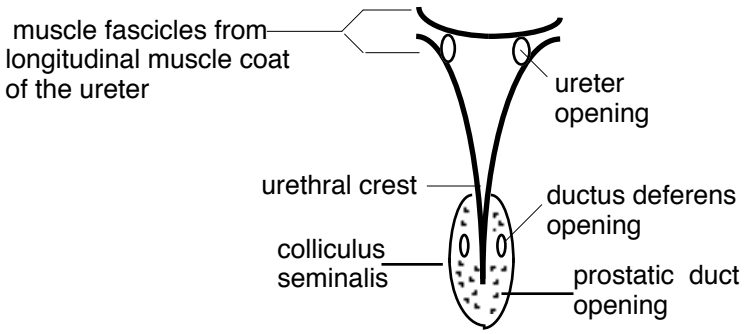
Female



Male Dog



Male Cat



Trigone

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

Female Genital Tract

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

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)

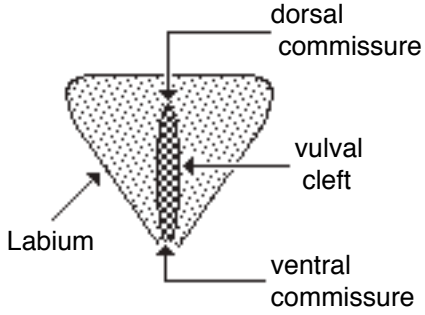
Uterus:
1. Cervix — short, thick muscular wall & narrow canal
2. Body — relatively short in carnivores
3. Uterine horns — paired, relatively long

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

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

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 ischio-cavernosus m. covers the crus

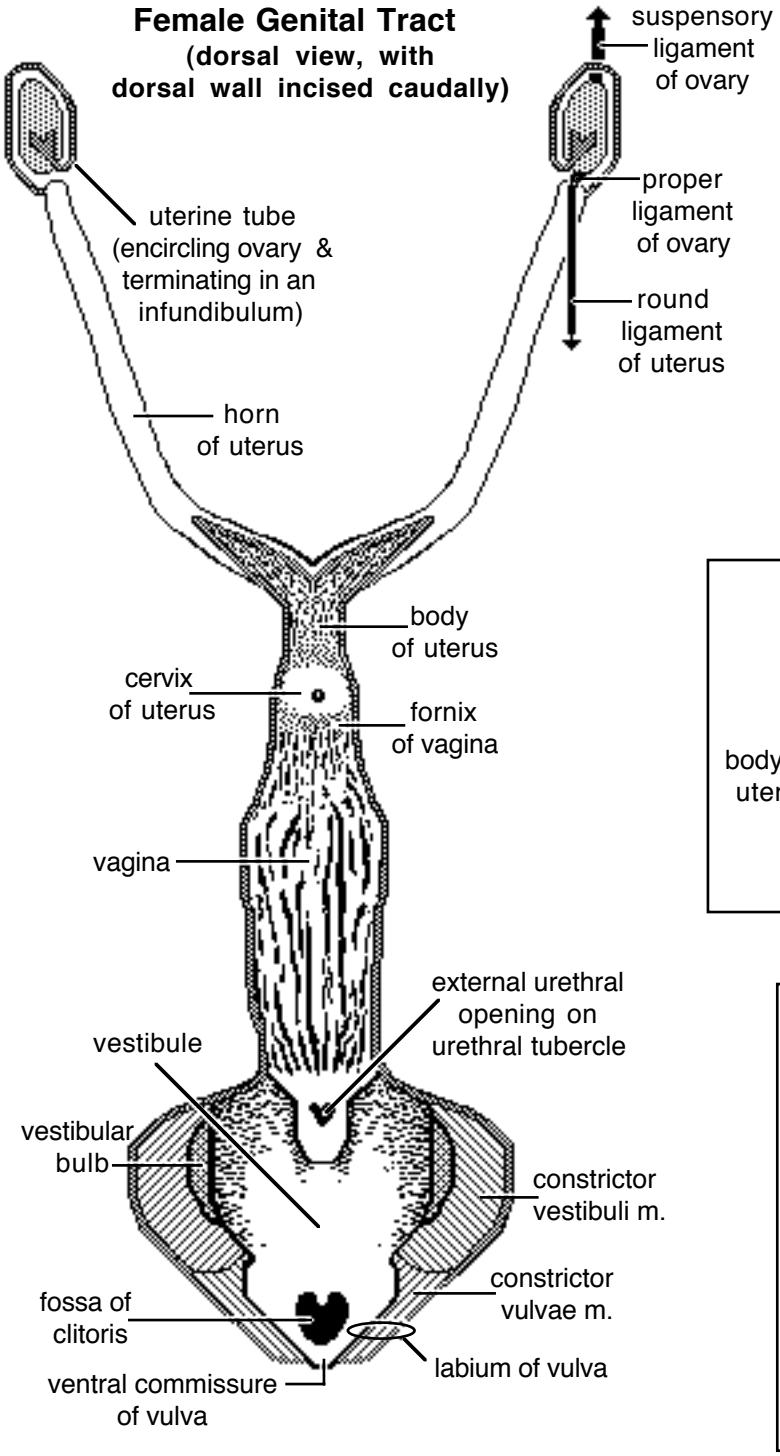


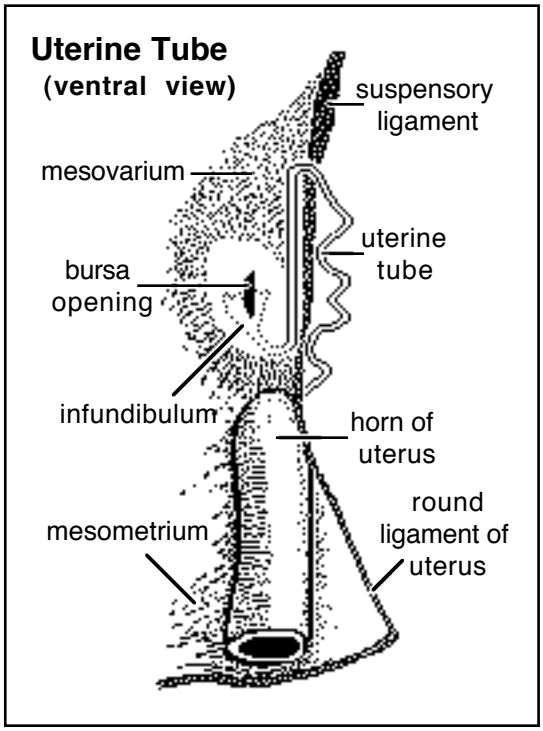
Vulva:*
- is composed of left & right labia which bound a vulval cleft
- constrictor vulvae m. (striated) is in the wall of each labium
- an indentation, the fossa of the clitoris, is present ventrally

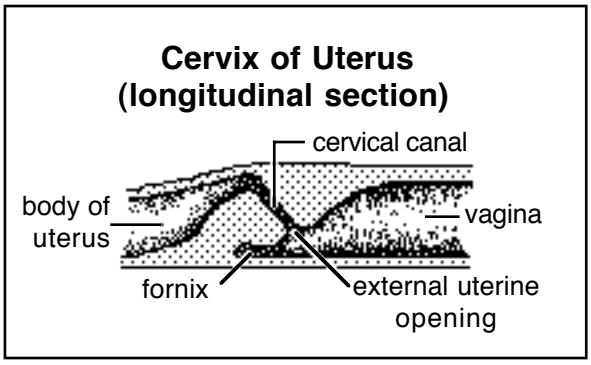
Ligaments associated with the female genital tract:
1) suspensory ligament of the ovary — extends from ovary to dorsal body wall
2) proper ligament of the ovary — extends between ovary & cranial end of uterine horn
3) round ligament of the uterus — extends from cranial end of uterine horn thru inguinal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

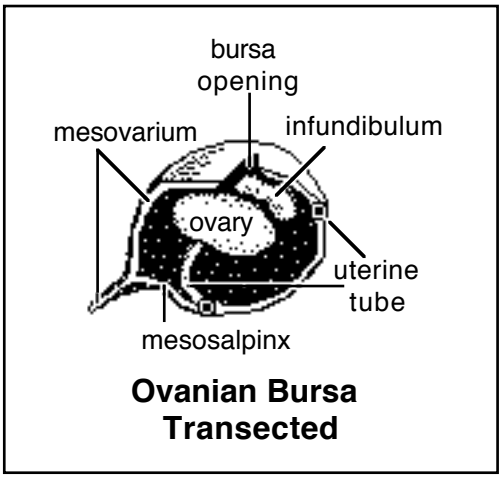
---

* 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.

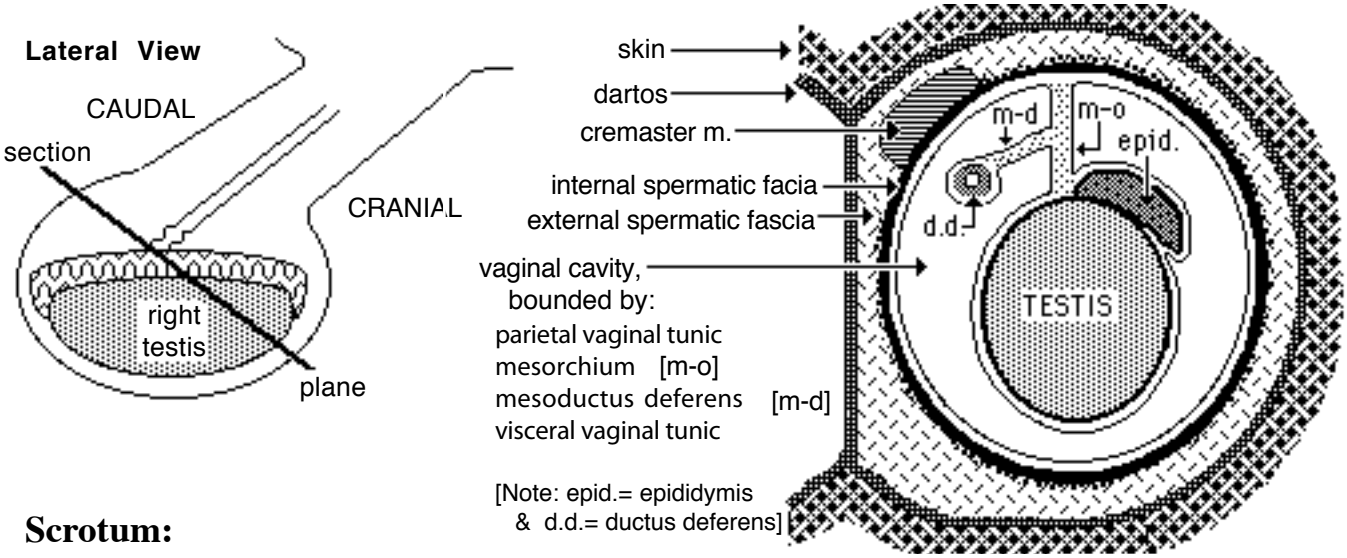

Female Genital Tract
(dorsal view, with dorsal wall incised caudally)
suspensory ligament of ovary
proper ligament of ovary
round ligament of uterus
uterine tube (encircling ovary & terminating in an infundibulum)
horn of uterus
body of uterus
cervix of uterus
fornix of vagina
vagina
external urethral opening on urethral tubercle
vestibule
vestibular bulb
constrictor vestibuli m.
constrictor vulvae m.
fossa of clitoris
labium of vulva
ventral commissure of vulva


Uterine Tube
(ventral view)
suspensory ligament
mesovarium
uterine tube
bursa opening
infundibulum
horn of uterus
round ligament of uterus
mesometrium


Cervix of Uterus
(longitudinal section)
cervical canal
body of uterus
vagina
fornix
external uterine opening


bursa opening
mesovarium
infundibulum
ovary
uterine tube
mesosalpinx
Ovanian Bursa Transected

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.

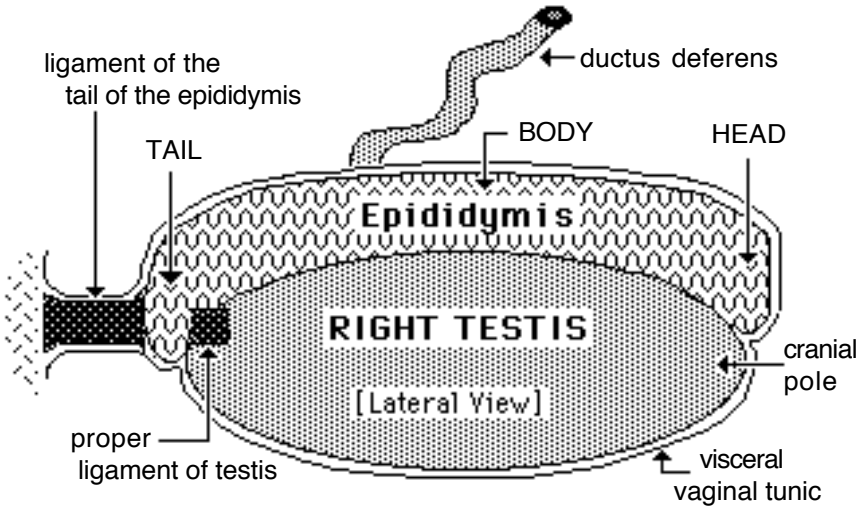
Epididymis:

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)
glans (corpus spongiosum glandis)
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 the "tie" during 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.

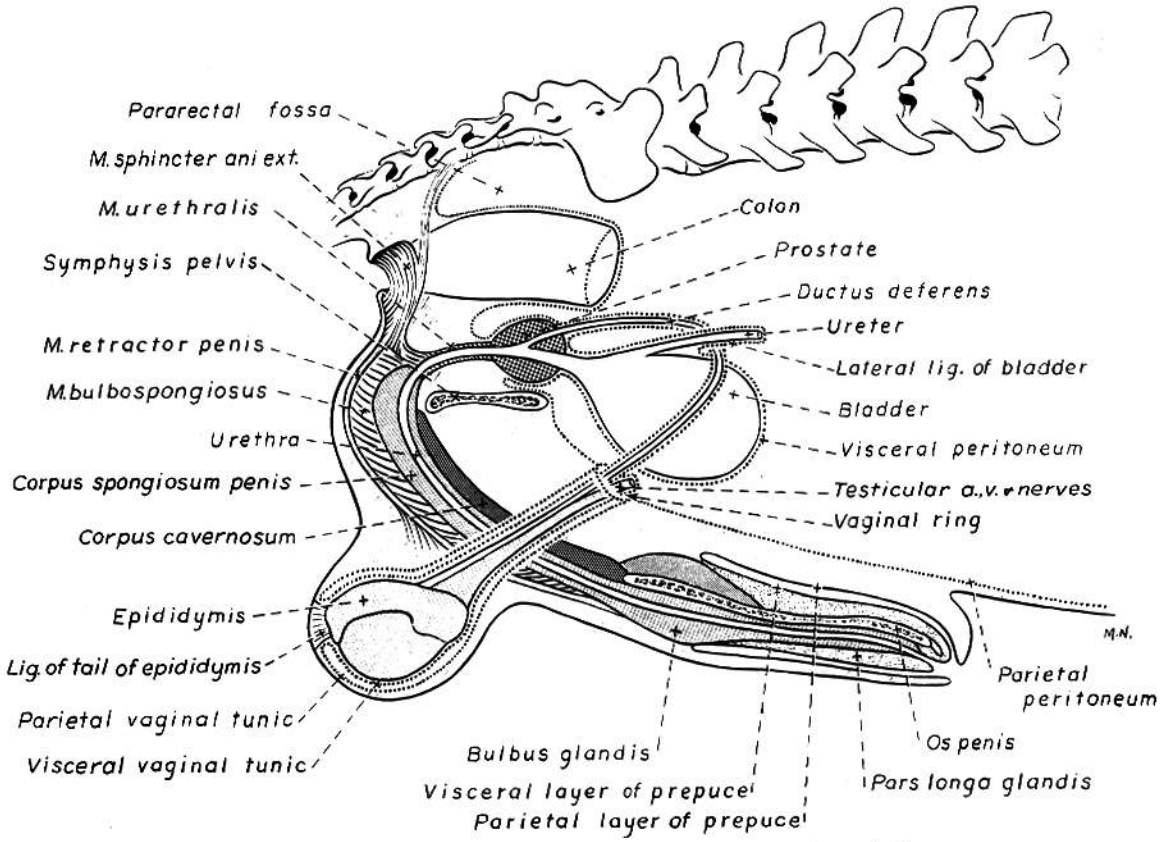
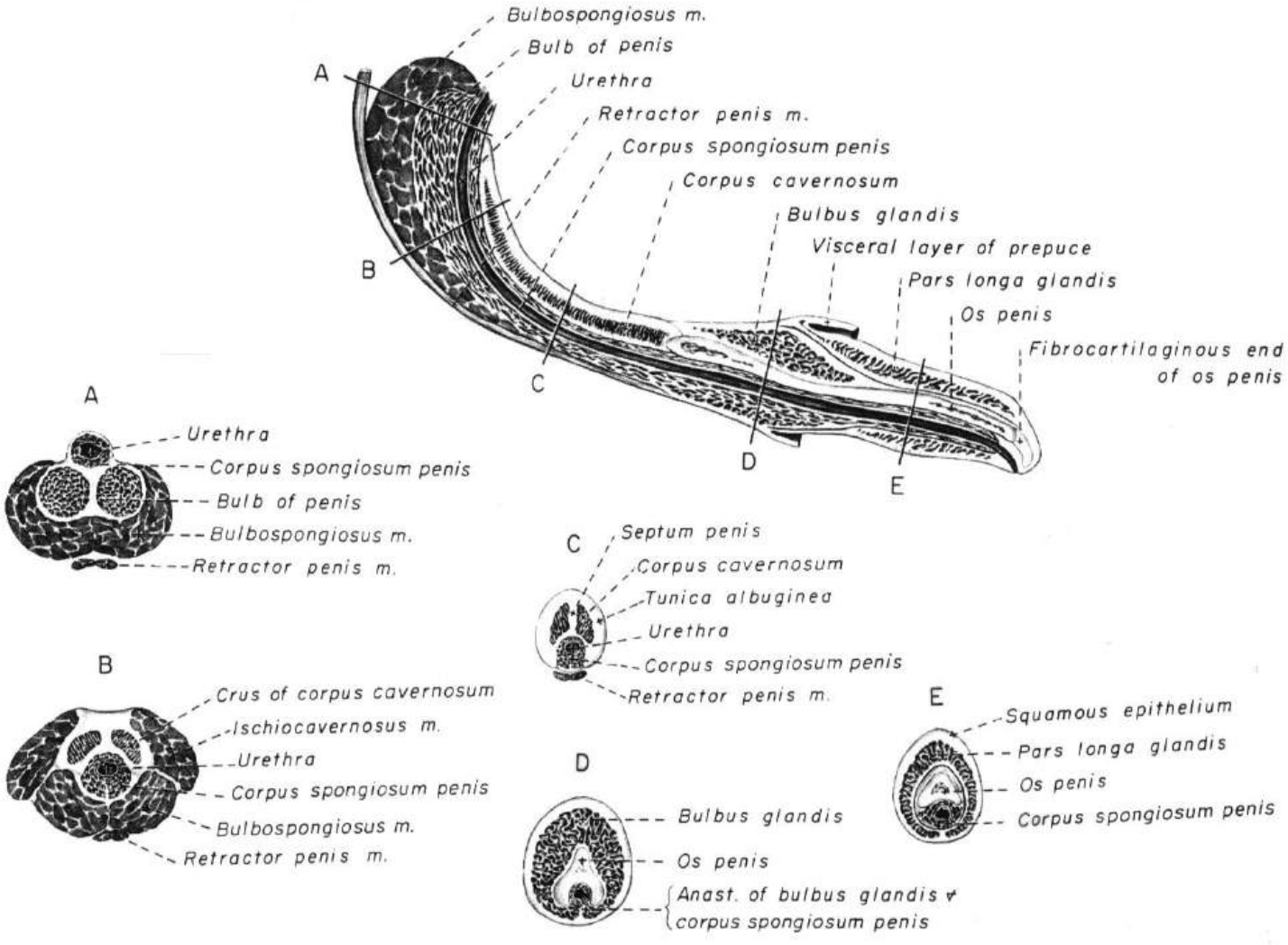


Figure 9–11. Diagram of peritoneal reflections and the male genitalia.



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)
atlanto-axial 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, medical, & rostral compartments)
maxillary recess (sinus) — contains lateral nasal gland

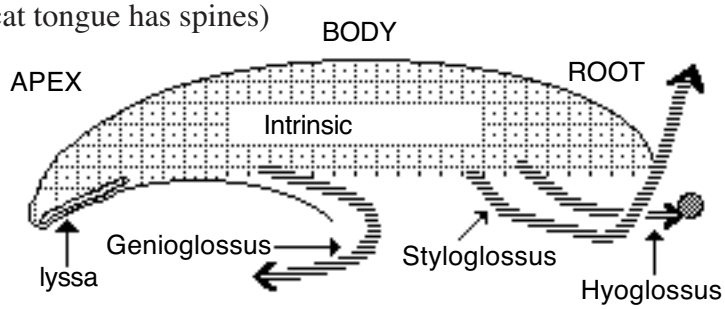
Hyoid apparatus = chain of bones attached to the skull
— provides muscle attachment sites for movement of the tongue & larynx
— anchored by geniohyoideus m. (rostrally) and sternohyoideus m. (caudally)

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

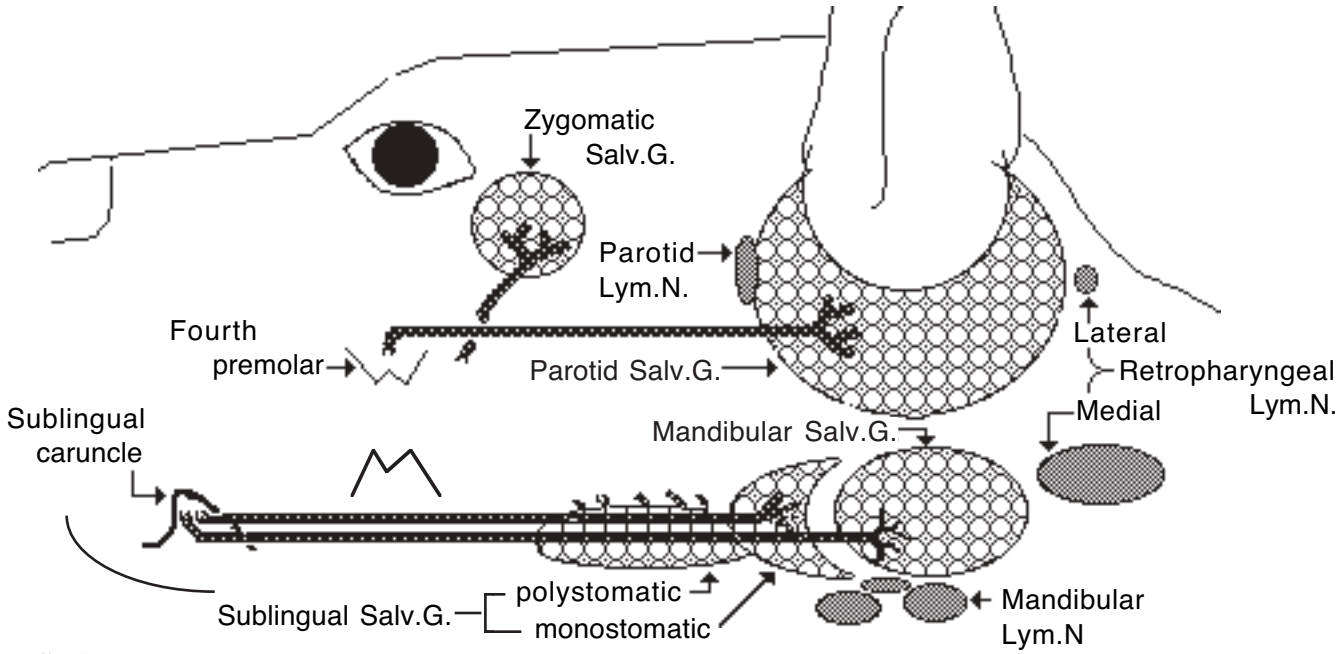
Oral cavity: vestibule (labial vestibule & buccal vestibule) — *TEETH* — *TEETH* — oral cavity proper (communicates caudally with pharynx)

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
Note: premolars have deciduous precursors; molars do not.
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
filliform, 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 (not in carnivore nor cattle); secretion is regulated by the autonomic nervous system (parasympathetic & sympathetic)

glands :

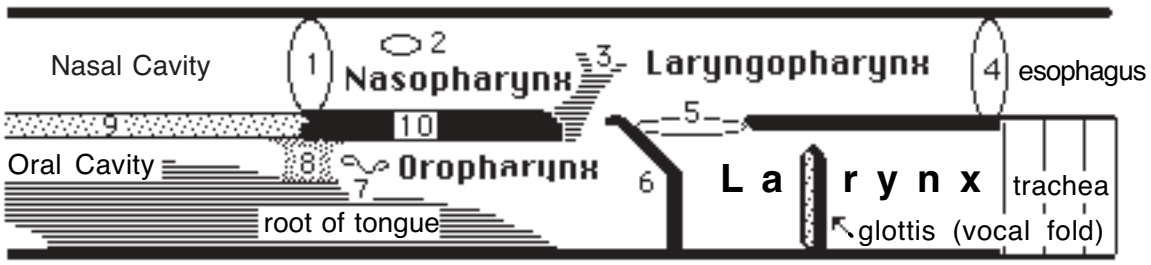
1) parotid — duct goes to upper buccal vestibule (beside upper 4th premolar)
2) zygomatic [carnivores] — ducts go to upper buccal vestibule (beside last upper tooth)
3) mandibular — duct goes to sublingual caruncle
4) sublingual: a} monostomatic gland — duct goes to sublingual caruncle
   b} polystomatic 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 = choana; 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 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.)

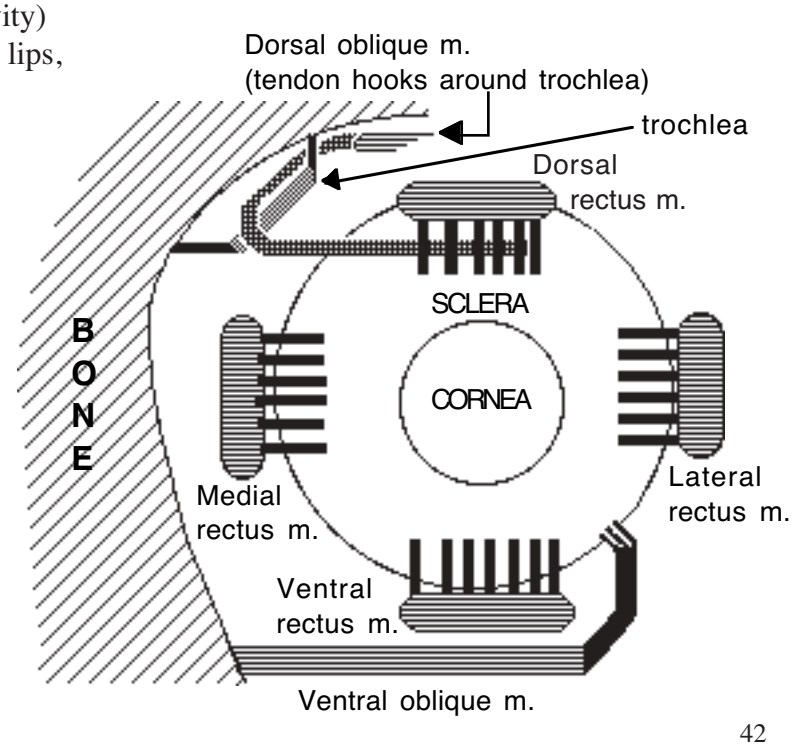
4] tongue mm. — intrinsic & extrinsic (HYPOGLOSSAL N.)

5] extrinsic eye mm. — seven muscles:

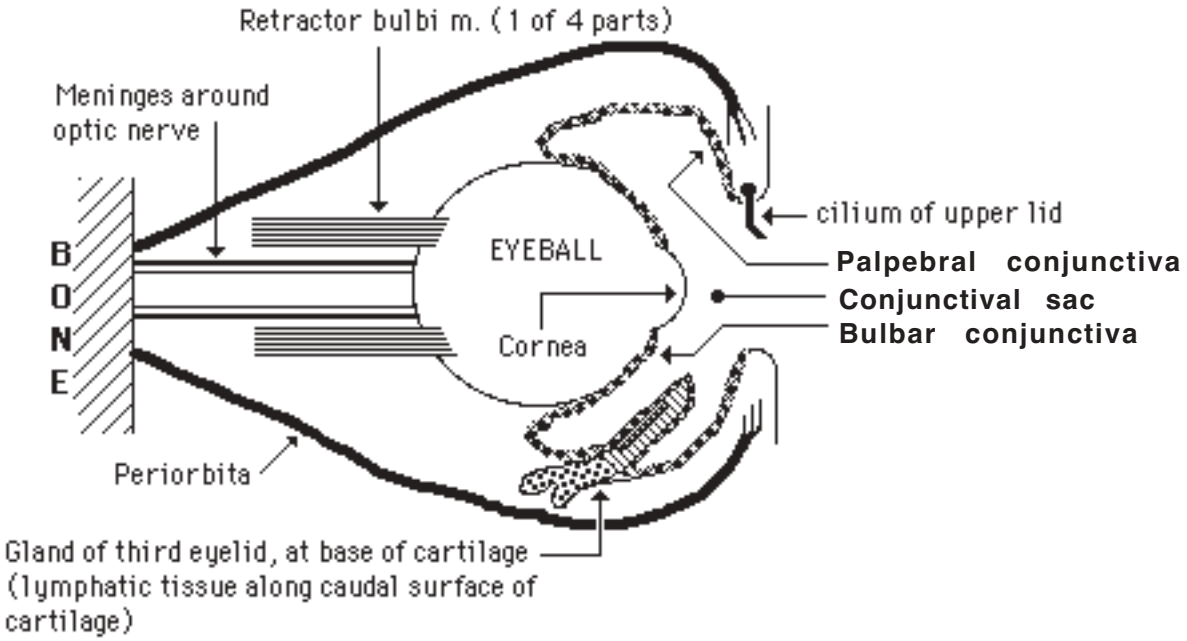
OCULOMOTOR N.
dorsal rectus m.
medial rectus m.
ventral rectus m.
ventral oblique m.

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)

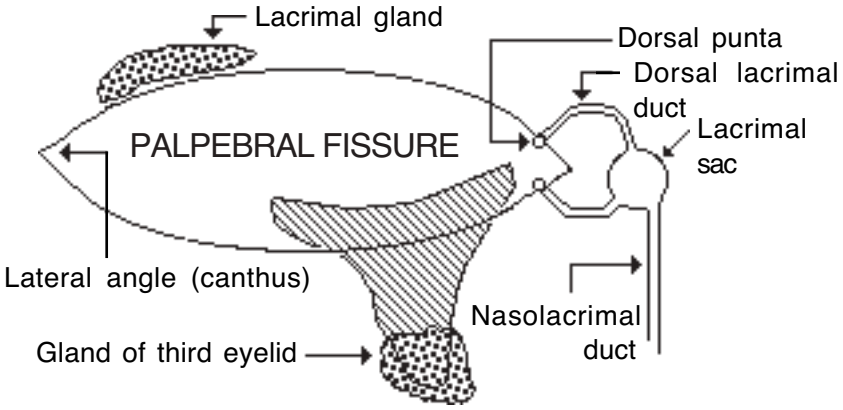


Note: Officially the third eyelid is called the *semilunar conjunctival fold* ; it is also called *nictitating membrane*

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.

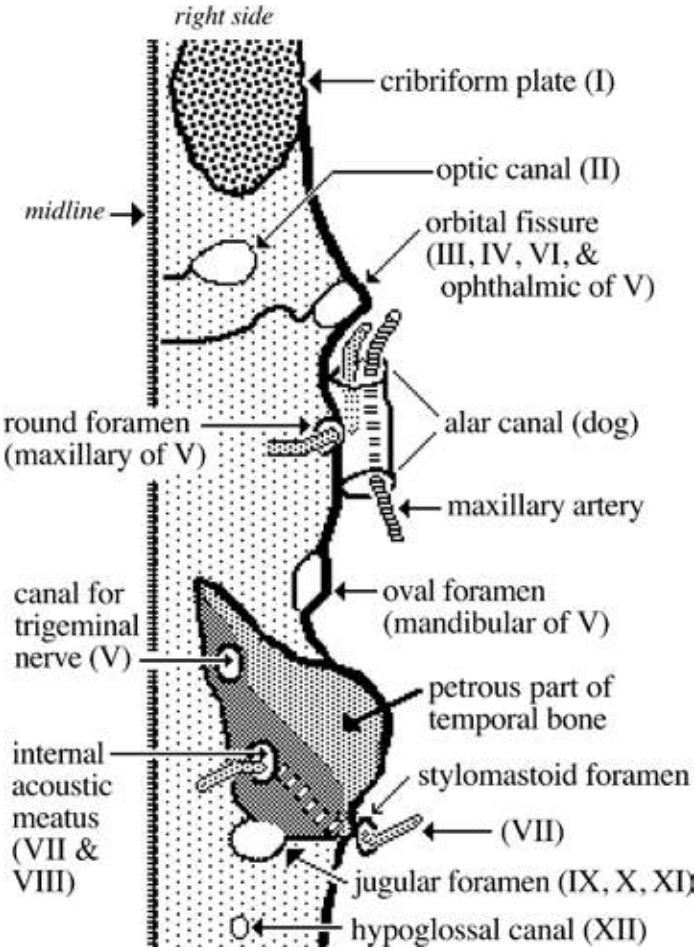
Carotid sinus = enlargement at the origin of the internal carotid a. (occipital a. in cat) that contains baroreceptors which reflexly regulate blood pressure (glossopharyngeal nerve).
Carotid body = chemoreceptors within arterial wall in the vicinity of the carotid sinus.

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" (GVE).

"Twelve" cranial nerves:

Vomeronasal Organ

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

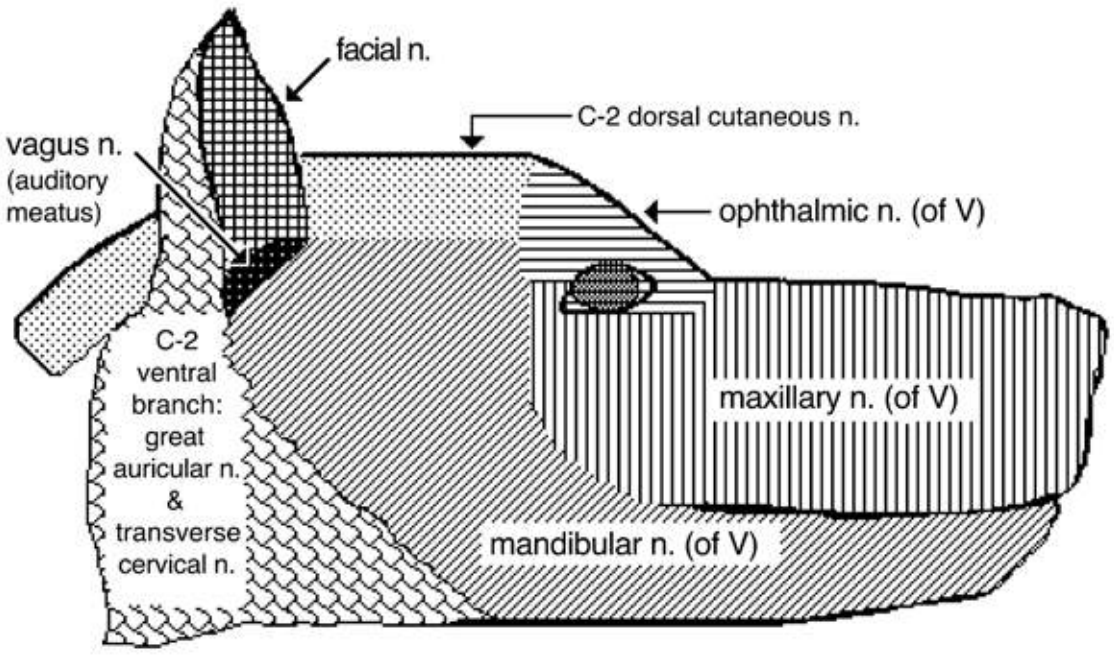
IV = Trochlear N. — smallest, exits dorsally, decussates [orbital fissure]
(SE) Dorsal oblique m.

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 pharyngeal 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 foramen & alar canal]
mandibular n.:	lower jaw, teeth, tongue; temporal region skin; also, innervates muscles of mastication	[oval foramen]

[plus mylohyoideus & tensor tympani mm.]



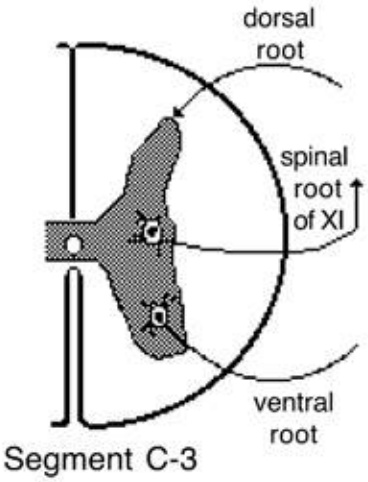
VII = Facial N. — Facial expression; taste; secretions (saliva, lacrimal, & nasal)
[int. acoustic meatus—>stylomastoid f.]
(SE) mm. of facial expression (ears, eye lids, nose, & lips) [old SVE to pharyngeal arch II]
(also, stapedius m. & caudal belly of the digastricus m.)
(VE) nasal glands, lacrimal gland, & the two ventral salivary glands (sublingual & mandibular)
[postganglionic neurons are in the pterygopalatine & mandibular 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

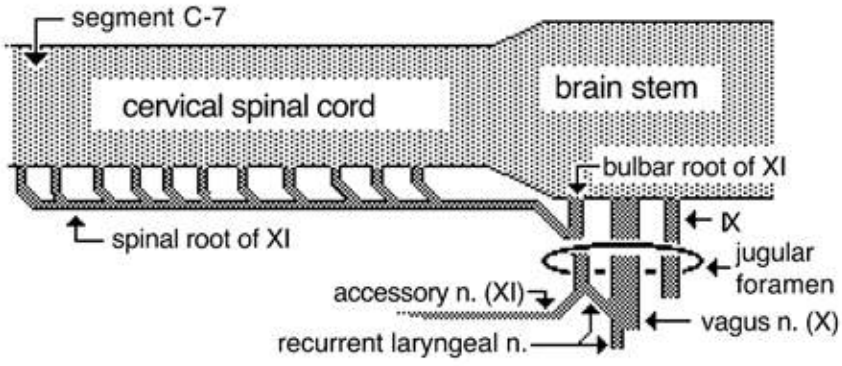
VIII = Vestibulocochlear N. — Hearing; Head acceleration (SSA) [internal acoustic meatus]
Within petrous part of temporal bone::
hearing: axons from bipolar cell bodies in spiral ganglion of the cochlea
acceleration: bipolar cell bodies in vestibular ganglion, associated with the vestibular apparatus

IX = Glossopharyngeal N. — Taste; Pharynx & middle ear 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 pharyngeal 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.: trapezius; omotransversarius; [old SVE to pharyngeal arches IV & VI]
cleidocephalicus (mastoid & cervical parts);
sternocephalicus (mastoid part);

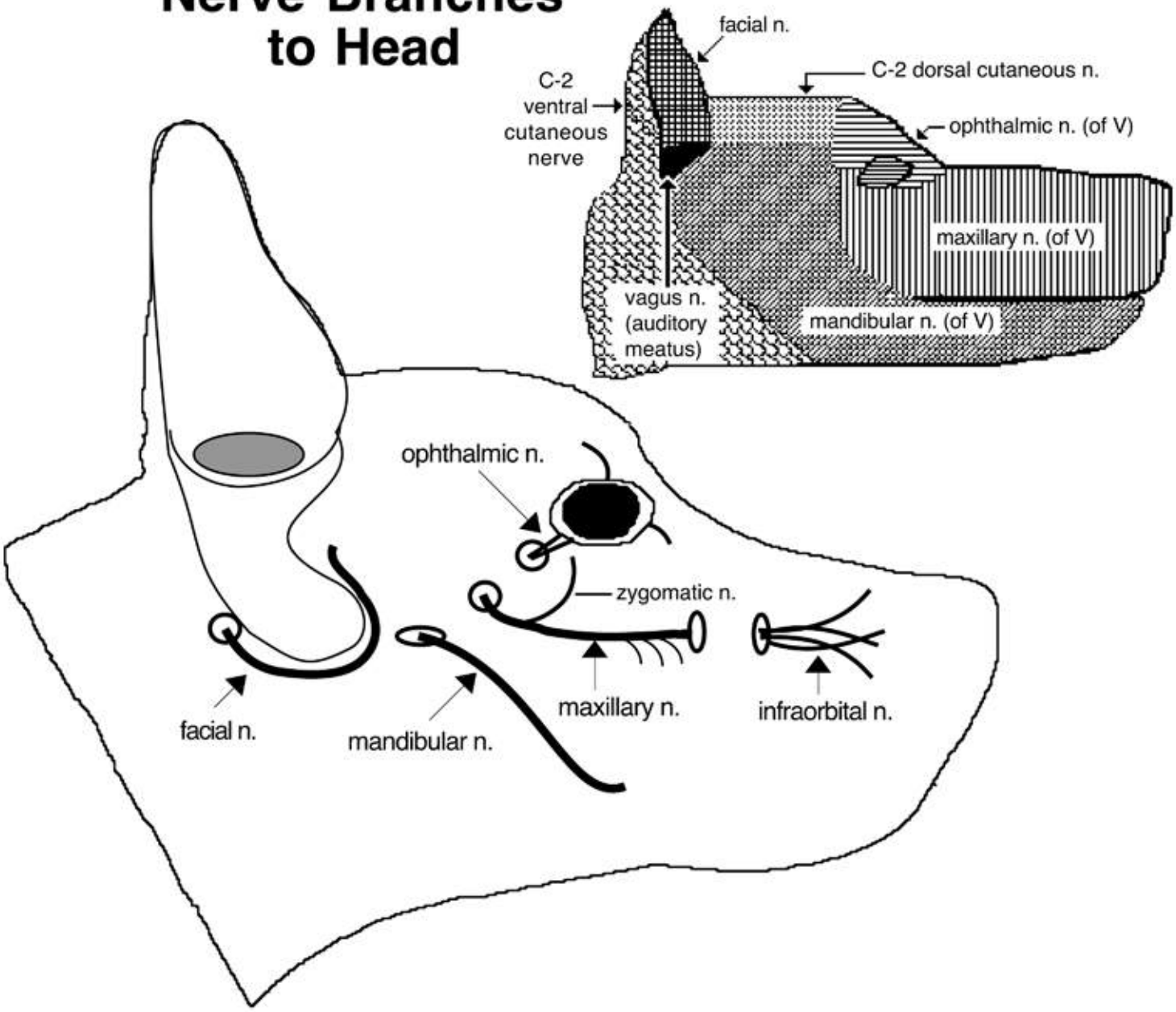


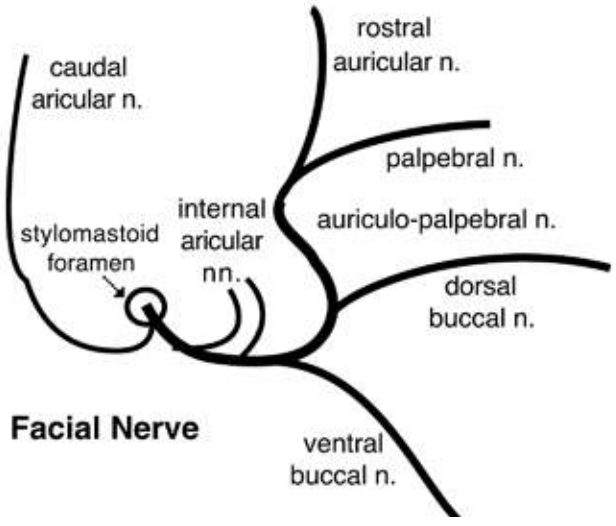


trapezius

XII = Hypoglossal N. — Tongue mm. [hypoglossal foramen]
(SE) styloglossus, hyoglossus, genioglossus & intrinsic tongue musculature)
[It also innervates the geniohyoideus m. and contibutes to innervation of sternohyoideus & sternothyroideus mm. via the *ansa cervicalis*, a neural loop between the hypoglossal nerve and the C_1 ventral branch.]

Distributions of Selected Nerve Branches to Head





Facial Nerve