Biology 223
Human Anatomy and Physiology
Week 5; Lecture 1; Monday
Dr. Stuart S. Sumida

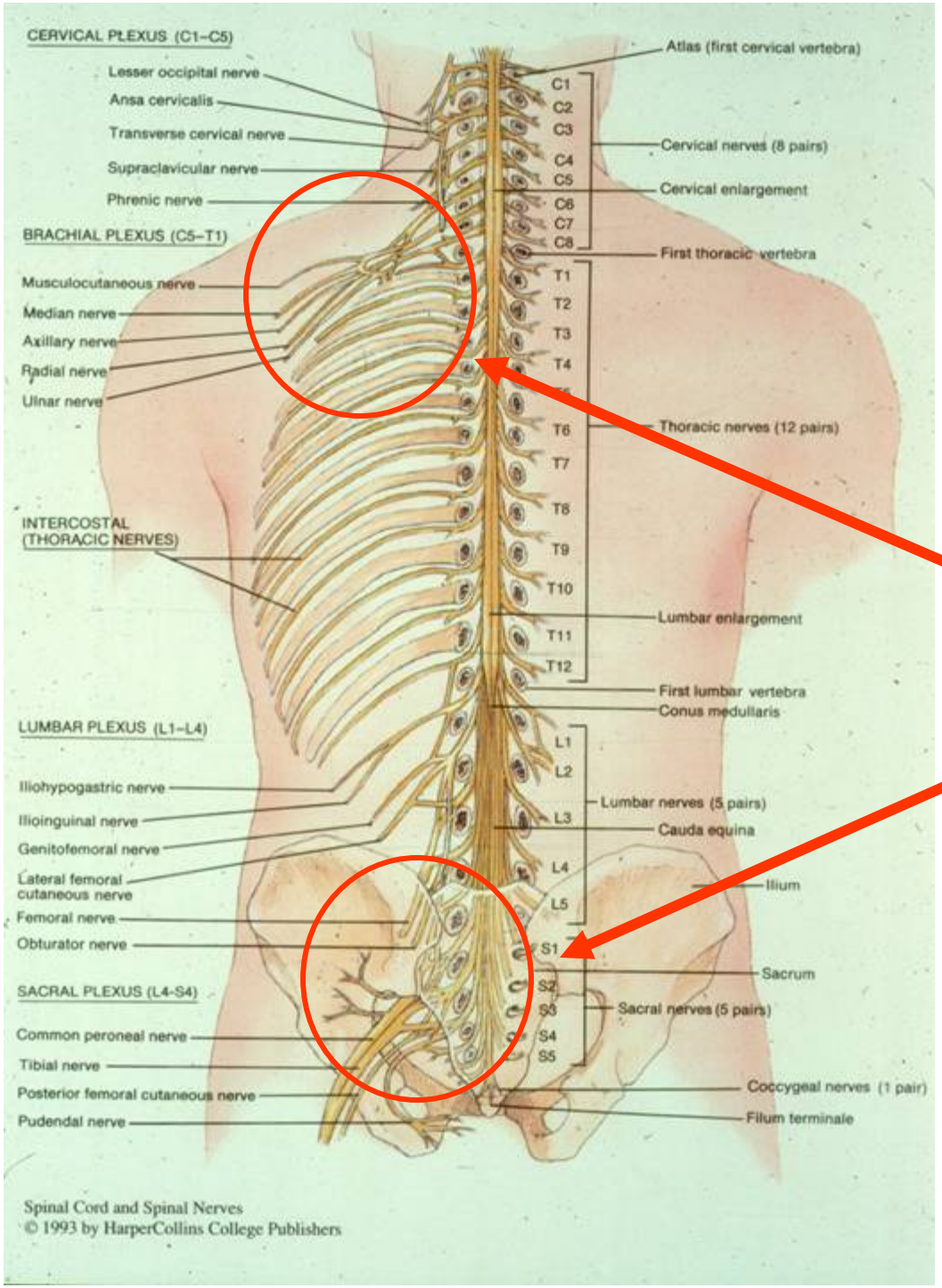
(Finish) VOLUNTARY NERVOUS SYSTEM

AUTONOMIC NERVOUS SYSTEM

MUSCLE PHYSIOLOGY

ORGANIZATION OF THE VOLUNTARY NERVOUS SYSTEM

ORGANIZATON OF A BASIC SEGMENTAL NERVE



Spinal Cord and Spinal Nerves

So...what the hell are these messes?!

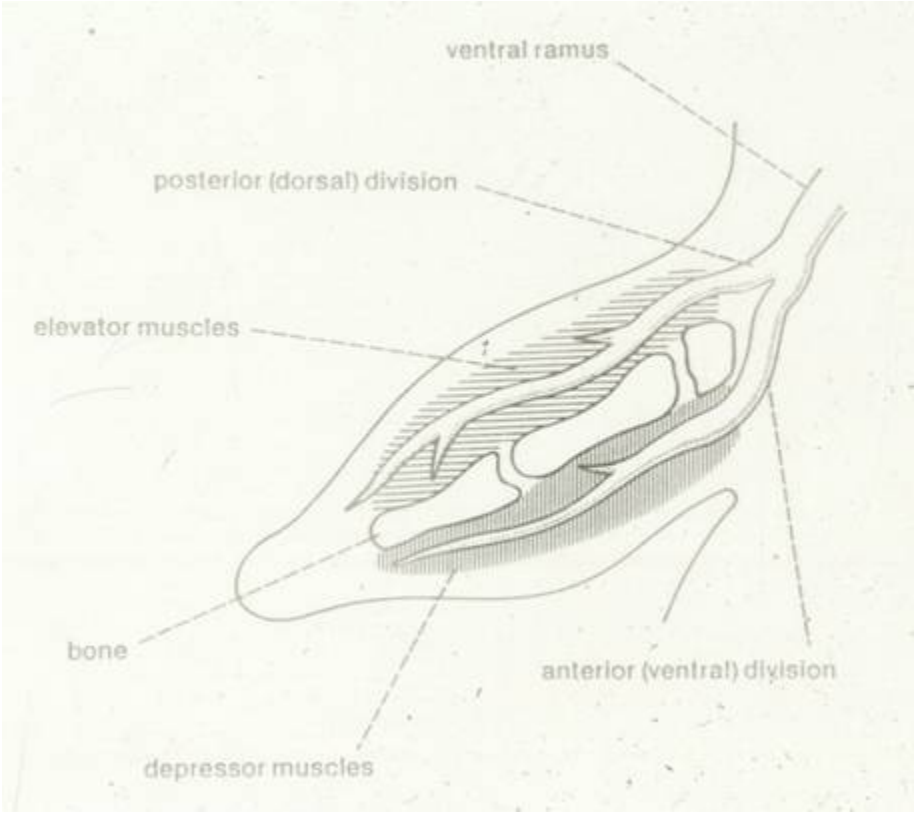
THE PLEXUS:

A complex interconnection of adjacent segmental nerves.

In this case, the ventral rami of adjacent spinal nerves are sorted and recombined so that fibers of a particular peripheral nerve contain elements from a number of segments.

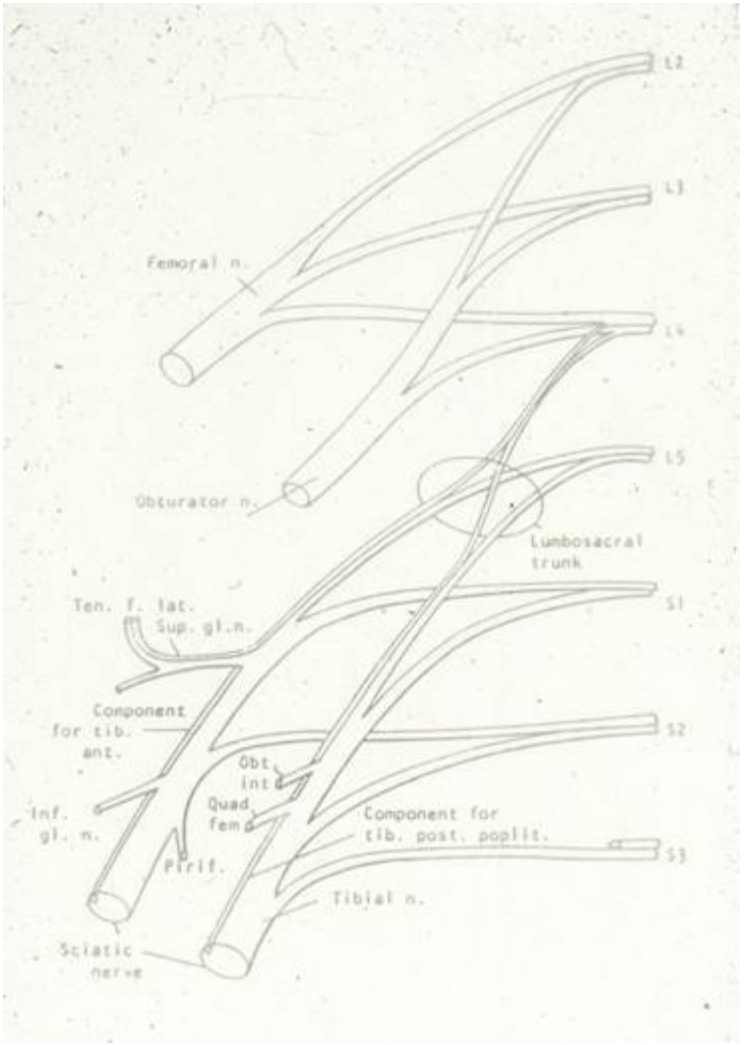
This allows a single segment to exert a greater influence than it could otherwise.

Remember, limbs are multisegmental. How many? 6
So, there should be components of six nerve segments serving each limb.



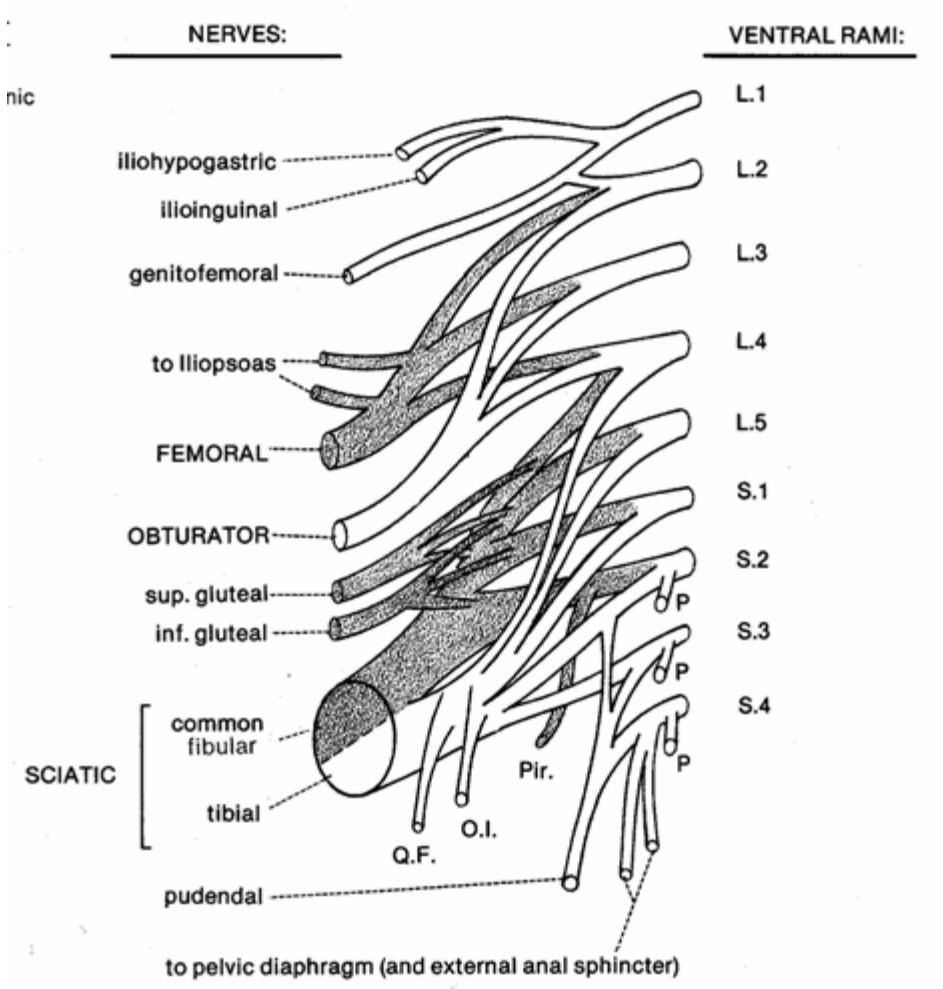
DORSAL DIVISIONS serve embryologically DORSAL muscles (extensors, elevators).

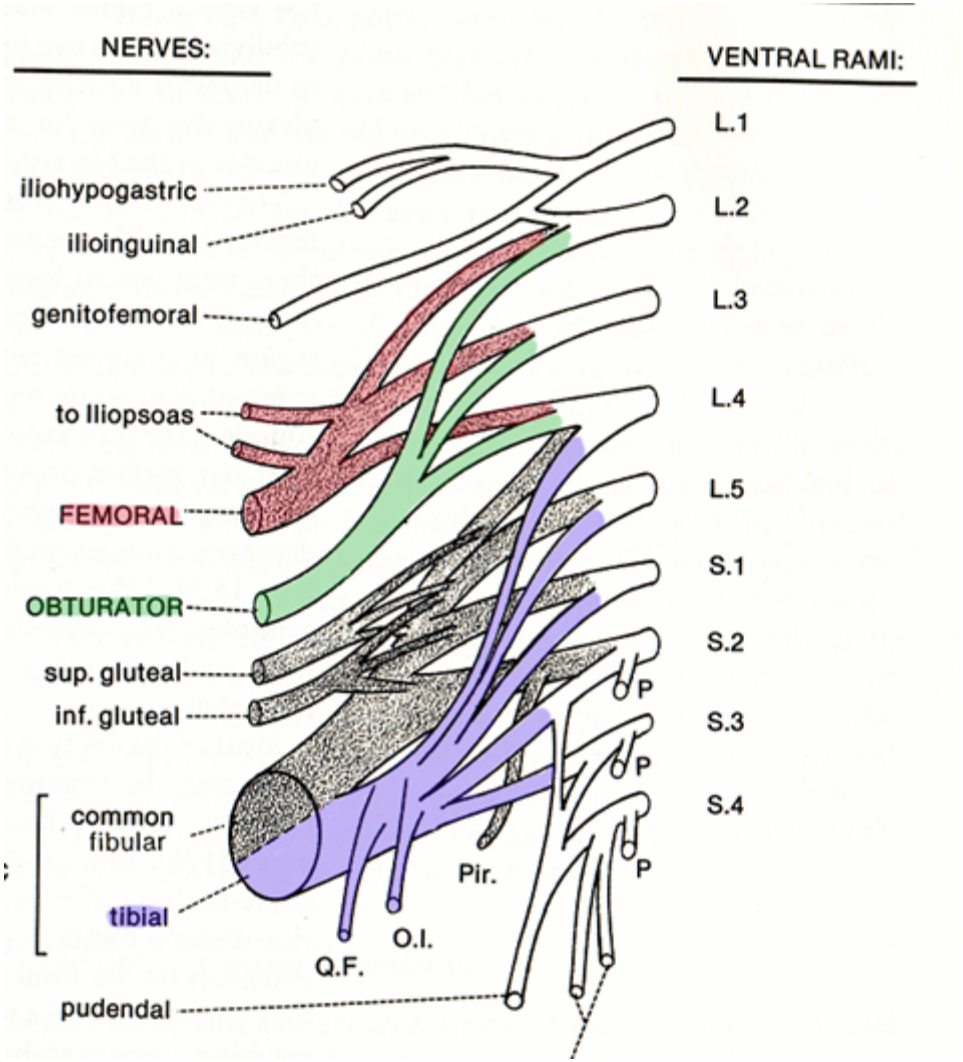
VENTRAL DIVISIONS serve embryologically VENTRAL muscles (flexors, depressors).



THE LUMBO-SACRAL PLEXUS

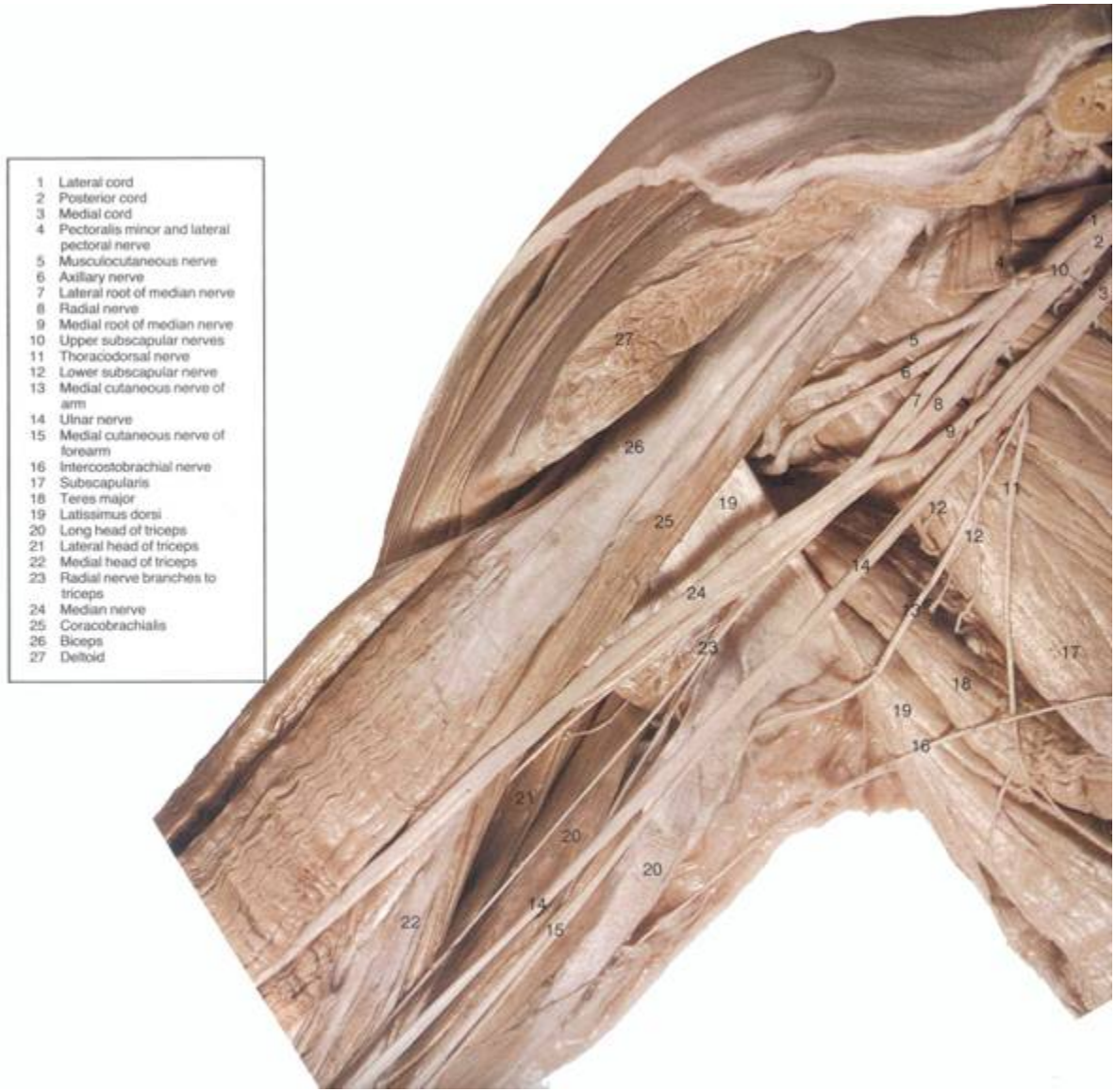
(Not as horrifying as you might think...)

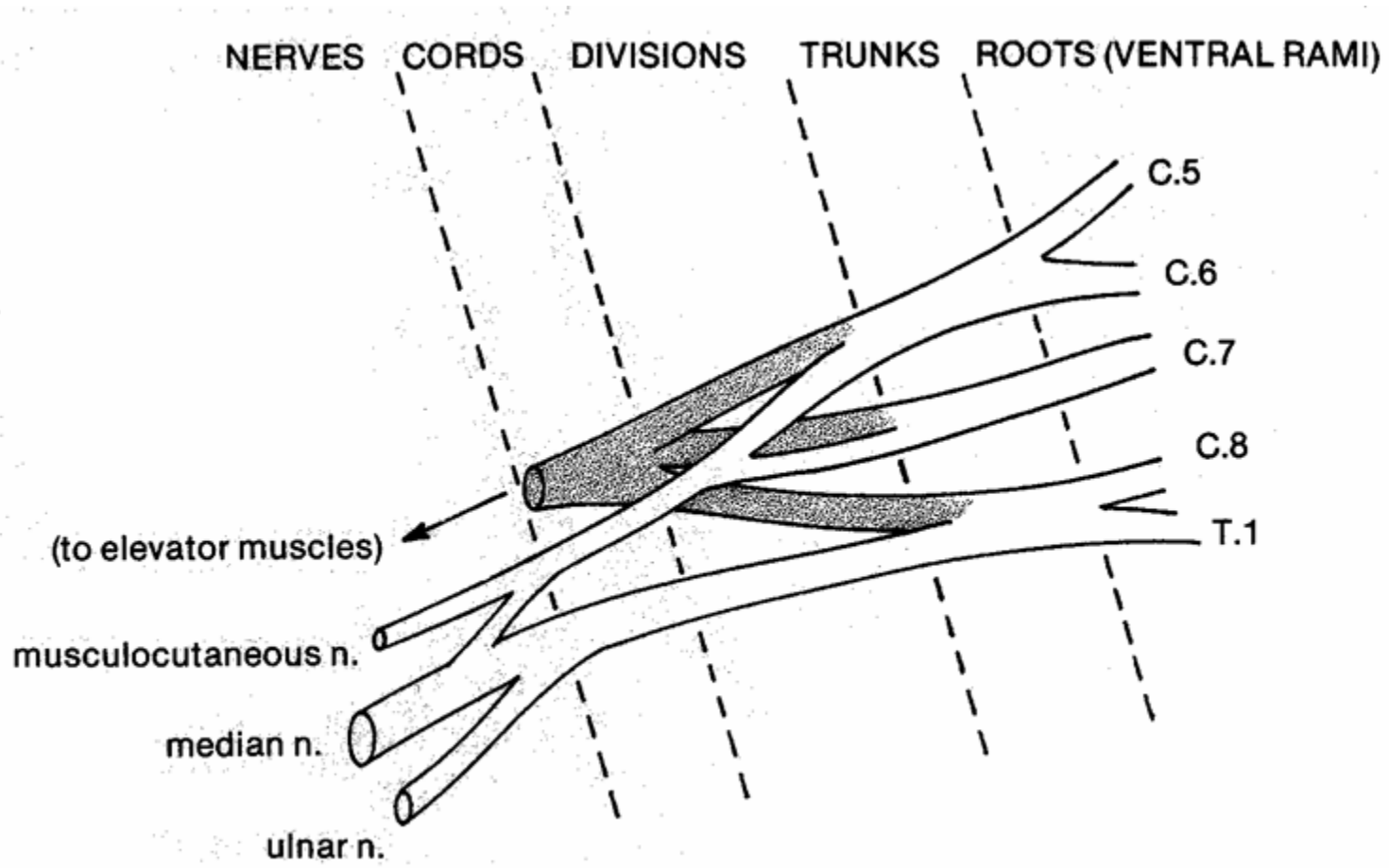

NERVES:
VENTRAL RAMI:
nic
L.1
iliohypogastric
L.2
ilioinguinal
L.3
genitofemoral
L.4
to Iliopsoas
L.5
FEMORAL
S.1
OBTURATOR
S.2
sup. gluteal
P
inf. gluteal
S.3
P
S.4
common fibular
SCIATIC
P
Pir.
tibial
O.I.
Q.F.
pudendal
to pelvic diaphragm (and external anal sphincter)


NERVES:
VENTRAL RAMI:
L.1
L.2
L.3
L.4
L.5
S.1
S.2
S.3
S.4
iliohypogastric
ilioinguinal
genitofemoral
to Iliopsoas
FEMORAL
OBTURATOR
sup. gluteal
inf. gluteal
common fibular
tibial
pudendal
Q.F.
O.I.
Pir.
P
P
P

THE BRACHIAL PLEXUS

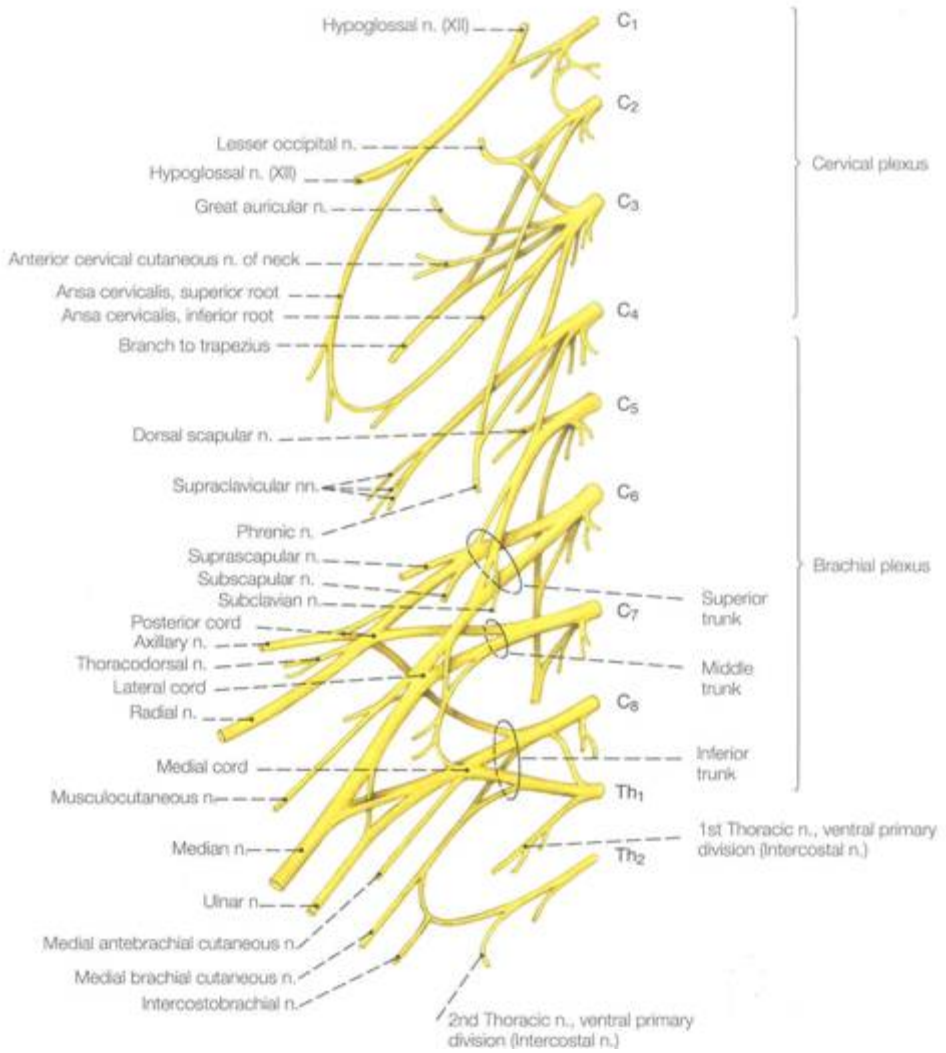
(About as horrifying as it looks...

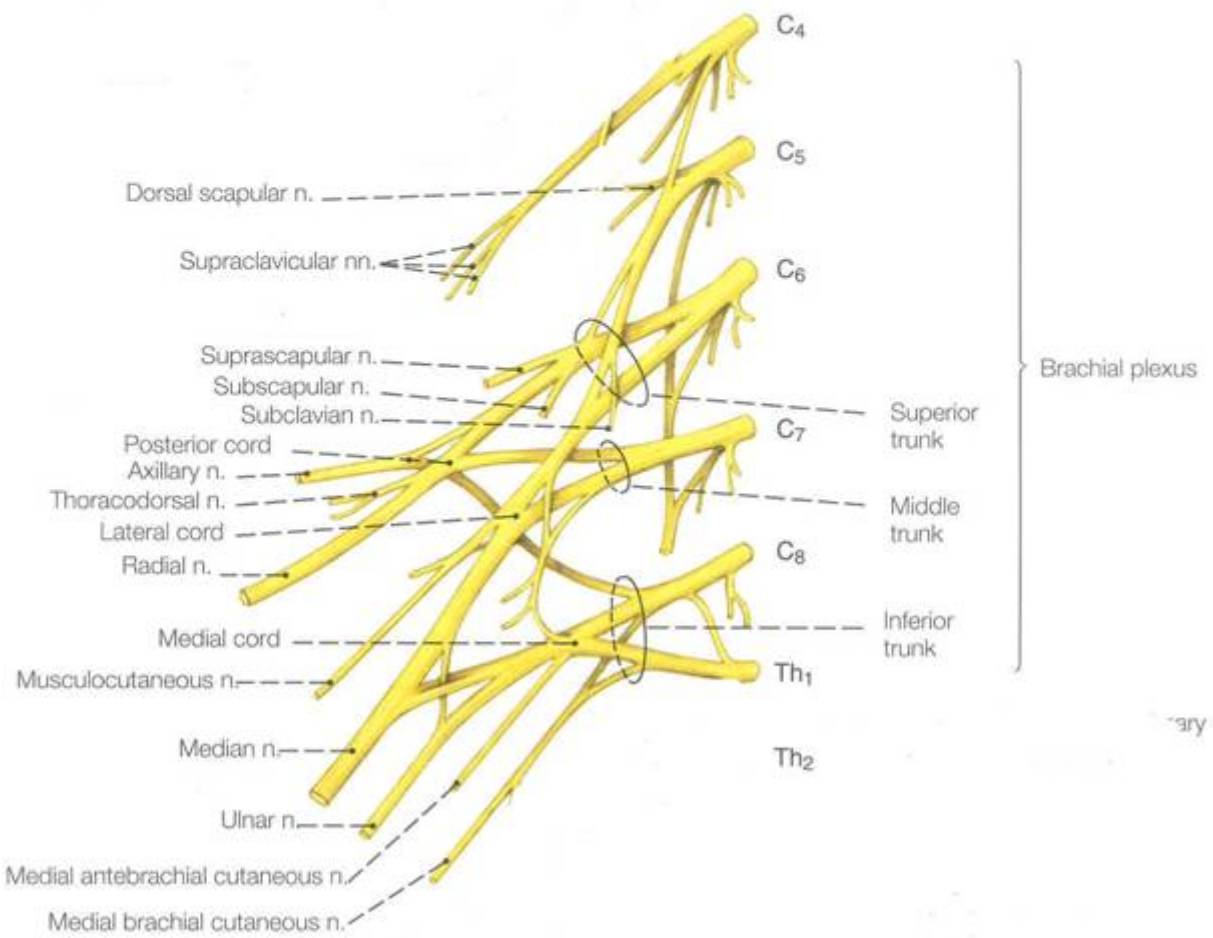



NERVES
CORDS
DIVISIONS
TRUNKS
ROOTS (VENTRAL RAMI)
C.5
C.6
C.7
C.8
T.1
(to elevator muscles)
musculocutaneous n.
median n.
ulnar n.

BREAKING DOWN THE BRACHIAL PLEXUS

5/6 SEGMENTAL ROOTS	3 TRUNKS	6 DIVISIONS	3 CORDS	5 TERMINAL NERVES
C4, C5, C6	Superior	Each of the 3 trunks divides into its component dorsal and ventral divisions (recall dorsal and ventral mm.)	All dorsal divisions unite to give POSTERIOR CORD.	AXILLARY N. RADIAL N.
C7	Middle		LATERAL & MEDIAL CORDS are ventral divisions	MUSCULOCU-TANEOUS N. MEDIAL N.
C8, T1	Inferior			ULNAR N.


Hypoglossal n. (XII)
C1
C2
Lesser occipital n.
Hypoglossal n. (XII)
Great auricular n.
C3
Anterior cervical cutaneous n. of neck
Ansa cervicalis, superior root
Ansa cervicalis, inferior root
C4
Branch to trapezius
Cervical plexus
C5
Dorsal scapular n.
Supraclavicular nn.
C6
Phrenic n.
Suprascapular n.
Subscapular n.
Subclavian n.
Brachial plexus
Superior trunk
C7
Posterior cord
Axillary n.
Thoracodorsal n.
Middle trunk
Lateral cord
C8
Radial n.
Medial cord
Inferior trunk
Musculocutaneous n.
Th1
1st Thoracic n., ventral primary division (Intercostal n.)
Median n.
Th2
Ulnar n.
Medial antebrachial cutaneous n.
Medial brachial cutaneous n.
Intercostobrachial n.
2nd Thoracic n., ventral primary division (Intercostal n.)


C4
C5
C6
C7
C8
Th1
Th2
Dorsal scapular n.
Supraclavicular nn.
Suprascapular n.
Subscapular n.
Subclavian n.
Posterior cord
Axillary n.
Thoracodorsal n.
Lateral cord
Radial n.
Medial cord
Musculocutaneous n.
Median n.
Ulnar n.
Medial antebrachial cutaneous n.
Medial brachial cutaneous n.
Superior trunk
Middle trunk
Inferior trunk
Brachial plexus

Autonomic Nervous System

Autonomic Nervous System

- Visceral Motor Component of the nervous system.
- TWO MOTOR NEURON system.

- For motor control of most intrnal organs, smooth muscle of gut and blood vessels, skin glands, cardiac muscle.

SEPARATION OF FUNCTION

- Sympathetic – Fight, flight, Fear, and F_____.
- Parasympathetic – Rest, rumination (digestion), calm

- Both involuntary

Comparisons

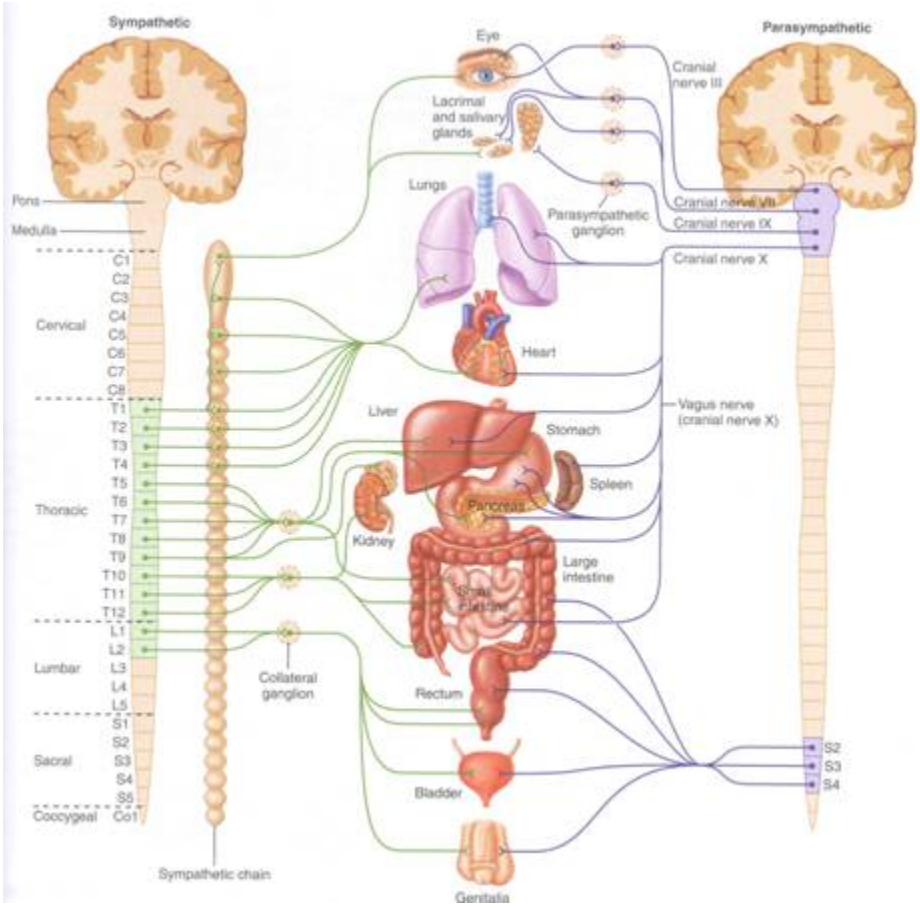
- SYMPATHETIC
- Neurotransmitter: norepinephrine
- Turn OFF most gut activities.
- Dilate blood vessels to somatopleure.
- Constrict blood vessels to splanchnopleure.

- PARASYMPATHETIC
- Neurotransmitter: acetylcholine
- Turn ON most gut activities.
- Constrict blood vessels to somatopleure and brain.
- Dilate blood vessels to splanchnopleure.

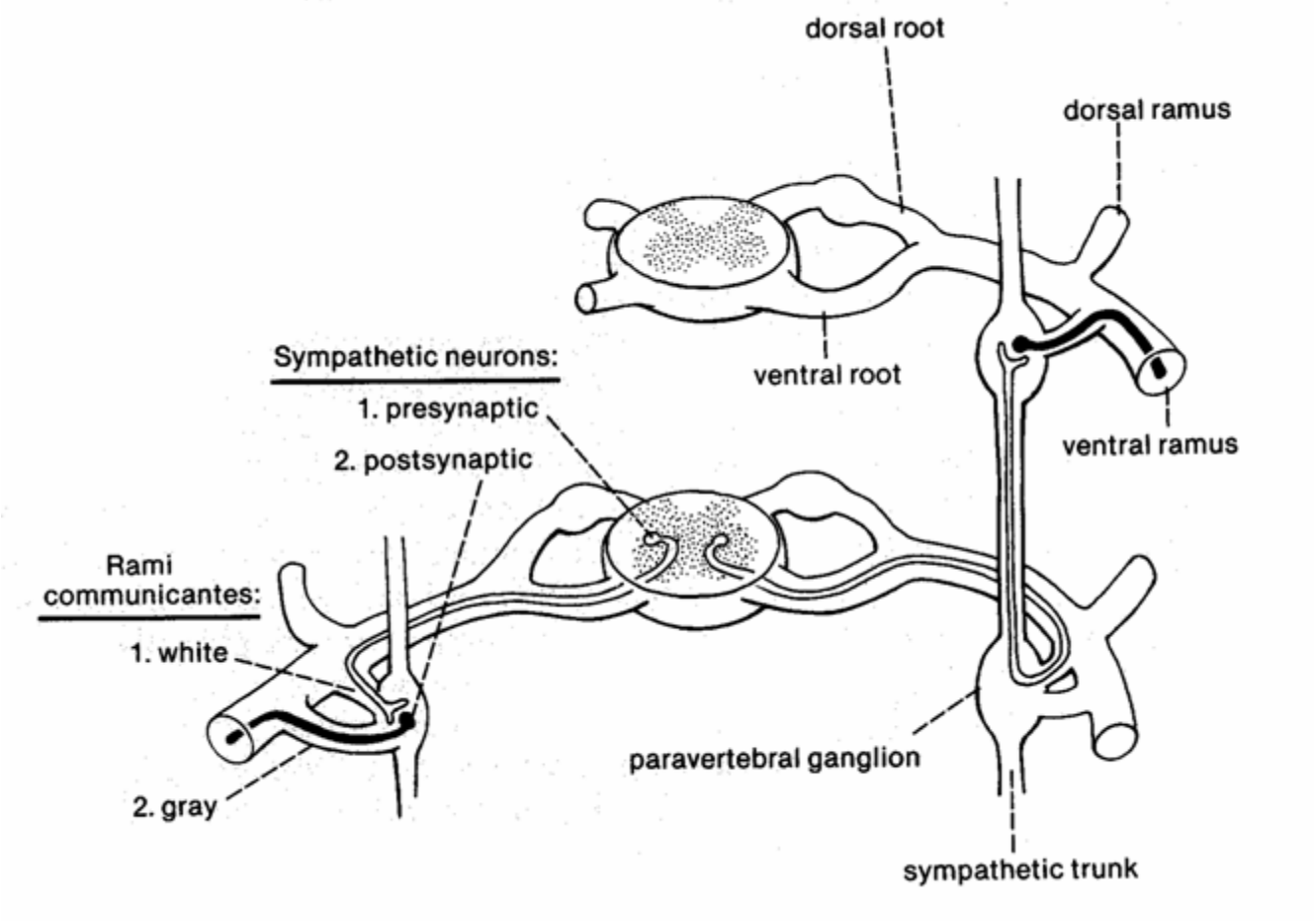
AUTONOMIC FIBER PLACEMENT:

Sympathetic – “Thoracolumbar” (T1-L2)

Parasympathetic = “Cranio-sacral” (Cnn III, VII, IX, X; S2-4



A typical sympathetic nerve



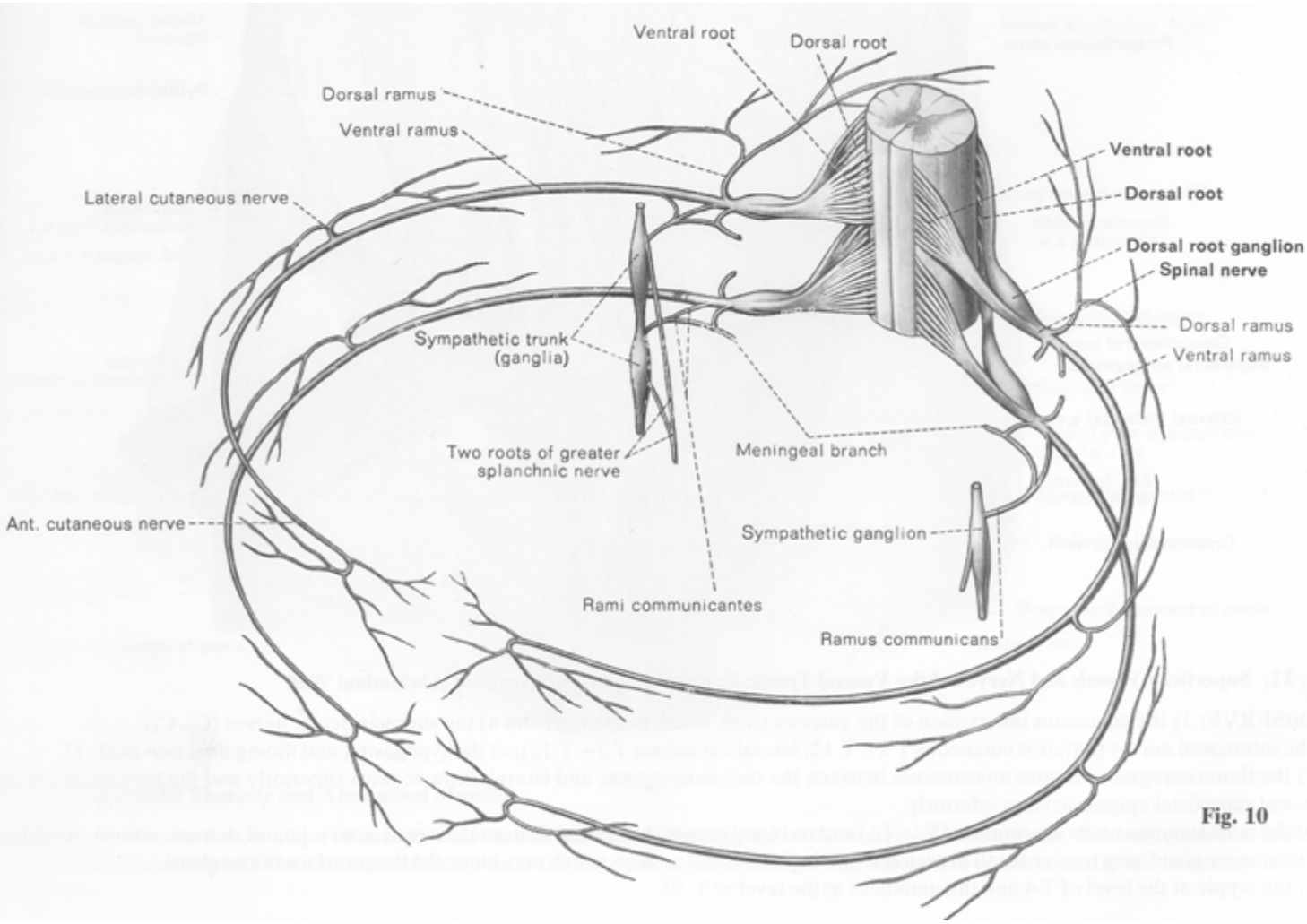
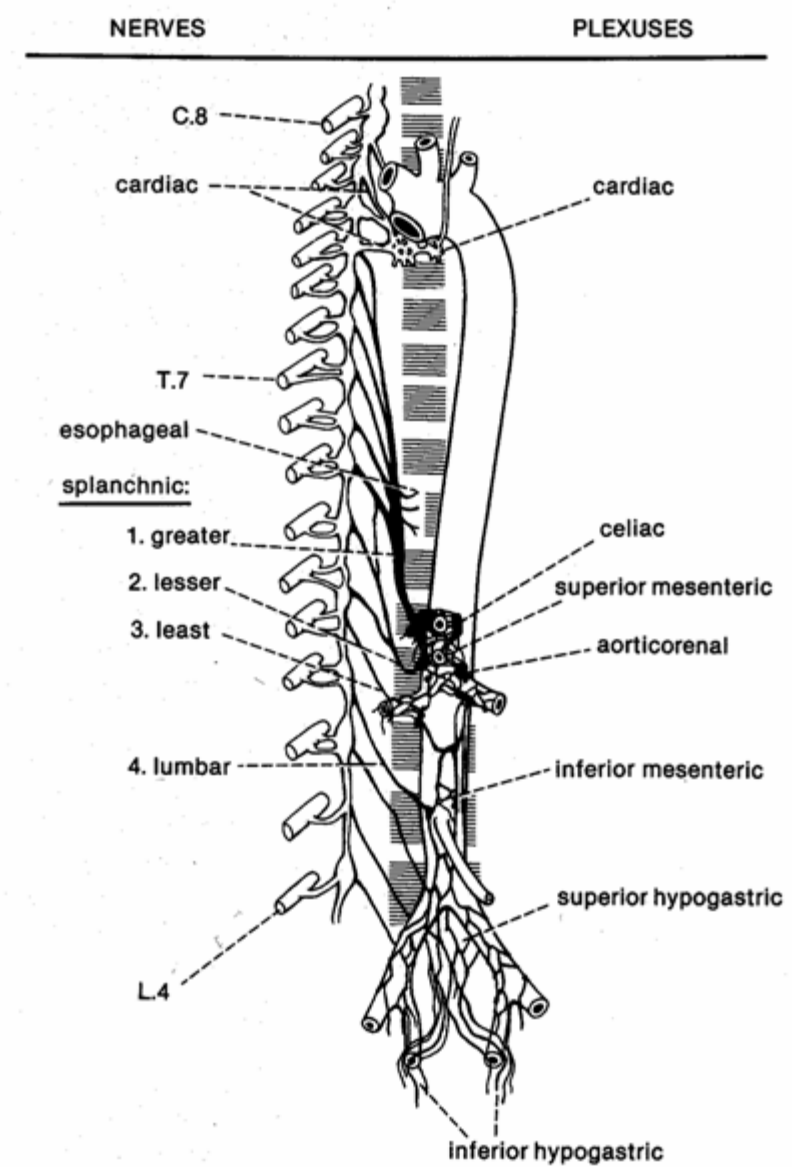
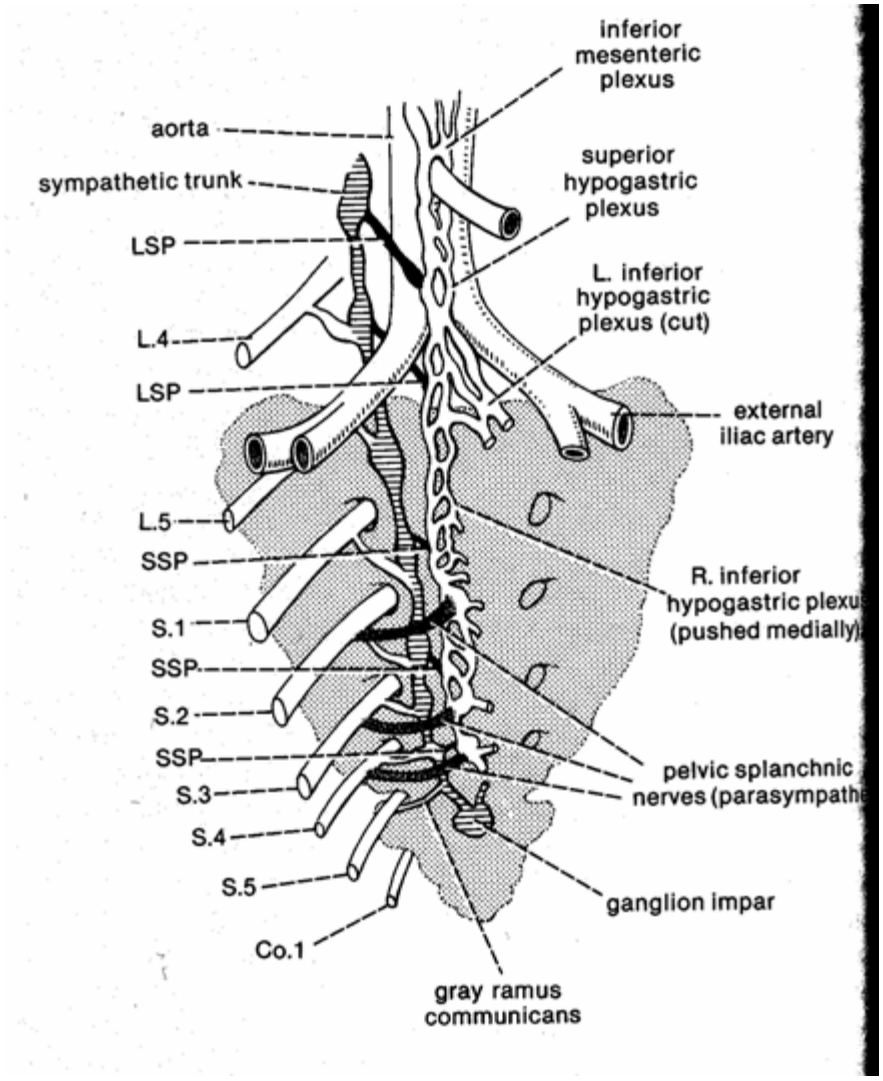

Ventral root
Dorsal root
Dorsal ramus
Ventral ramus
Lateral cutaneous nerve
Ventral root
Dorsal root
Dorsal root ganglion
Spinal nerve
Dorsal ramus
Ventral ramus
Sympathetic trunk
(ganglia)
Two roots of greater
splanchnic nerve
Meningeal branch
Ant. cutaneous nerve
Sympathetic ganglion
Rami communicantes
Ramus communicans

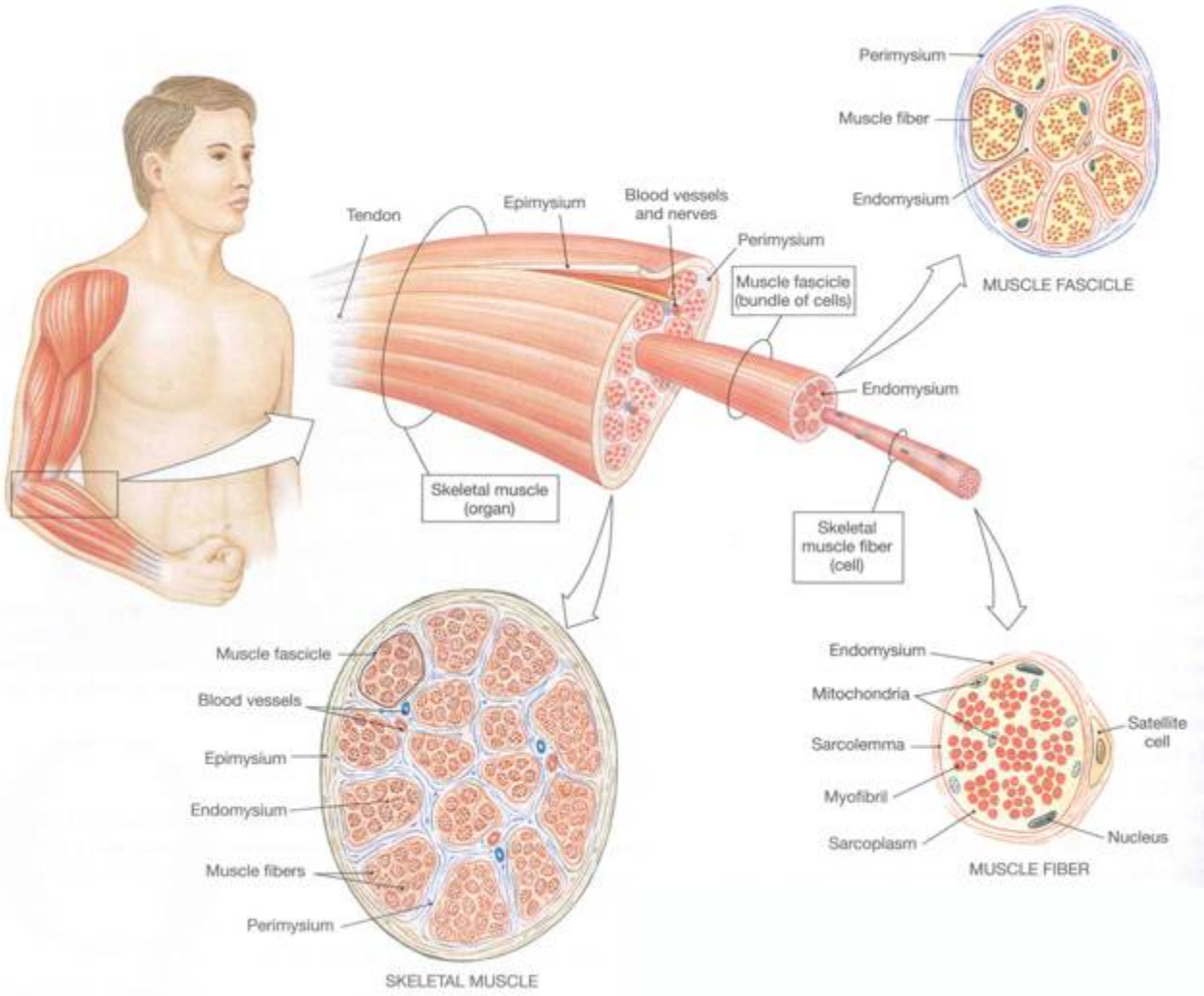
Fig. 10


NERVES
PLEXUSES
C.8
cardiac
cardiac
T.7
esophageal
splanchnic:
1. greater
2. lesser
3. least
celiac
superior mesenteric
aorticorenal
4. lumbar
inferior mesenteric
superior hypogastric
L.4
inferior hypogastric


inferior mesenteric plexus
aorta
sympathetic trunk
superior hypogastric plexus
LSP
L. inferior hypogastric plexus (cut)
L.4
LSP
external iliac artery
L.5
SSP
R. inferior hypogastric plexu
(pushed medially)
S.1
SSP
S.2
SSP
pelvic splanchnic
S.3
nerves (parasympath
S.4
S.5
ganglion impar
Co.1
gray ramus communicans

MUSCLE:

MICROSCOPIC STRUCTURE & PHYSIOLOGICAL FUNCTION


Perimysium
Muscle fiber
Endomysium
MUSCLE FASCICLE
Tendon
Epimysium
Blood vessels and nerves
Perimysium
Muscle fascicle (bundle of cells)
Endomysium
Skeletal muscle (organ)
Skeletal muscle fiber (cell)
Muscle fascicle
Blood vessels
Epimysium
Endomysium
Muscle fibers
Perimysium
SKELETAL MUSCLE
Endomysium
Mitochondria
Satellite cell
Sarcolemma
Myofibril
Sarcoplasm
Nucleus
MUSCLE FIBER

STURCTURE	SURROUNDED BY (CONNECTIVE TISSUE)	MADE UP OF MANY
Muscle	Epimysium	Muscle Bundles
Muscle Bundle	Perimysium	Muscle Fibers (Muscle Cells)
Muscle Fiber	Endomysium	Muscle Fibrils
Muscle Fibril		Sarcomeres
Sarcomere		Muscle Filaments
Muscle Filaments		Proteins

General Functions of Muscle

- Movement/Stability of Somatopleure
- Movement of Splanchnopleure
- Heat Production (“muscular thermogenesis”
- Coelomic pressurization
- Heartbeat
- Structural integrity of blood vessels
- Communication (facial muscles)

MUSCLE CELL TYPES

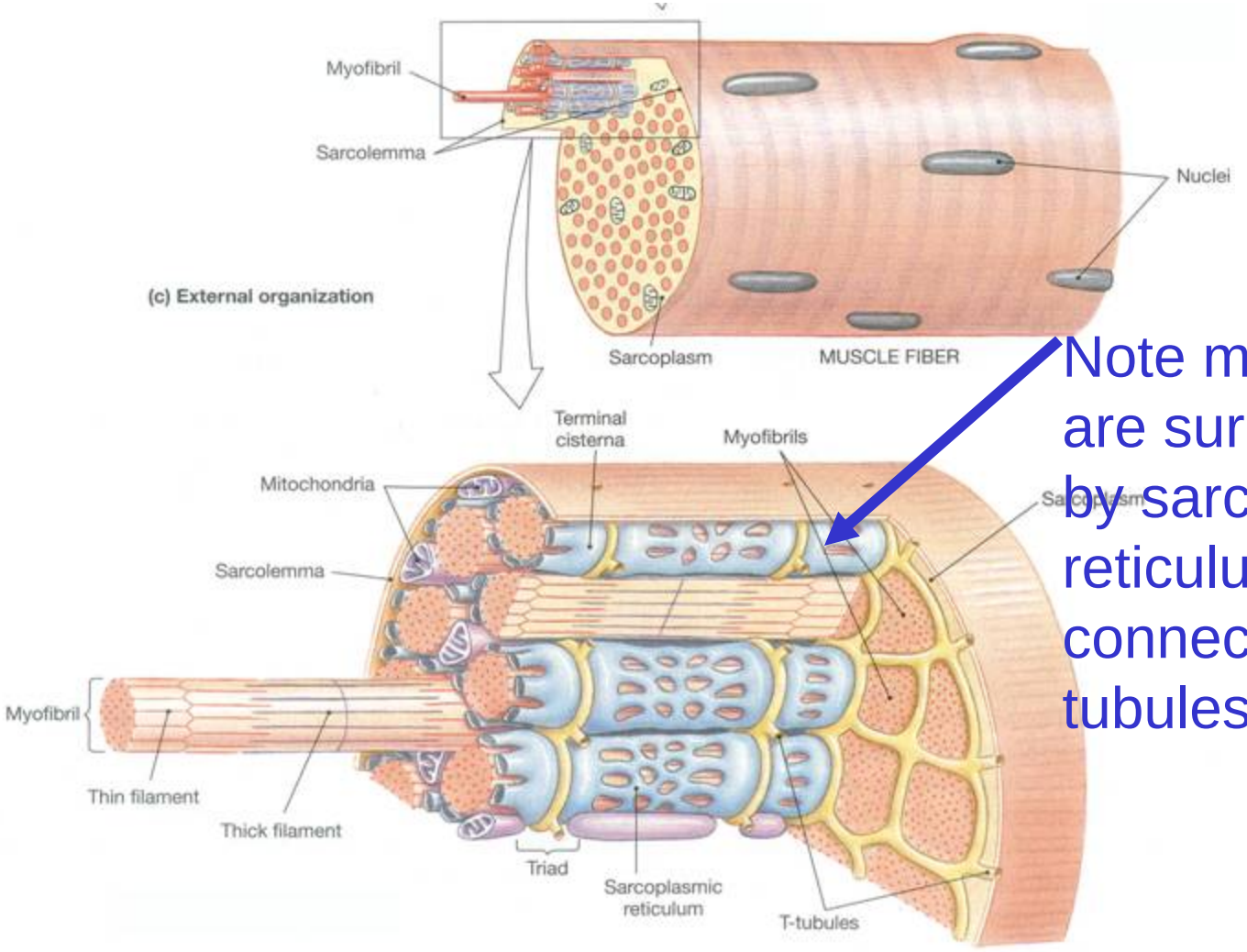
Striated	Multinucleate	Striations
Smooth	Uninucleate	No visible striations
Cardiac	Uninucleate	Striations

SMOOTH MUSCLE (as opposed to striated)

- Uninucleate
- Not as long as striated muscles
- Sarcoplasmic reticulum not as well developed
- Lack striations
- Contract more slowly
- Contraction can continue for long periods of time (tonus).
- More stamina

MYOFIBRILS

- Myofibrils are grouped in parallel with one another within a muscle cell.
- The working units of the muscle cell.
- What gives ‘striated muscle’ its striated or striped appearance.
- Made up of many components laid end-to-end called SARCOMERES.
- Sarcomeres are made of yet smaller components called MYOFILAMENTS.

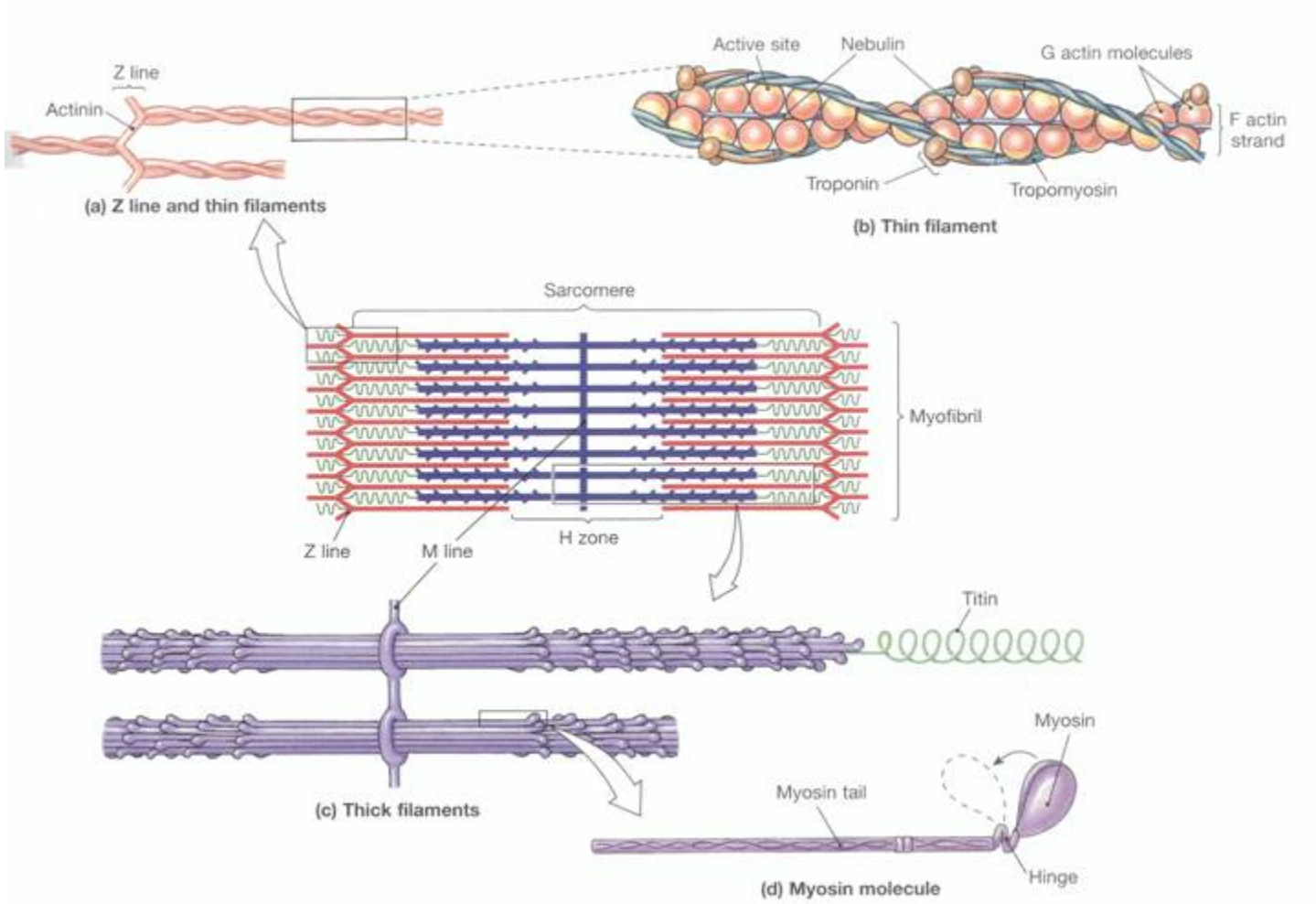


Note muscle cells are surrounded by sarcoplasmic reticulum which connects to T-tubules.

Striated muscle

MYOFILAMENTS

- Two major types, THIN AND THICK.
- Called ACTIN and MYOSIN respectively.
- They are laid down PARALLEL to one another so they can SLIDE PAST ONE ANOTHER.
- One bundle of these thick and thin myofilaments is called a SARCOMERE.


Z line
Actinin
(a) Z line and thin filaments
Active site
Nebulin
G actin molecules
F actin strand
Troponin
Tropomyosin
(b) Thin filament
Sarcomere
Myofibril
Z line
M line
H zone
Titin
(c) Thick filaments
Myosin
Myosin tail
Hinge
(d) Myosin molecule

SARCOPLASMIC RETICULUM AND T-TUBULES - 1

- Each myofibril within a muscle cell is surrounded by network of tubes and sacs.
- These tubes & sacs transmit the continuation of the nerve impulse to the muscle cell.
- Network = specialized membrane-bound organelle called SARCOLASMIC RETICULUM.

SARCOPLASMIC RETICULUM AND T-TUBULES - 2

- SARCOLASMIC RETICULUM contains Ca^{2+} .
- TRANSVERSE TUBULES (T-tubules) run at right angles, and connect the sarcoplasmic reticulum.
- Depolarization from neuron at neuromuscular junction carries on through the T-tubules.

ARRANGEMENT OF FILAMENTS WITHIN SARCOMERE - 1

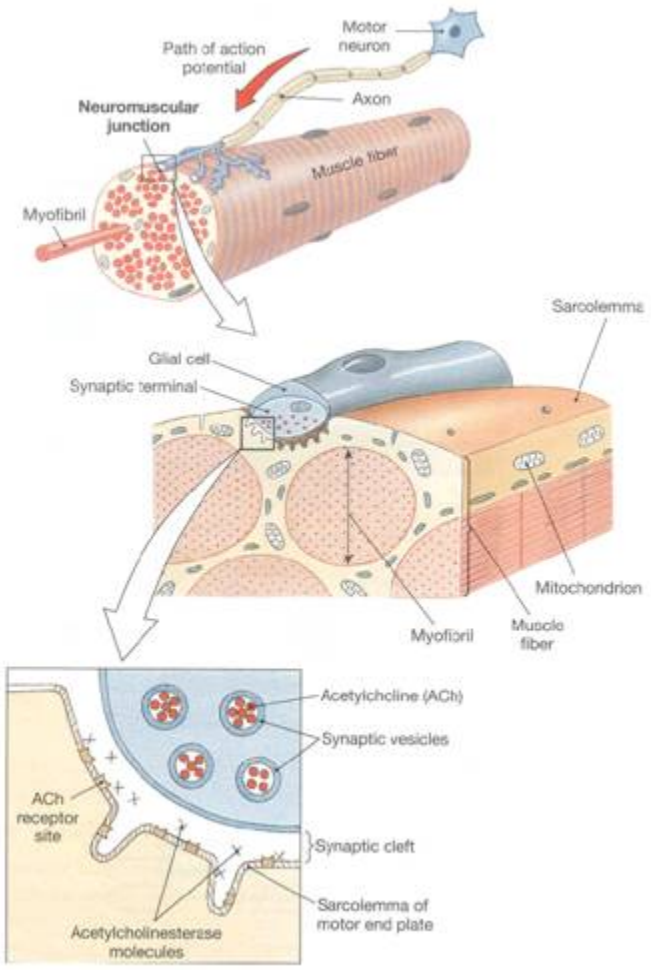
- Endplate of each sarcomere is called a Z-LINE.
- The thinner ACTIN attaches to these endplates.
- MYOSIN is laid down between the actin.
- Portion of the actin that doesn't overlap with myosin shows up as lighter looking, and is called the I-BAND.

ARRANGEMENT OF FILAMENTS WITHIN SARCOMERE - 2

- Region where actin that do overlap with myosin shows up as darker looking, and is called the A-BAND.
- Slightly lighter region with only thick myosin (no actin overlap) is called the H-BAND.
- A SARCOMERE is defined as the region between two successive Z-lines.

NEUROMUSCULAR JUNCTION - 1

- Many muscle fibers (muscles cells) may be innervated by one motor neuron. This complex is called the MOTOR UNIT.
- Junction between neuron and muscle fiber is the NEUROMUSCULAR JUNCTION.
- Actual contact is at the MOTOR ENDPLATE.


Motor neuron
Path of action potential
Axon
Neuromuscular junction
Muscle fiber
Myofibril
Sarcolemma
Glial cell
Synaptic terminal
Mitochondrion
Myofibril
Muscle fiber
Acetylcholine (ACh)
Synaptic vesicles
ACh receptor site
Synaptic cleft
Sarcolemma of motor end plate
Acetylcholinesterase molecules

NEUROMUSCULAR JUNCTION - 2

- As with typical neuron, Ca^{2+} floods into end of neuron at NM-junction, releasing a neurotransmitter – in this case, ACETYLCHOLINE.

- Just as if it were another nerve, this causes a depolarization at the motor endplate and through the SARCOPLASMIC RETICULUM.
-
- The ACTION POTENTIAL is carried though the muscle cell via the T-tubules.

SLIDING FILAMENT MODEL - 1

- Recall parallel (thin and thick) ACTIN & MYOSIN.
- They touch one another via angled projections off of the myosin called CROSS BRIDGES.
- At end of each cross bridge is the MYOSIN HEAD.

SLIDING FILAMENT MODEL - 2

- Myosin head NEARLY touches actin, but is prevented from complete attachment by a protein called TROPONIN.
- Troponin is laced around the actin in a spiral-like manner by a structural protein called TROPOMYOSIN.

SLIDING FILAMENT MODEL - 3

- In their natural state, the cross bridges and their heads want to rock back on themselves, to cause the filaments to slide past one another.

- BUT – the troponin is in the way (sort of like a doorstop).

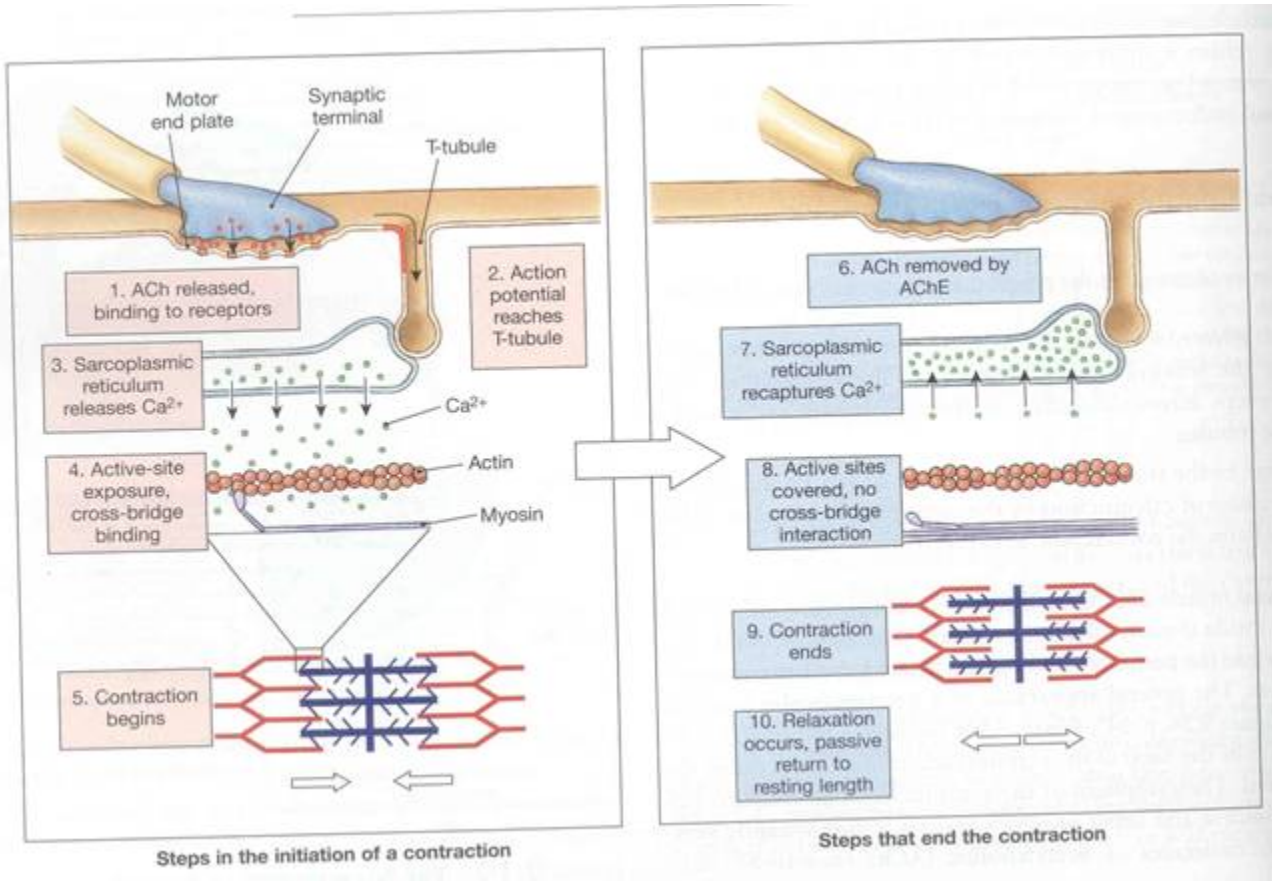
SLIDING FILAMENT MODEL - 4

- When Ca^{2+} floods in, the Ca^{2+} ions bind to the troponin complex.
- This changes its shape enough to move the troponin out of the way enough to allow the cross bridges to rock.
- Actin and Myosin slide PAST one another, shortening the sarcomere, and thus the muscle of which it is a part.

SLIDING FILAMENT MODEL - 5

- When Ca^{2+} ions move away, the troponin is again blocked.

- It takes ATP not to rock the cross bridges, but to detach & reset them.
- That’s why when death occurs and no ATP is available, you can’t move (rigormortis).



Steps in the initiation of a contraction

Steps that end the contraction