Nervous System

The Nervous System

"An organ system of specialized cells (neurons) that coordinate the actions of an animal by transmitting different signals between parts of the body."

It has 3 main roles:

- **Assemble information about conditions external and internal to the body**
- **Analyze information**
- **Initiate response that may be necessary to satisfy certain needs of the body**

Central Nervous System (CNS)

- Brain and spinal cord

-main control centre for almost all body's activities

-receives and interprets signals → commands

-the brain consists of 6 main parts (determine the function of each part –pg 95)

- **Cerebrum**
- **Cerebellum**
- **Brain stem**
- **Diencephalon**
- **Limbic system**
- **Reticular activating system**

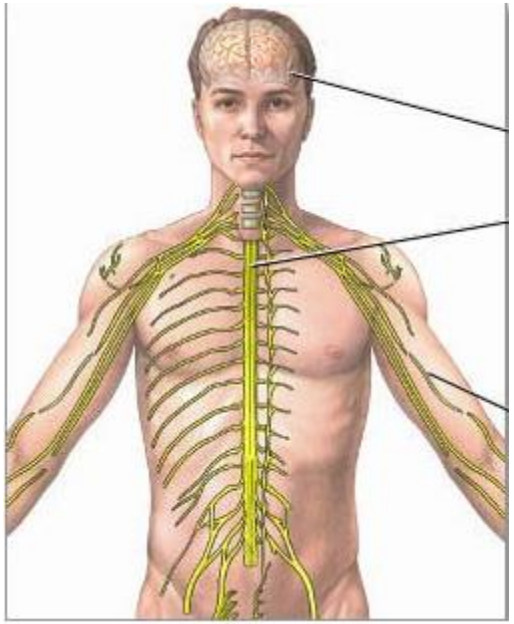
-main information pathway

-spinal nerves branch off cord reaching different organs and tissues

-named after where exit

Ex. L3 → innervates the rectus femoris (extend knee)

Peripheral Nervous System (PNS)



- "roadway" carrying all information towards and away from the CNS
- Contains 12 pairs of cranial and 31 pairs of spinal nerves

2 roots: 1) Motor (efferent)

2) Sensory (afferent)

Autonomic Nervous System

- "automatic" –involuntary contraction

  -cardiac muscles, muscles organs
- 2 opposing branches

Sympathetic

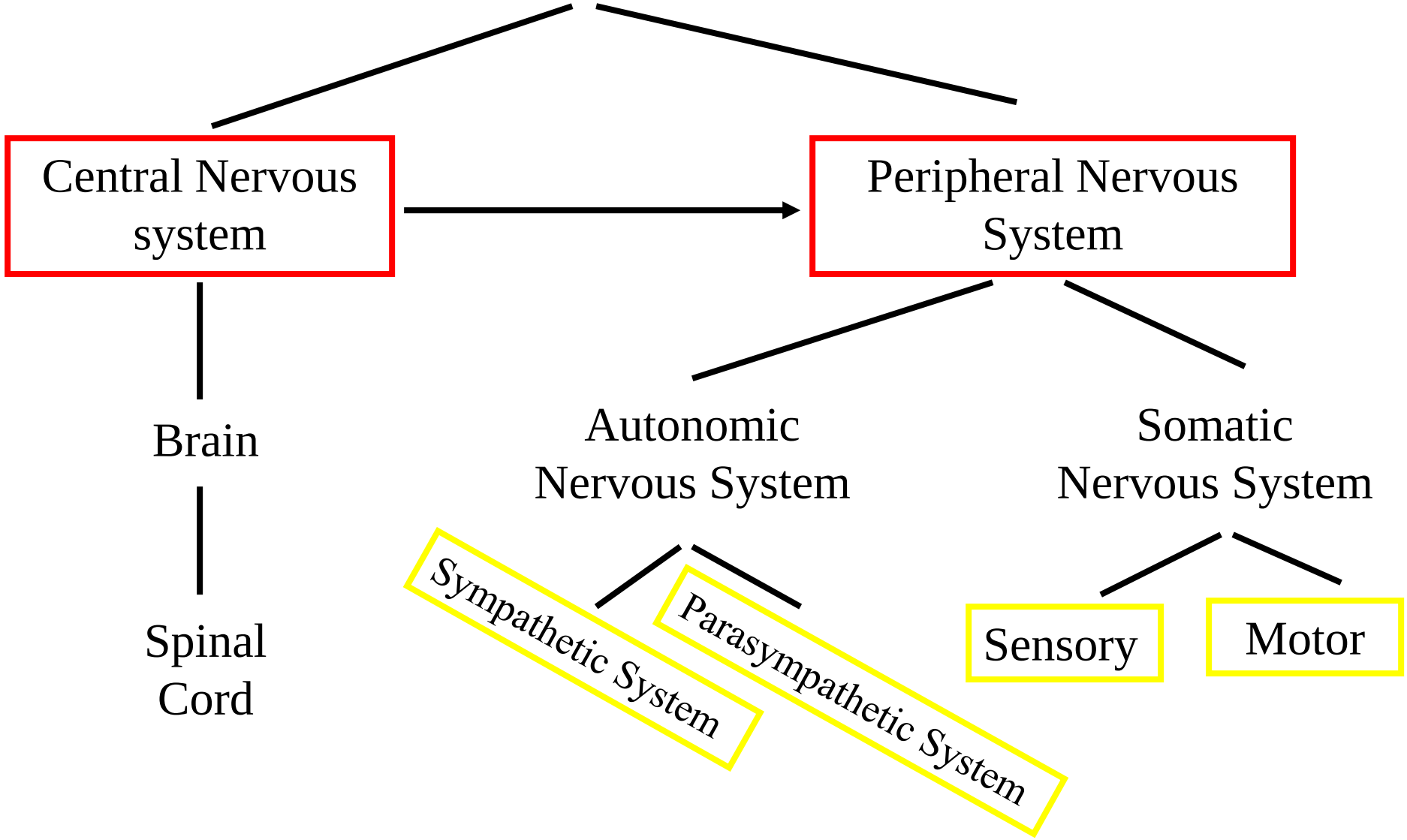
- localized bodily adjustments
- prepare for emergencies (fight or flight)
- adrenaline, increased HR

Parasympathetic

- returns body to normal state
- decrease HR, rest, digest, etc

Even though there are 2 major components to this system, they are interconnected

"Nervous Breakdown"



What is a reflex?

- Automatic and rapid responses to particular stimulation

  -pain or the threat of pain

- 2 types of reflexes:

  1. Autonomic
  2. Somatic → -stimulation of skeletal muscle

What signals a reflex?

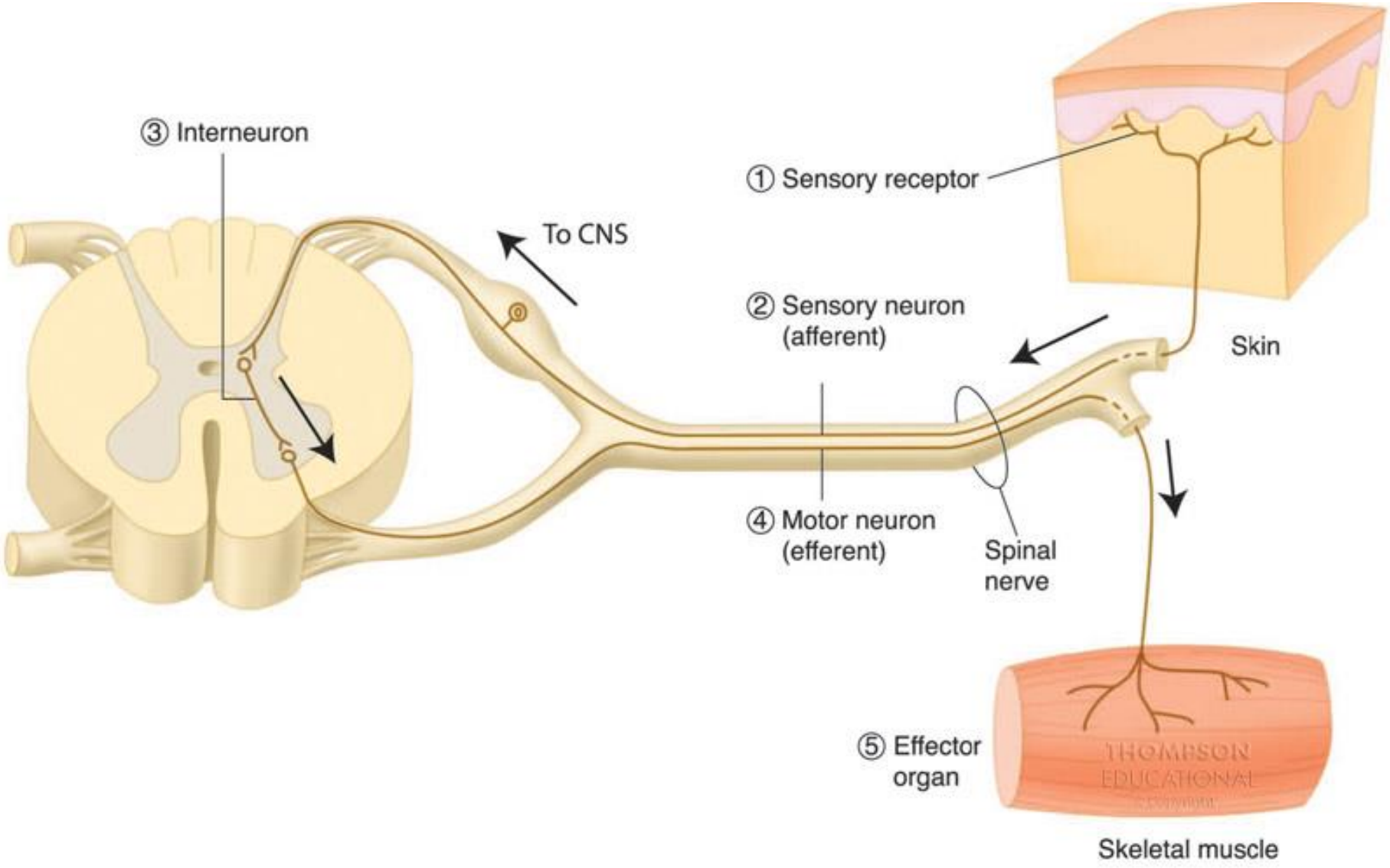
Reflex arc: the pathway along which the stimulus and response messages travel

•Composed of a(n): 1) receptor

2) adjustor

3) effector

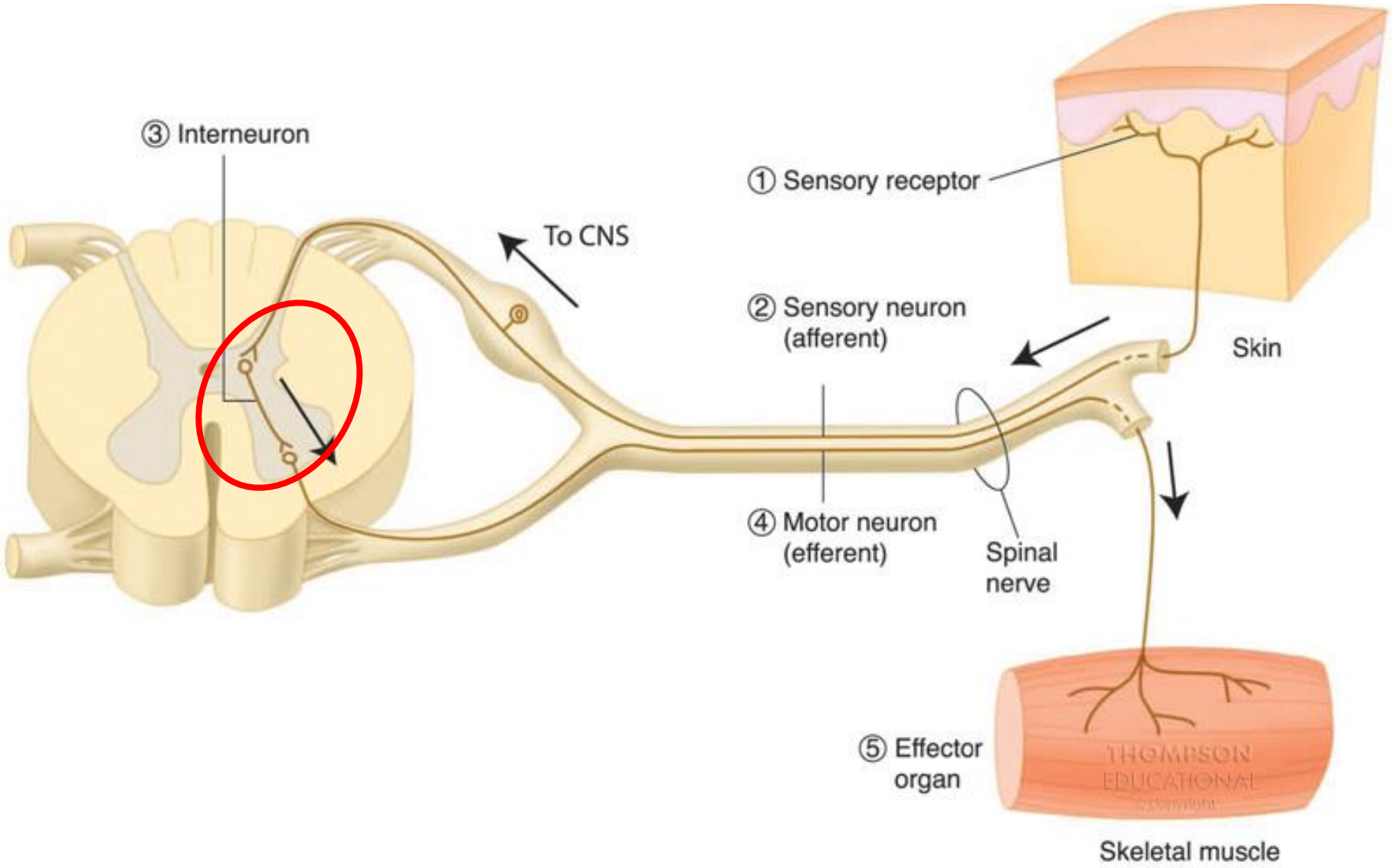
Reflex Arc


③ Interneuron
To CNS
① Sensory receptor
② Sensory neuron
(afferent)
Skin
④ Motor neuron
(efferent)
Spinal
nerve
⑤ Effector
organ
Skeletal muscle

Receptor	
Sensory (afferent) nerve	
Interneuron (intermediate nerve fibre)	
Motor (efferent) nerve	
Effector	

Key to a reflex → it is not the brain that sends the motor signal to the effector.

Reflex Arc



-video

We already discussed how a sensory impulse can cause a muscle to contract

But how does that muscle fibre know when, how much and who to contract with?

Proprioceptors

"Provide constant sensory information about the state of muscle contraction"

-specialized sensory receptors found in tendons, muscles and joints

- **There are 2 we will be looking at:**

1. Golgi Tendon Organs (GTO)

-in series where muscles and tendons meet

-when muscles stretch GTO's stretch

-therefore detect TENSION changes

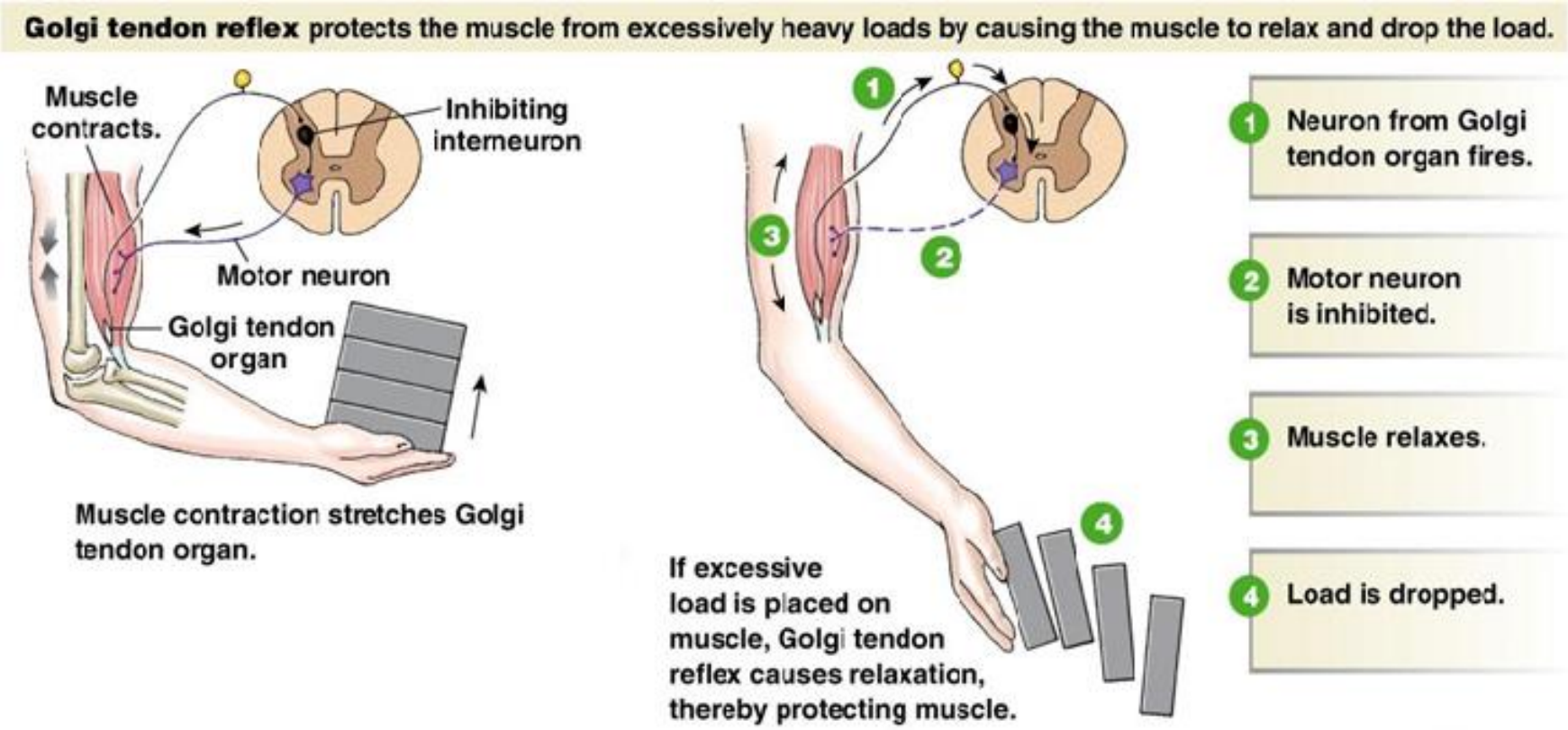
-protect muscle from excessive tension (damage)

-development of power and strength

-overcome GTO's

(1844-1926)

Golgi Tendon Organs (GTO's)



Change in tension → impulse sent along sensory (afferent) neuron to spinal cord → synapse with interneuron → motor (efferent) neuron sends impulse → muscle relaxes (preventing injury)

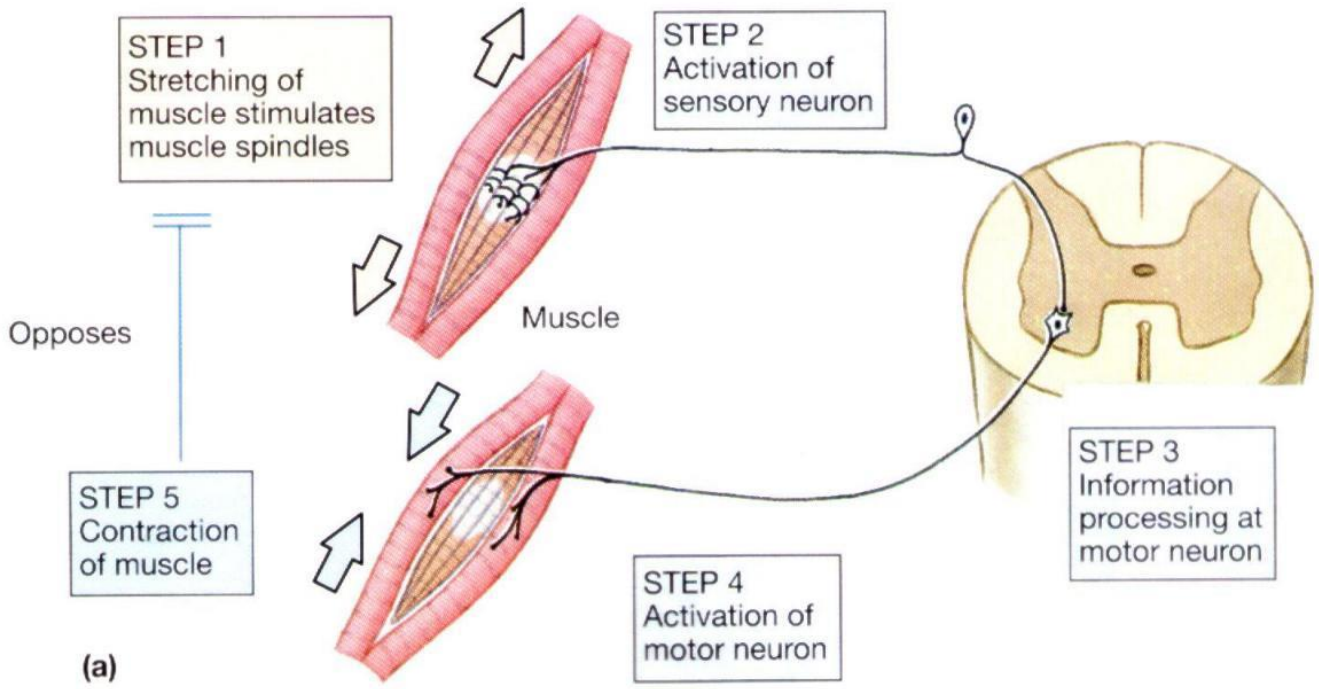
2. Muscle Spindles

-smaller more specialized muscles fibres (intrafusal) running parallel to the main muscle fibres

-help maintain muscle tension (eg. standing erect)

-detect changes in muscle LENGTH

• Change in muscle length → sensory impulse to spinal cord (x2) → motor response → muscle contracts (remains in proper tension)



-video

Golgi Tendon Organs & Muscle Spindles

	Golgi Tendon Organs	**Muscle Spindles**
Location	Where tendon meets muscle fibre	In belly of muscle fibre
Position	In series with muscle fibre	Parallel to muscle fibre
Respond to	Changes in muscle/tendon tension	Changes in muscle length
Sensory neurons	1	2

Muscle spindles are responsible for one of the most recognizable reflexes . . .

The Stretch Reflex (Knee –Jerk)

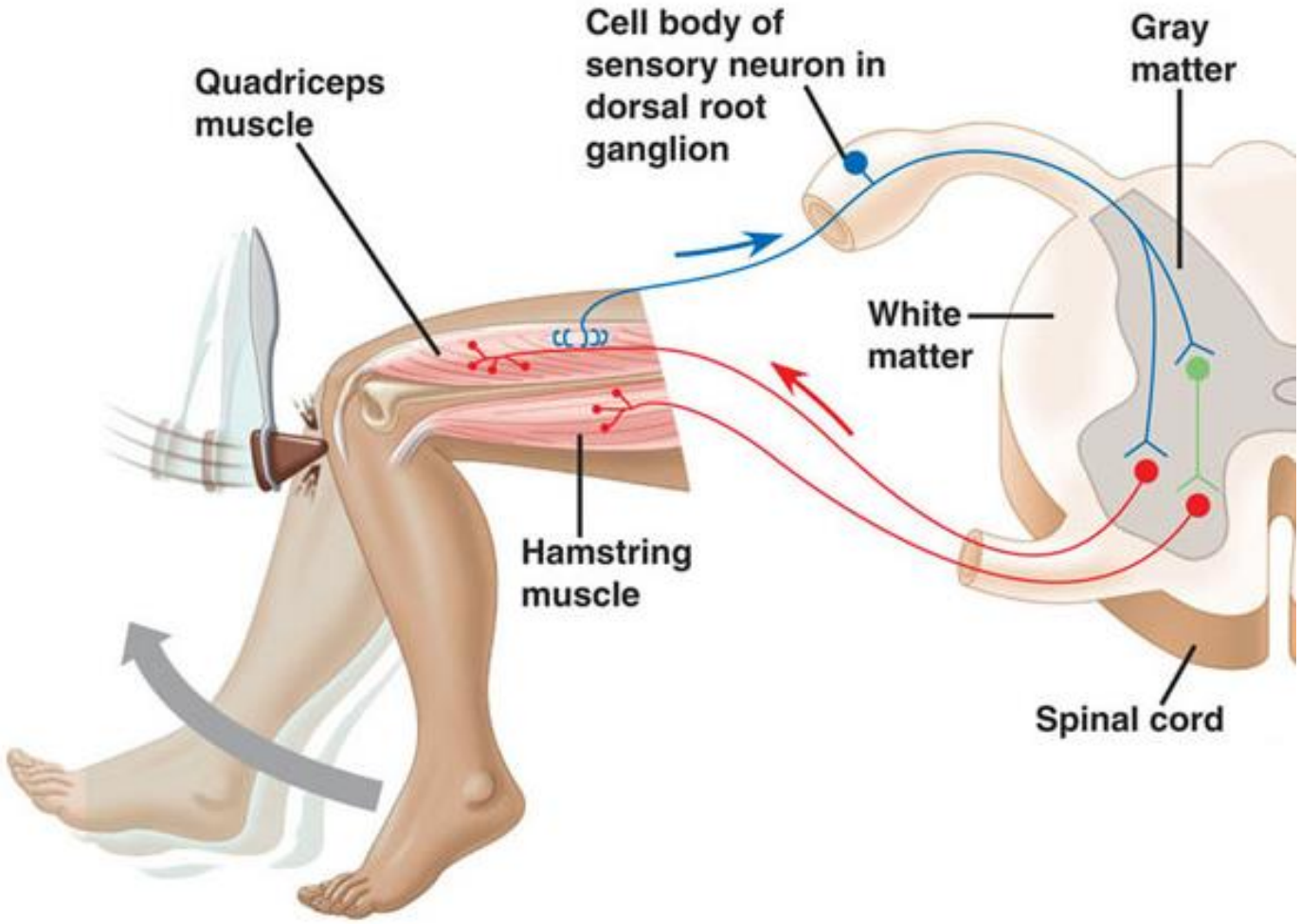
- Monosynaptic reflex → only one connection between sensory and motor neuron

Tapping petallar tendon → Pulls on quad femoris → excites spindles (length change) → sensory to spinal cord → motor to contract quad femoris → knee-jerk

Sudden increase in carrying weight?

1. Stimulus
2. Receptor
3. Sensory impulse
4. Motor impulse
5. Muscle contracts

Reciprocal Inhibition


Cell body of sensory neuron in dorsal root ganglion
Gray matter
Quadriceps muscle
White matter
Hamstring muscle
Spinal cord

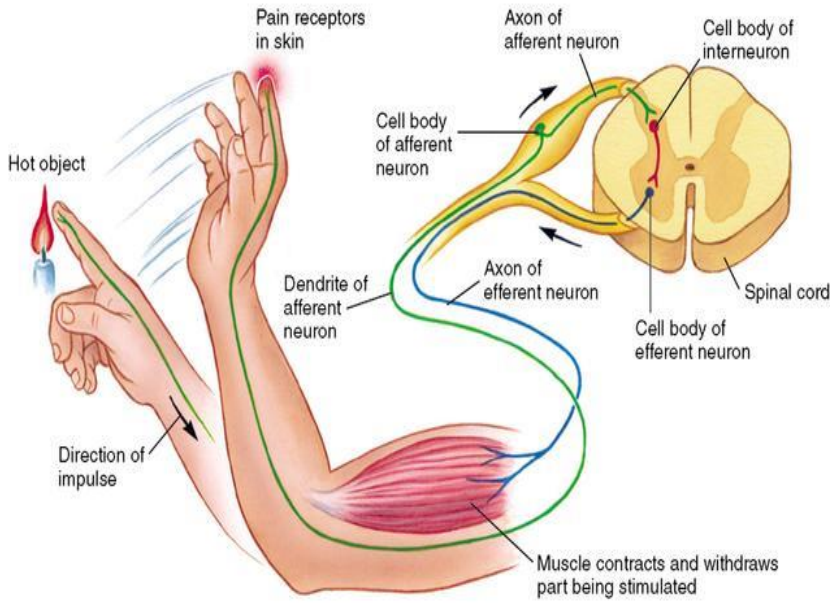
But we're missing something. What did we say was the key to a reflex?

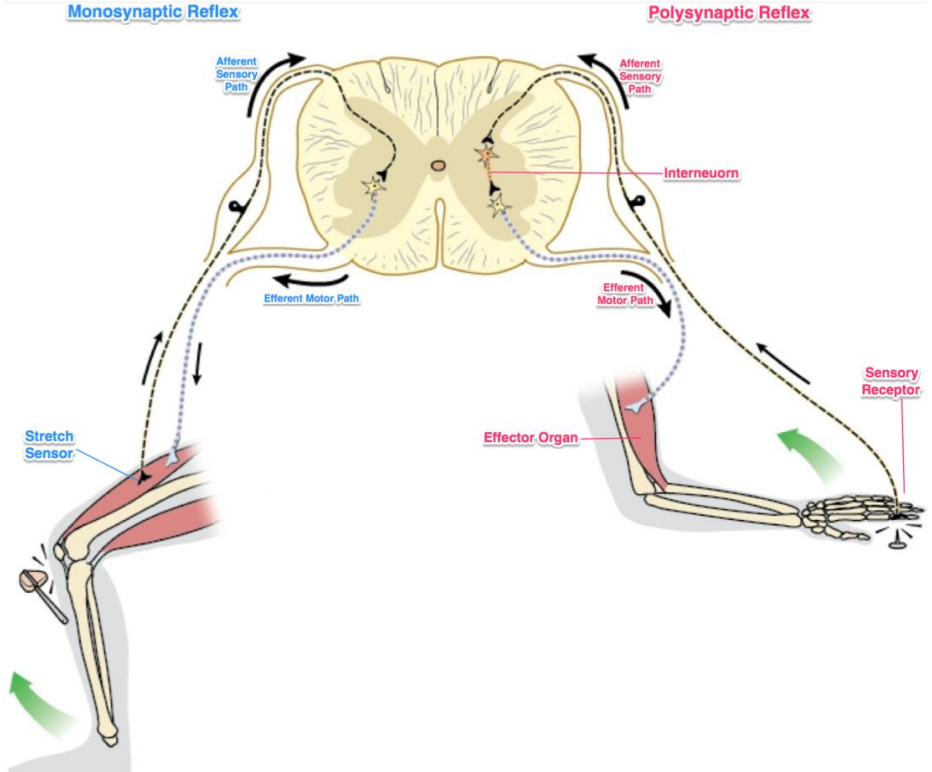
Polysynaptic Reflex

- **A reflex with one or more between the primary sensory fibres and motor neurons**

More = more complex = slower

Withdrawal Reflex (Pain –sharp/hot)





1. Stimulus from skin in form of heat (receptor)

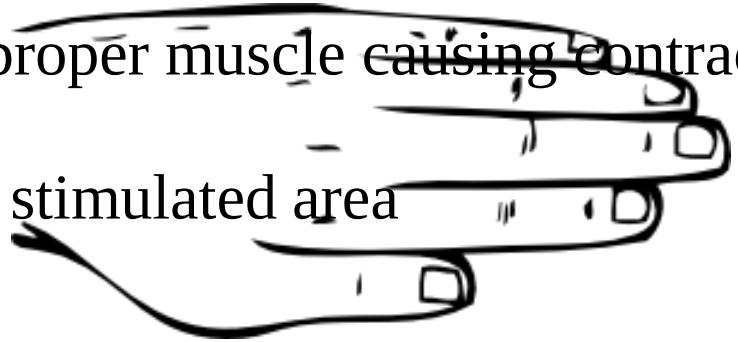
2. Sensory impulse generated

3. Interneuron synapse in spinal column

4. Motor impulse generated by interneuron (others to brain = pain)

5. Impulse to proper muscle causing contraction

6. Removal of stimulated area

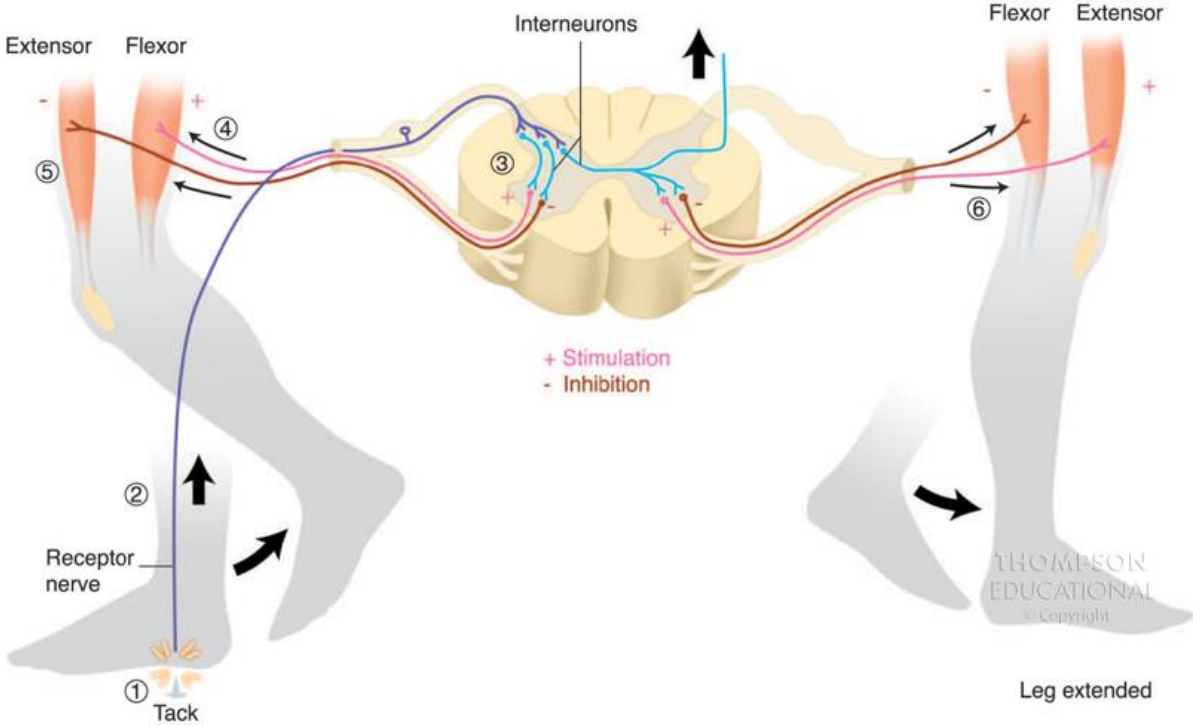


But why do we still feel pain when we place our hand over a flame?

- **There is still a sensory impulse sent to the brain, but it only reacts to make us feel pain.**
  - **Because it is further away and contains more interneurons it is a slower process**

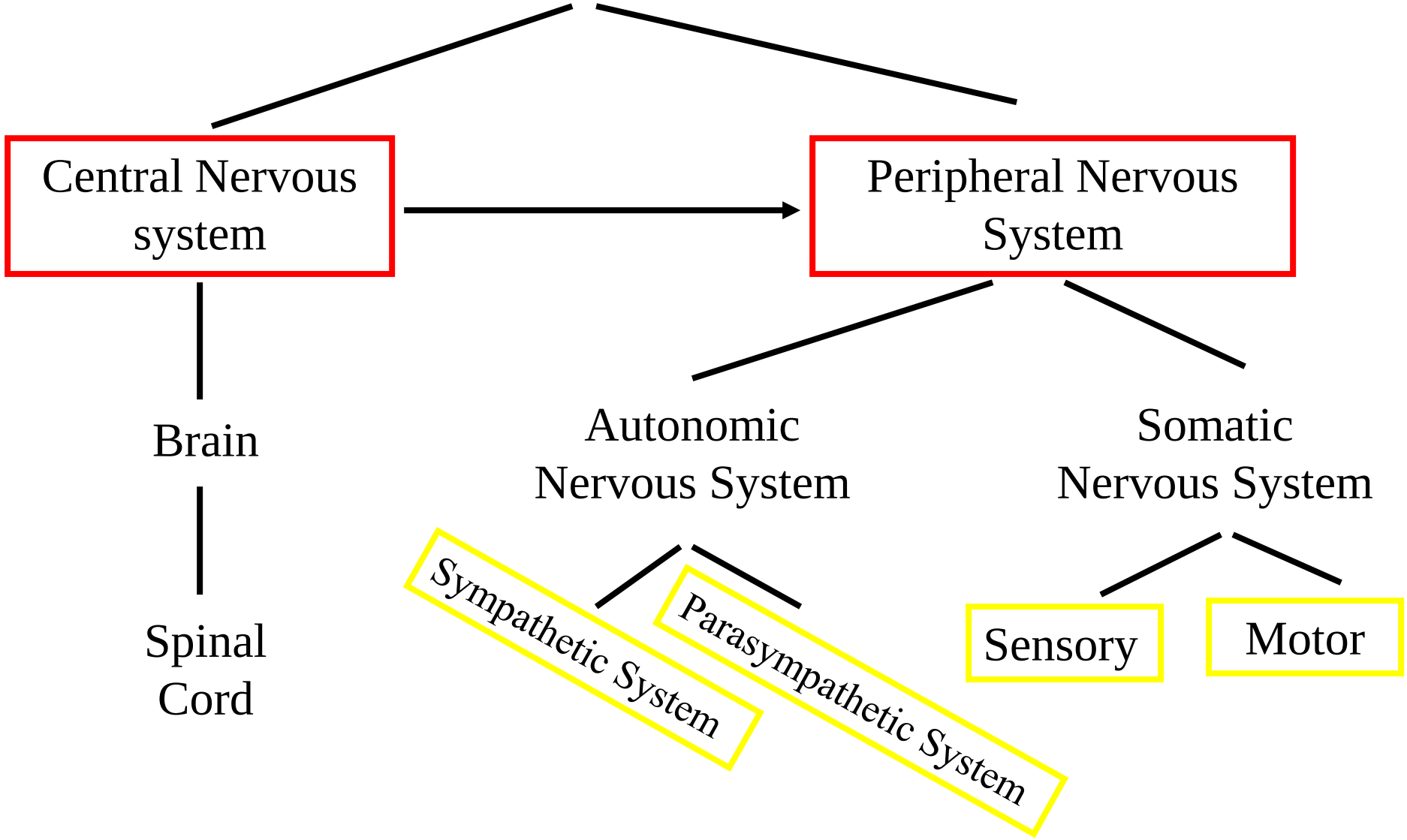
Crossed-Extensor Reflex:

- Observed when one leg or arm automatically compensates for a reflex action in opposing leg or arm
- Involves multiple synapses and muscle groups



Even though there are 2 major components to this system, they are interconnected

"Nervous Breakdown"



Somatic Nervous System

- awareness to external environment
- motor movements to cope

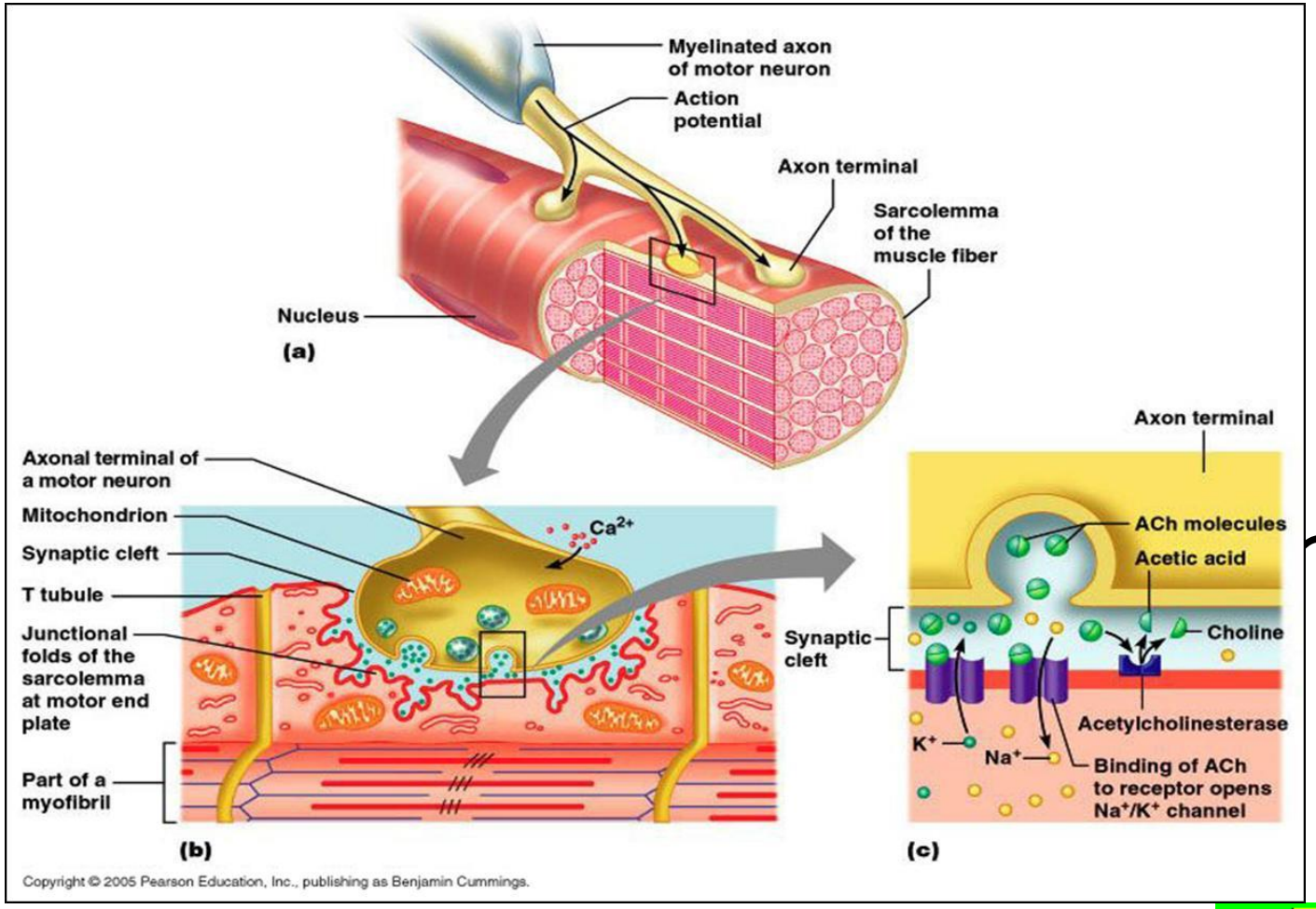
1. **Afferent**
2. **Efferent**

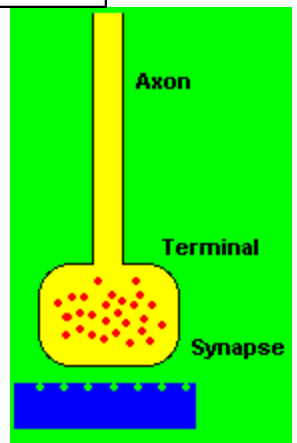
-info from skin, joints, muscles → touch, pain, heat, cold, balance, body position

- voluntary movements to respond to stimuli

Look at example on page 97 (fig. 6.2)

The m





FAST-TWITCH VS. SLOW-TWITCH

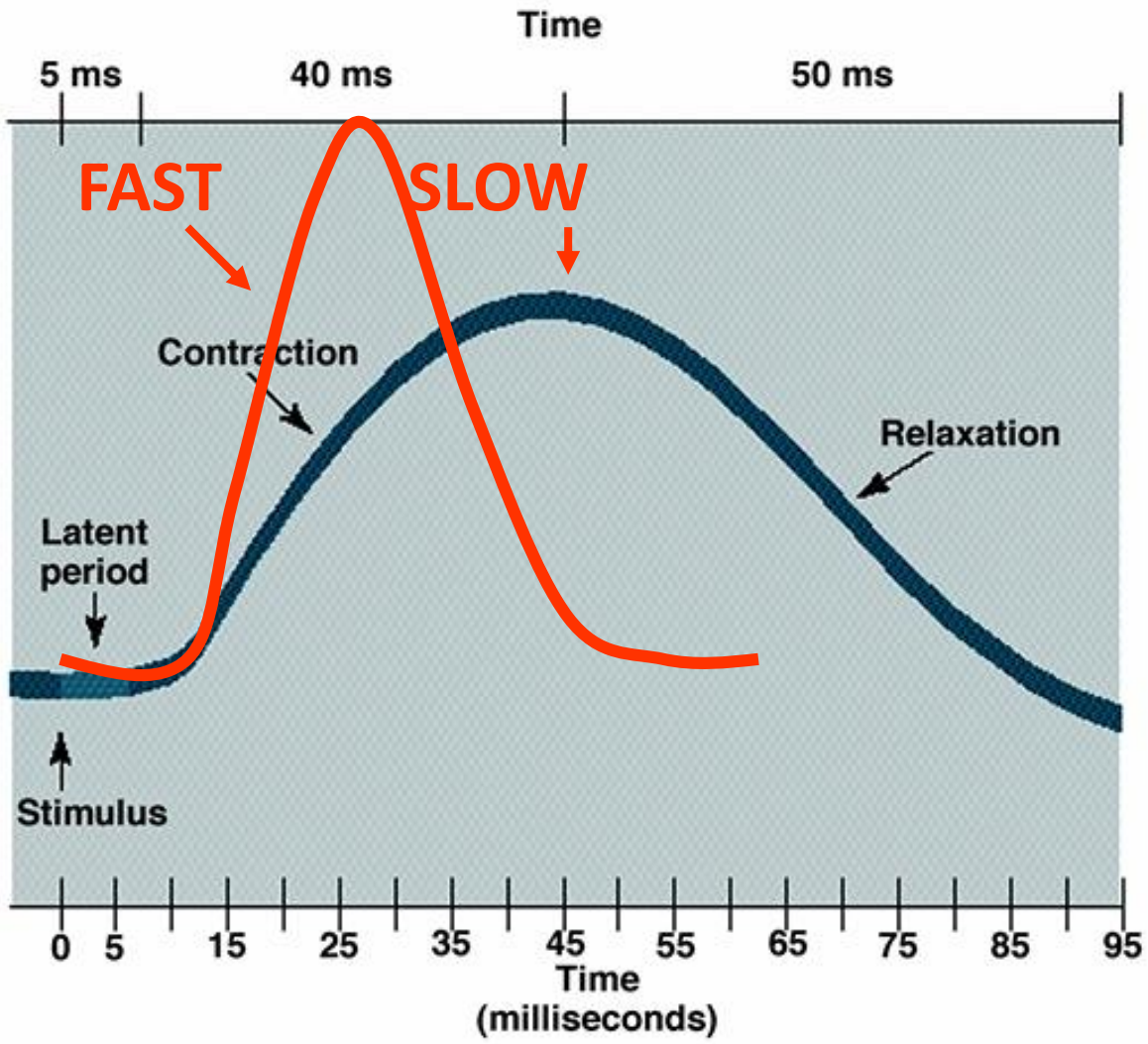


FIG 8.15 Powers

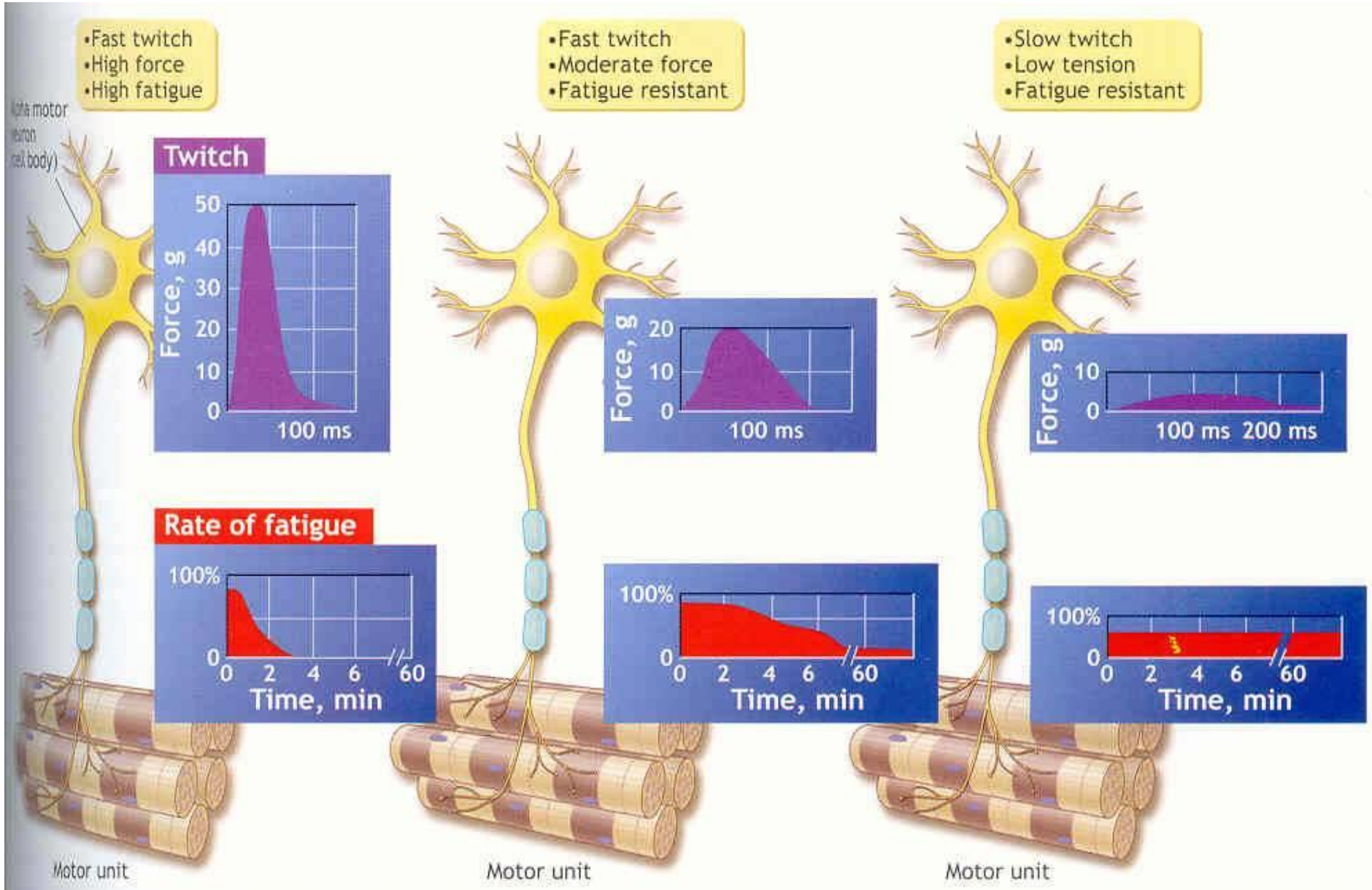
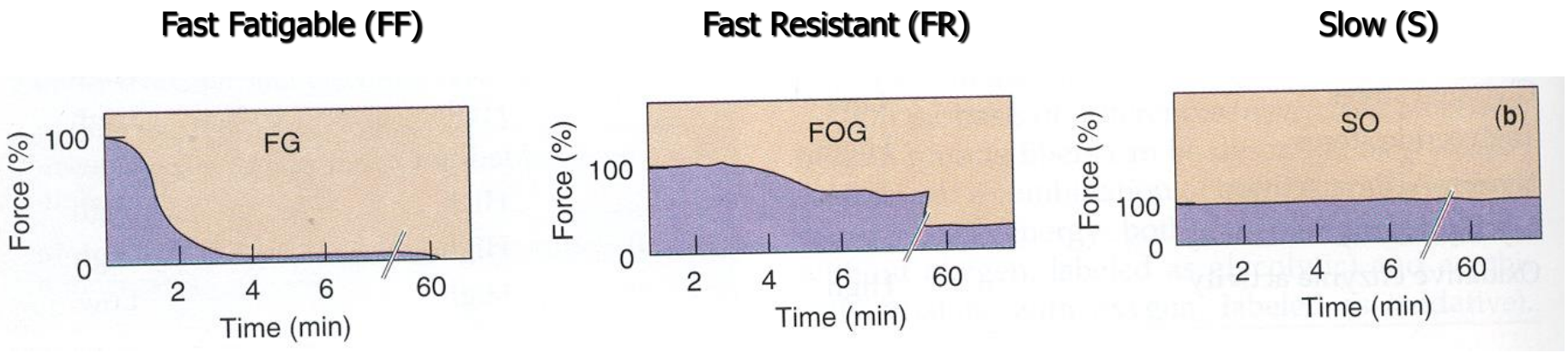


FIGURE 19.13 • Speed, force, and fatigue characteristics of motor units. "Phasic" motor neurons fire rapidly with short bursts; "tonic" motor neurons fire slowly but continuously.

Muscle Fiber Types

Second factor that differentiates muscle or muscle fiber types:

- FATIGUE Characteristics
  - Fatigue Index



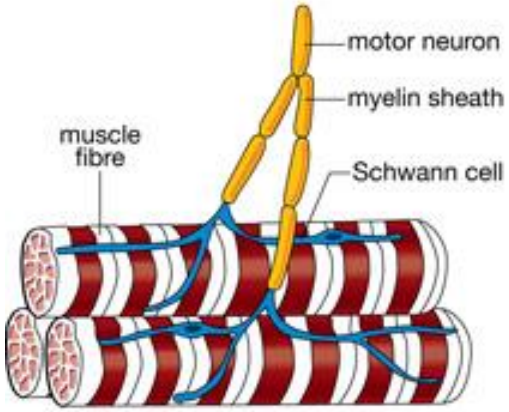
Muscle Fiber Types

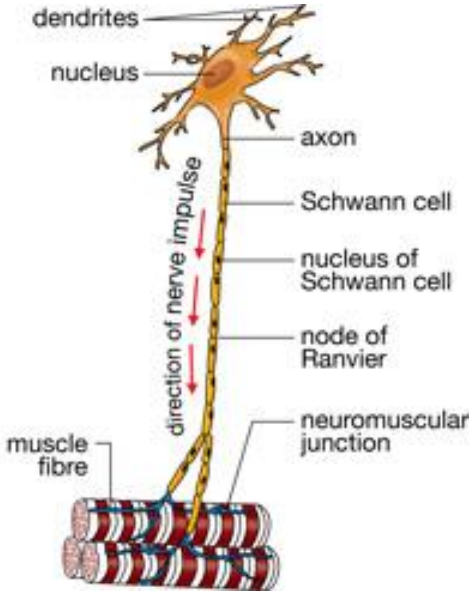
Characteristic	Fast fibers Type IIb	Type IIa	Slow fibers Type I
Number of mitochondria	Low	High/moderate	High
Resistance to fatigue	Low	High/moderate	High
Predominant energy system	Anaerobic	Combination	Aerobic
ATPase activity	Highest	High	Low
V_{max} (speed of shortening)	Highest	Intermediate	Low
Efficiency	Low	Moderate	High
Specific tension	High	High	Moderate

Table. 8.1 Powers.

The Neuromuscular System (p.172)

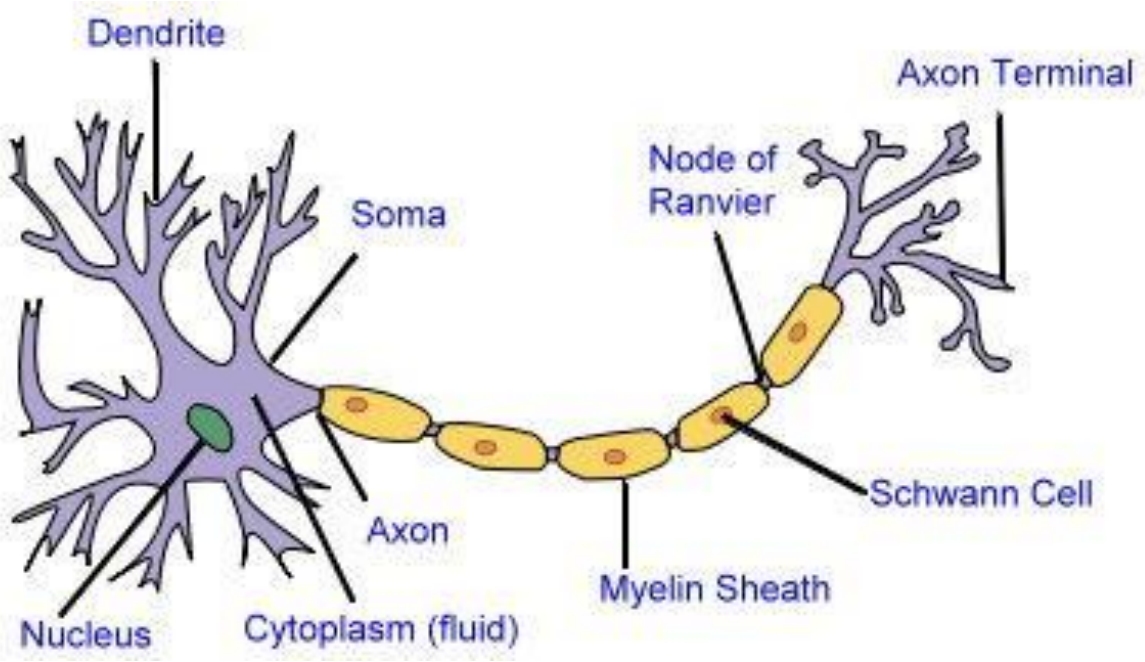
- - **The interrelated workings of the nervous system and the muscles to bring about movement**
  - The brain and spinal cord control skeletal (voluntary) muscles through specialized nerves





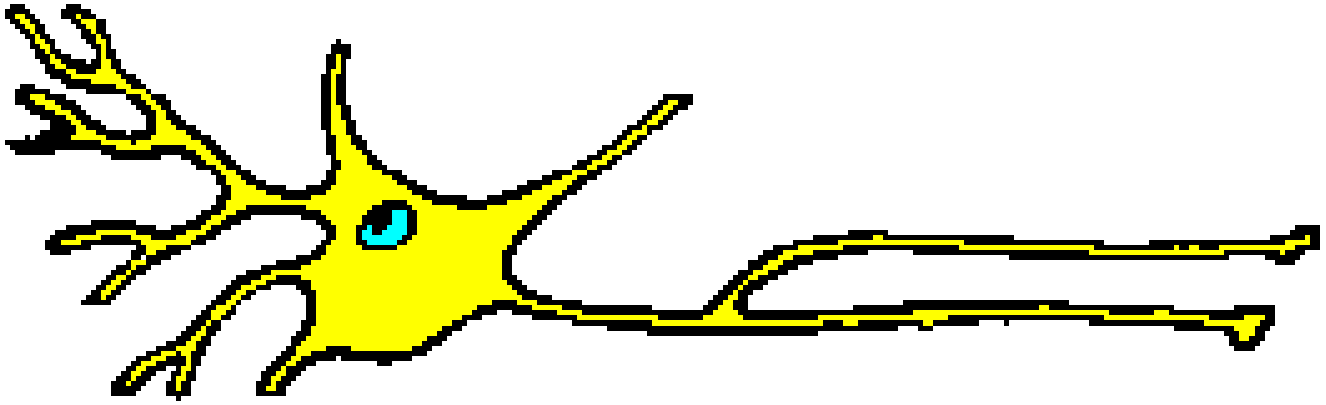
The Nerve Cell

- **Neurons are nerve cells, found in the nervous system.**
- These are specialized cells designed to stimulate other cells in the body in order to communicate.



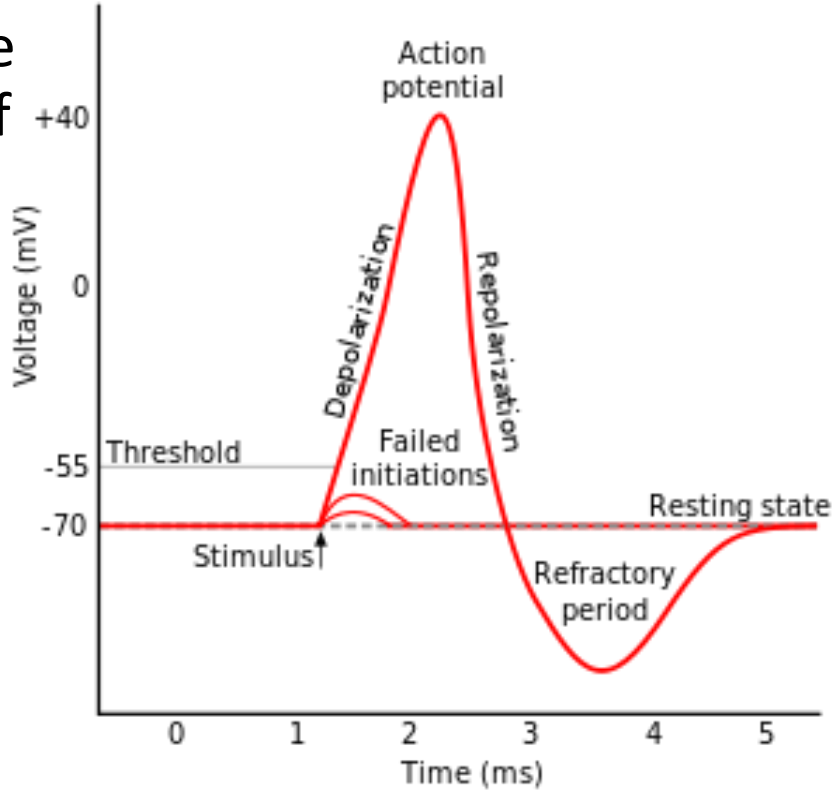
The Nerve Cell

- **Neurons are excitable, which means they function by using electrical stimulation**.

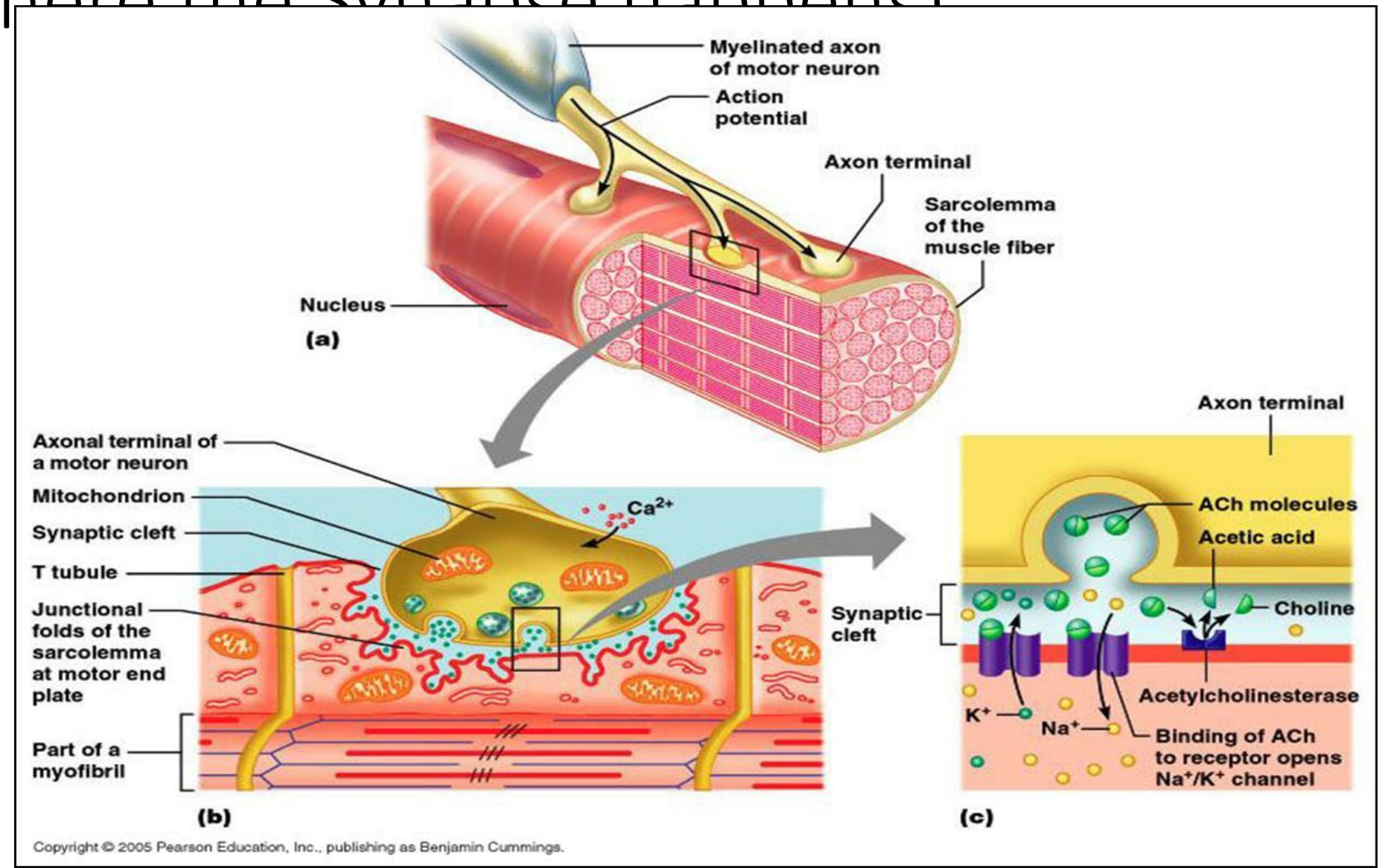


Action Potential

- Action Potential
  - a short-lasting event in which the electrical membrane **potential** of a cell rapidly rises and falls, following a consistent trajectory

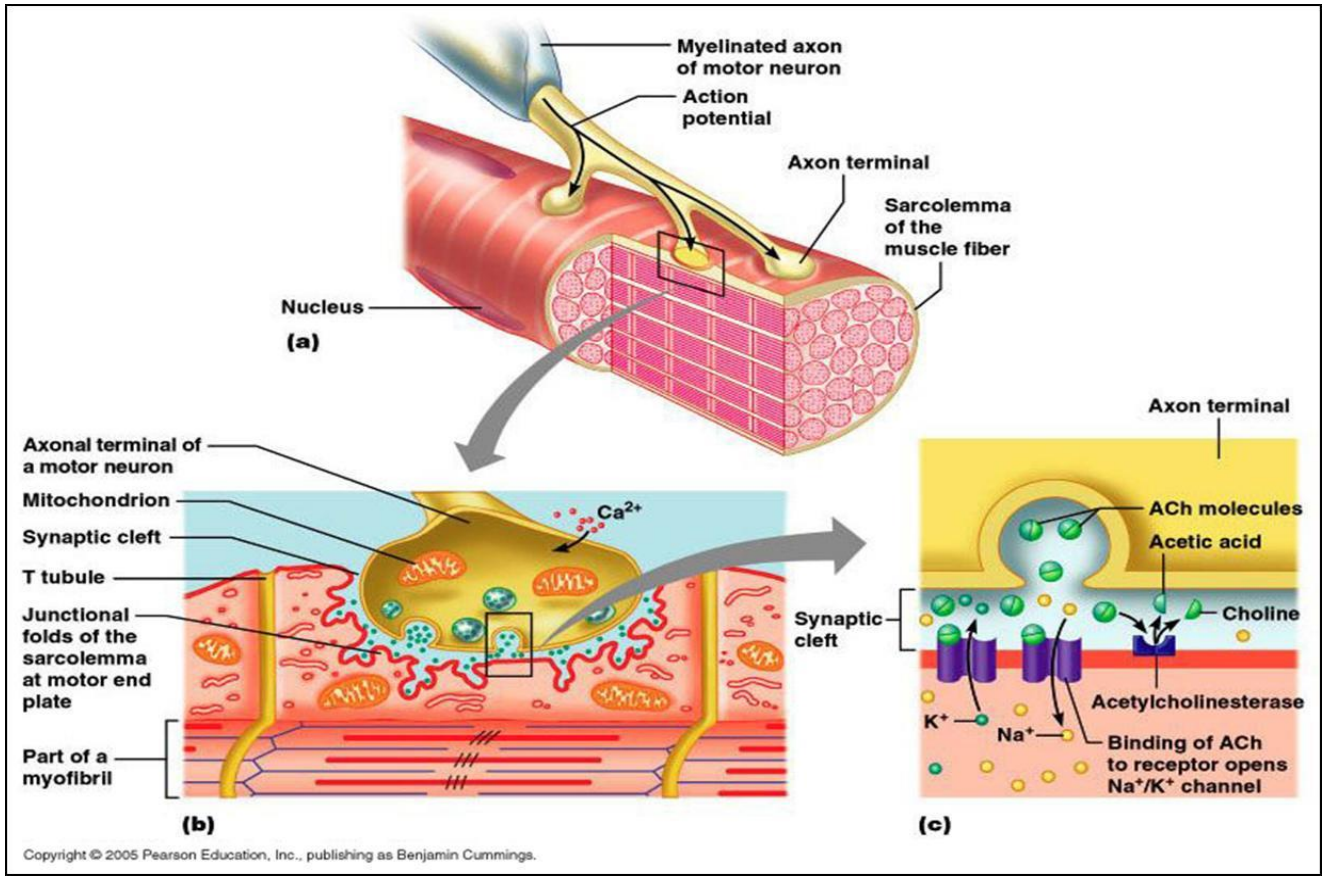


Neuromuscular Junction
(Where the Synapse happens)



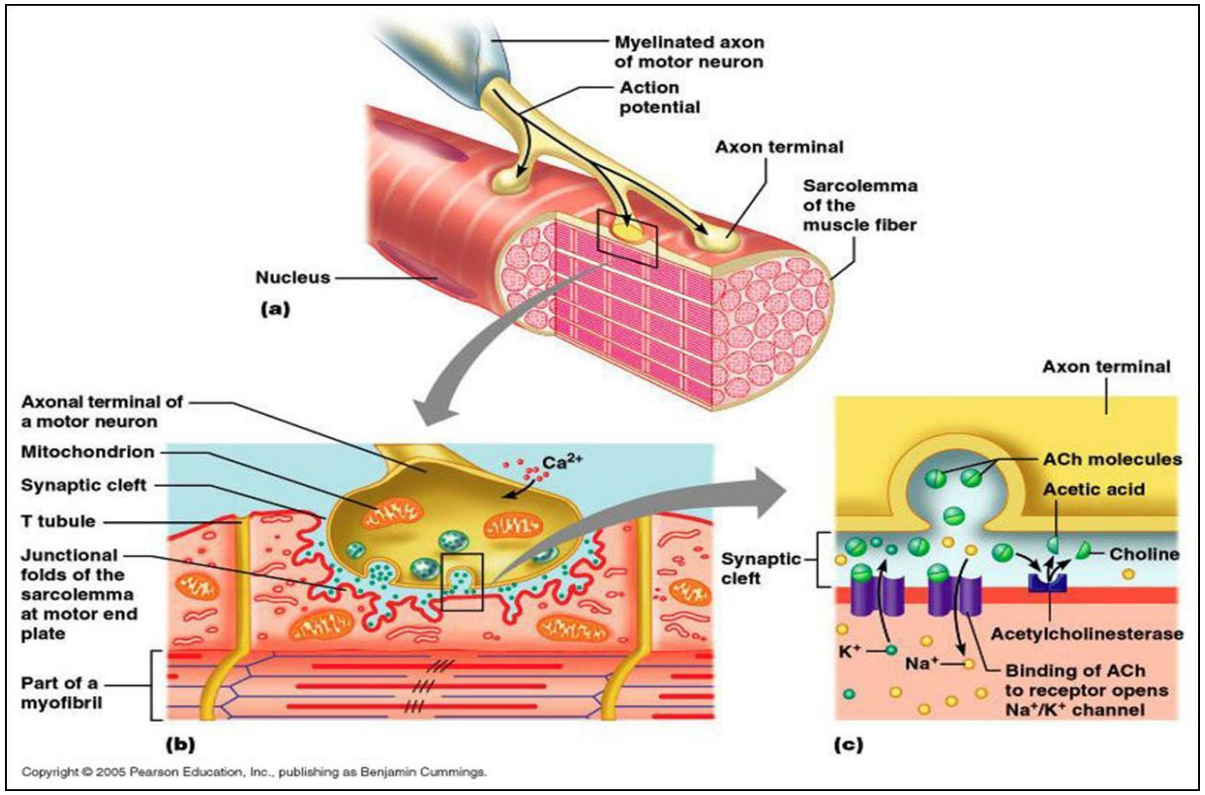
Neuromuscular Junction - Steps

1. Action potential travels down the Axon and depolarizes the axon terminal



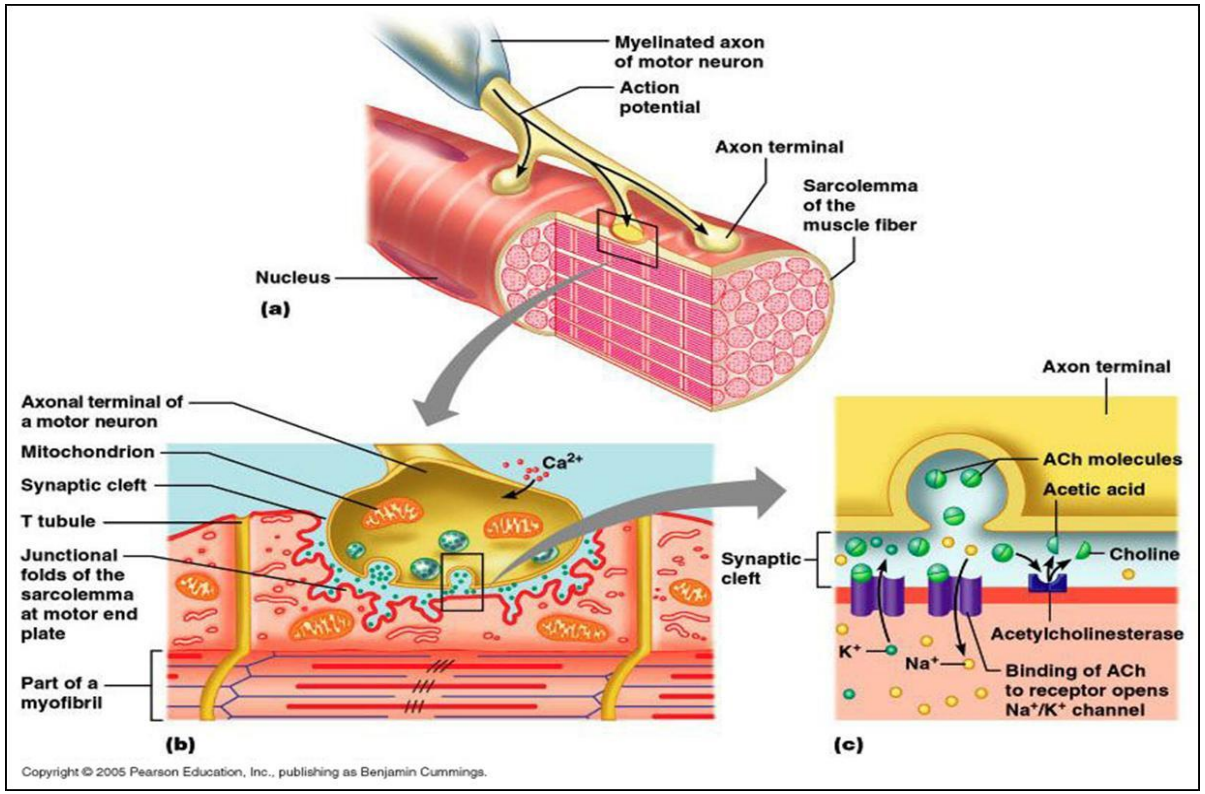
Neuromuscular Junction - Steps

2. The depolarization opens voltage gated Ca^{2+} channels and Ca^{2+} enters the cell



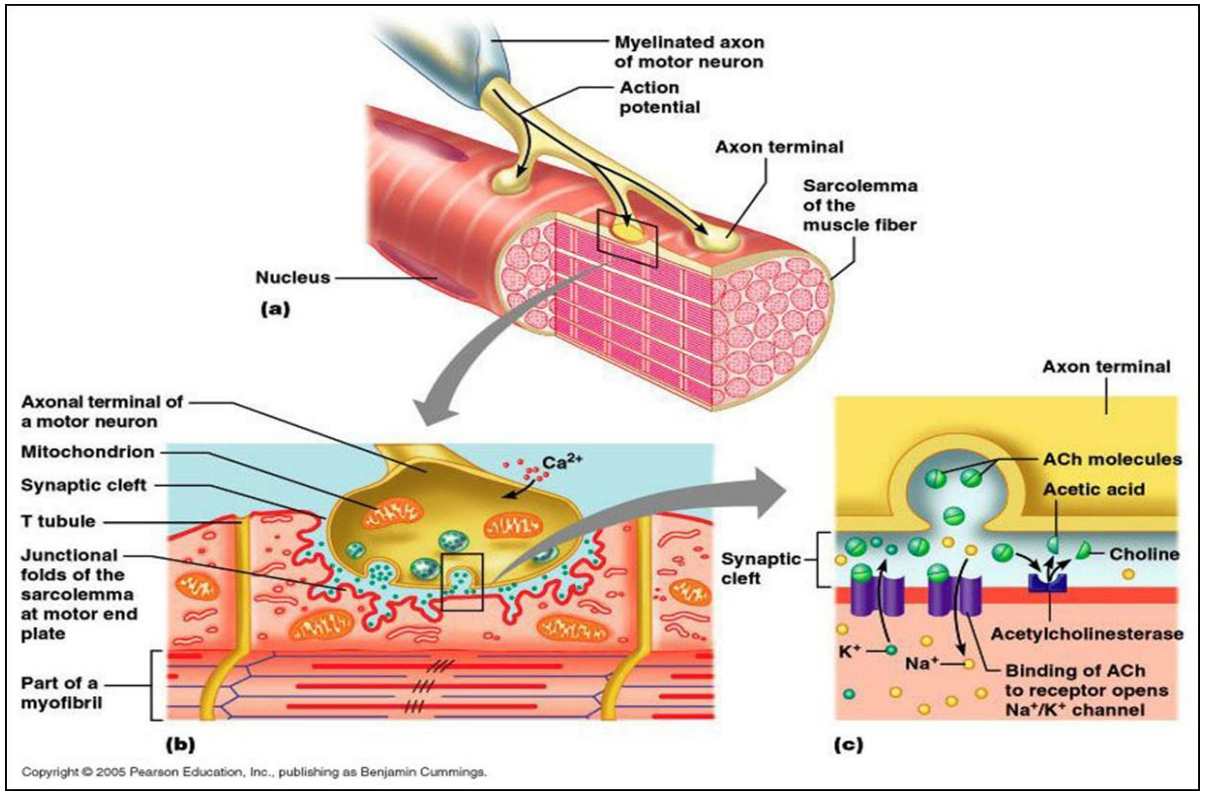
Neuromuscular Junction - Steps

3. Calcium entry triggers exocytosis of synaptic vessels neurotransmitter (acetylcholine - ACh)



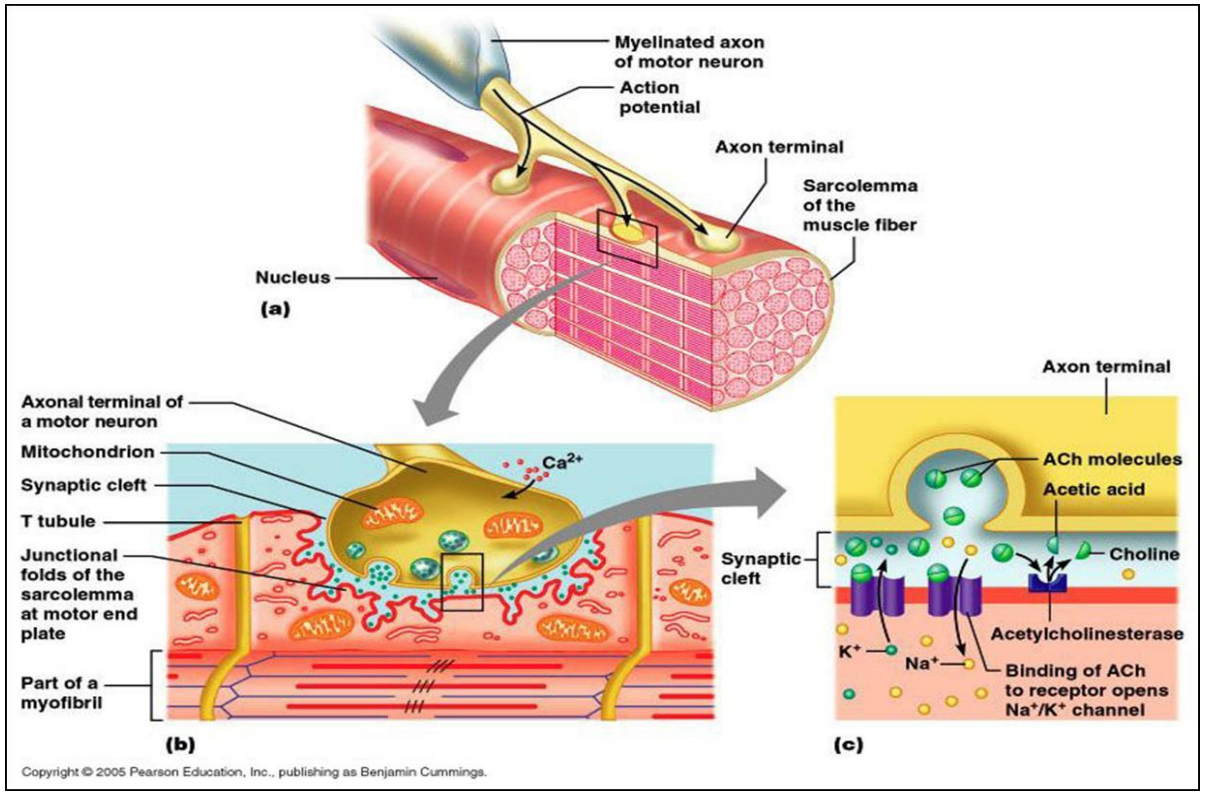
Neuromuscular Junction - Steps

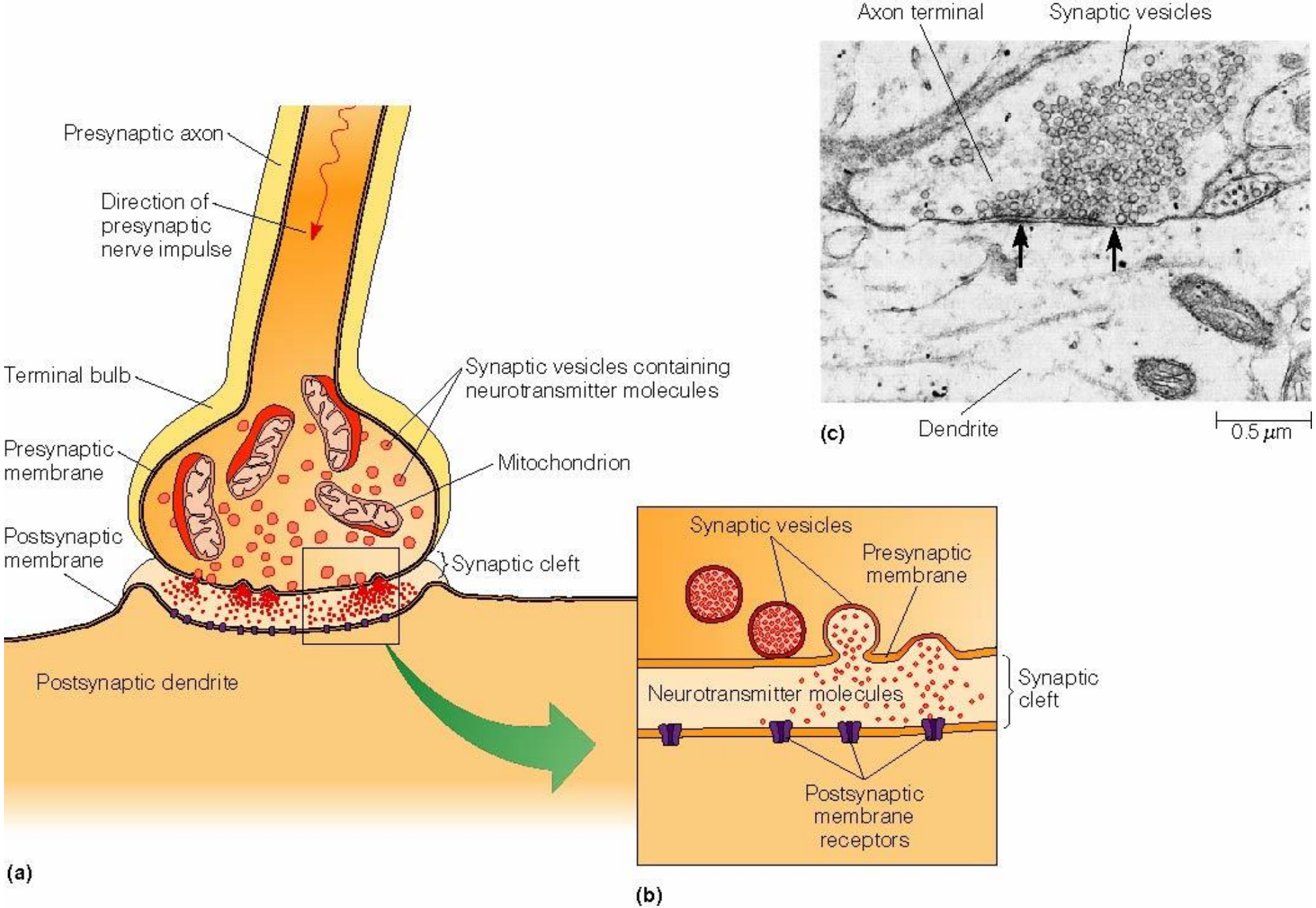
4. Neurotransmitter diffuses across the synaptic cleft and binds on receptors



Neuromuscular Junction - Steps

1. Action potential travels down the Axon and depolarizes the axon terminal



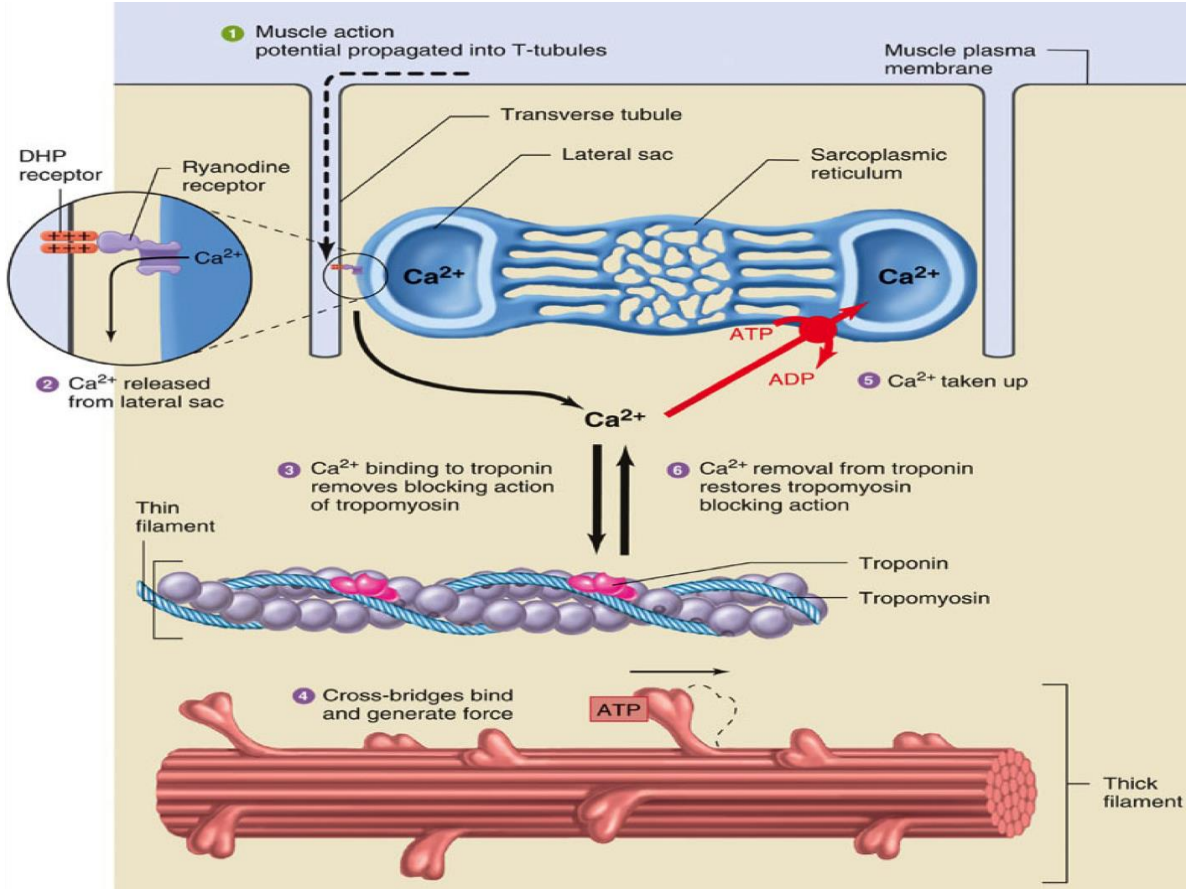


Excitation – Contraction Coupling

- **The physiological process of converting an electrical stimulus to a mechanical response.**
- **It is the link (transduction) between the action potential generated in the sarcolemma and the start of a muscle contraction**

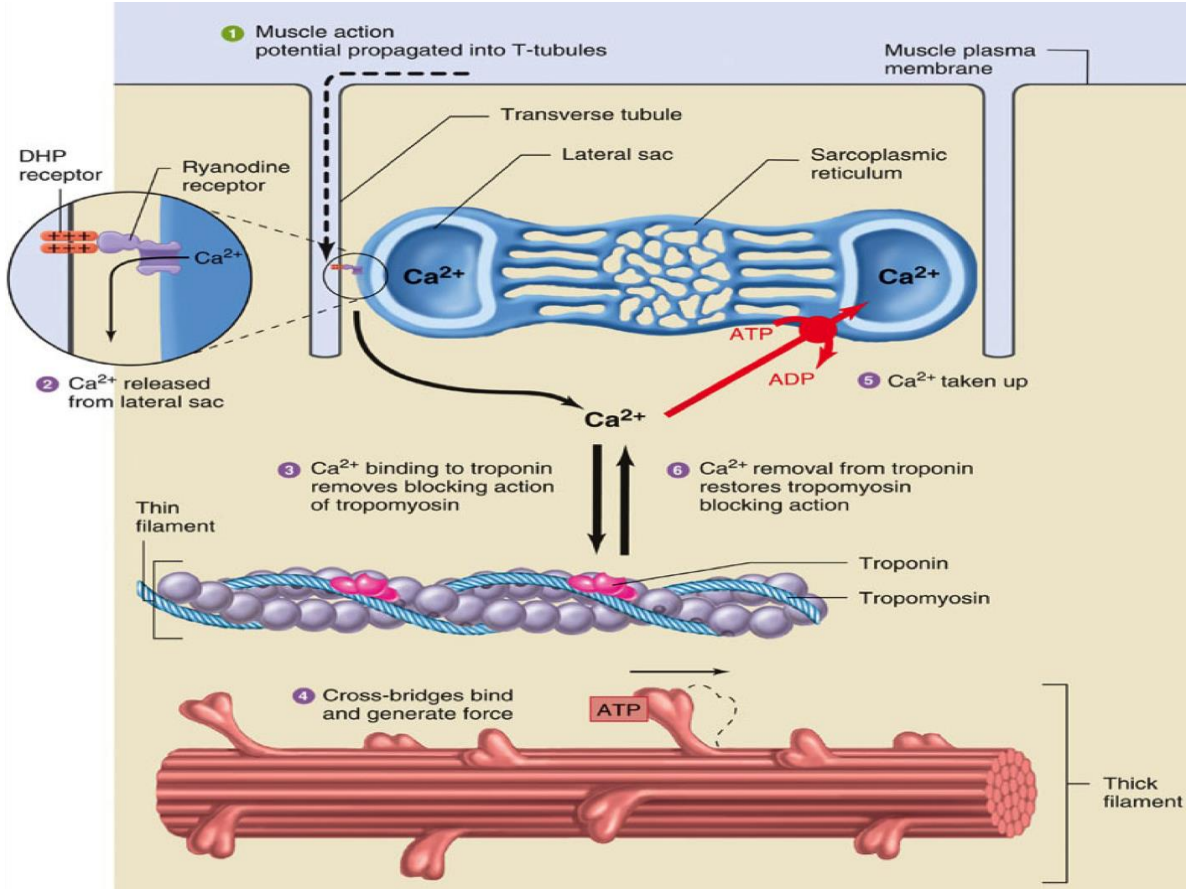
Steps

1. Muscle action potential propagation into – T-tubules



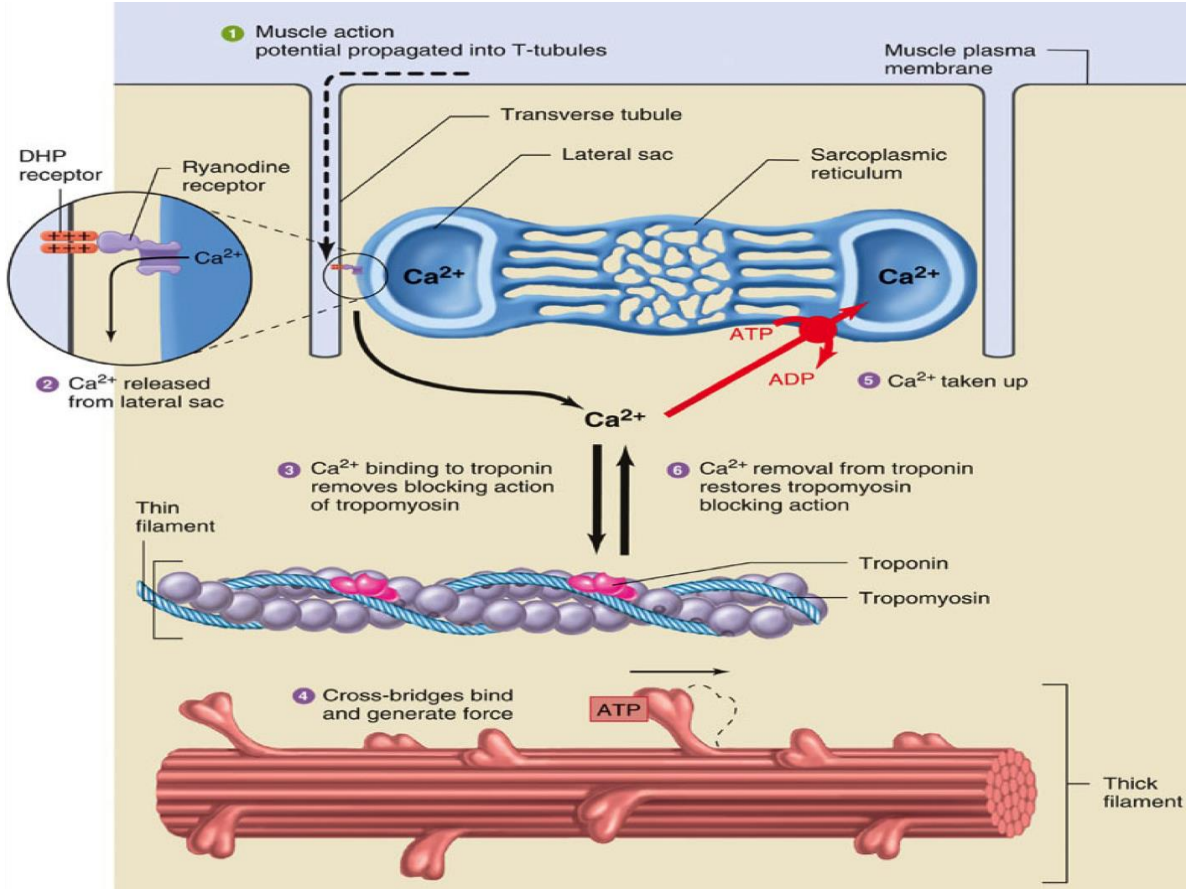
Steps

2. Ca^{2+} released from sarcoplasmic reticulum



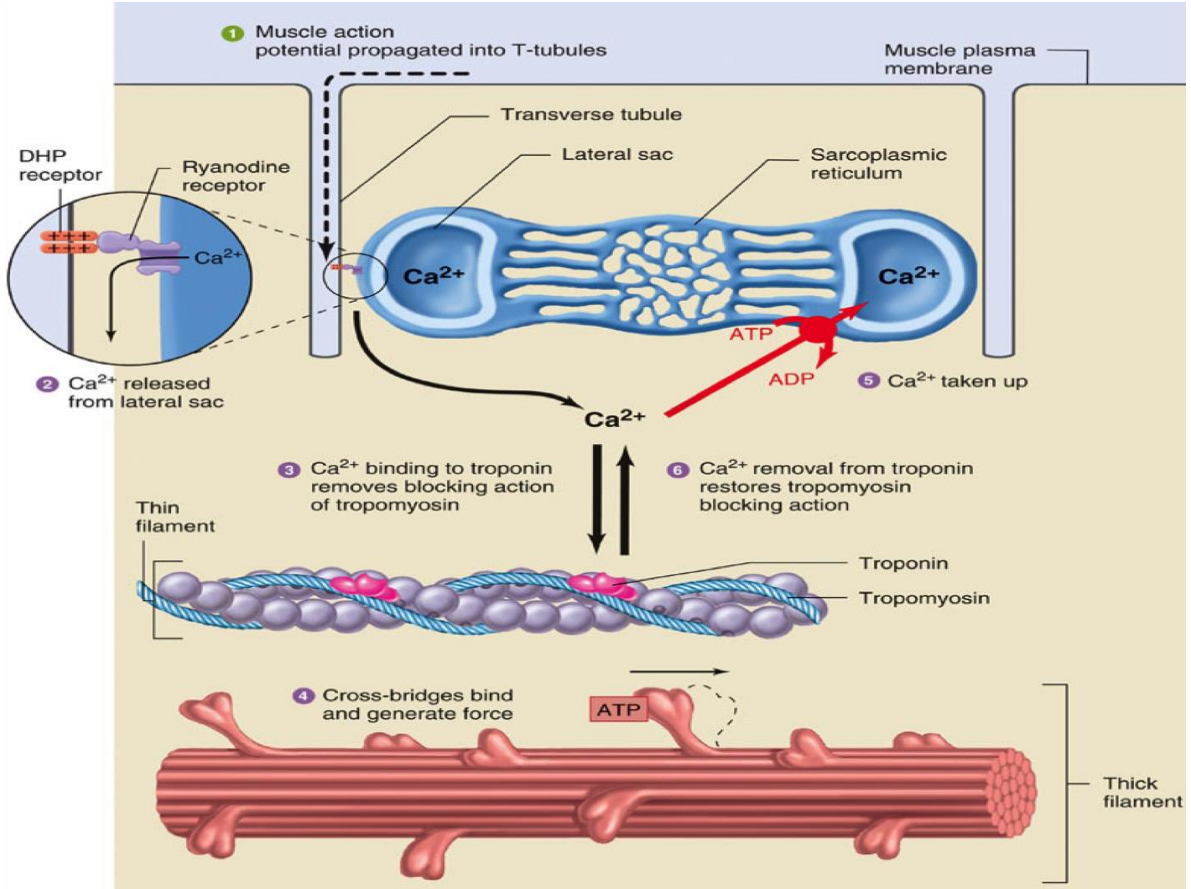
Steps

3. Ca^{2+} binds to troponin and removes blocking action for tropomyosin



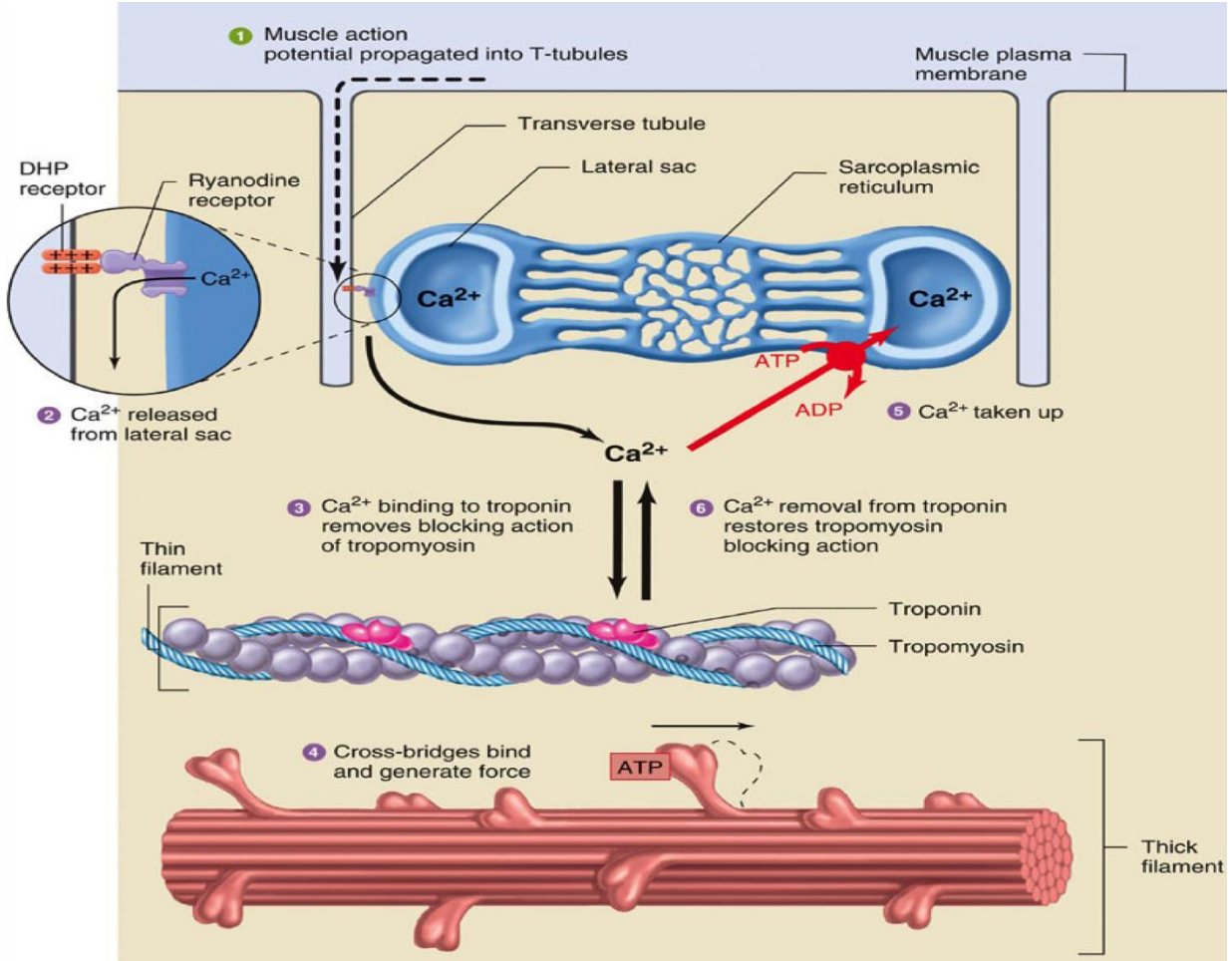
Steps

4. Cross –bridges bind and generate force (muscle shortens)



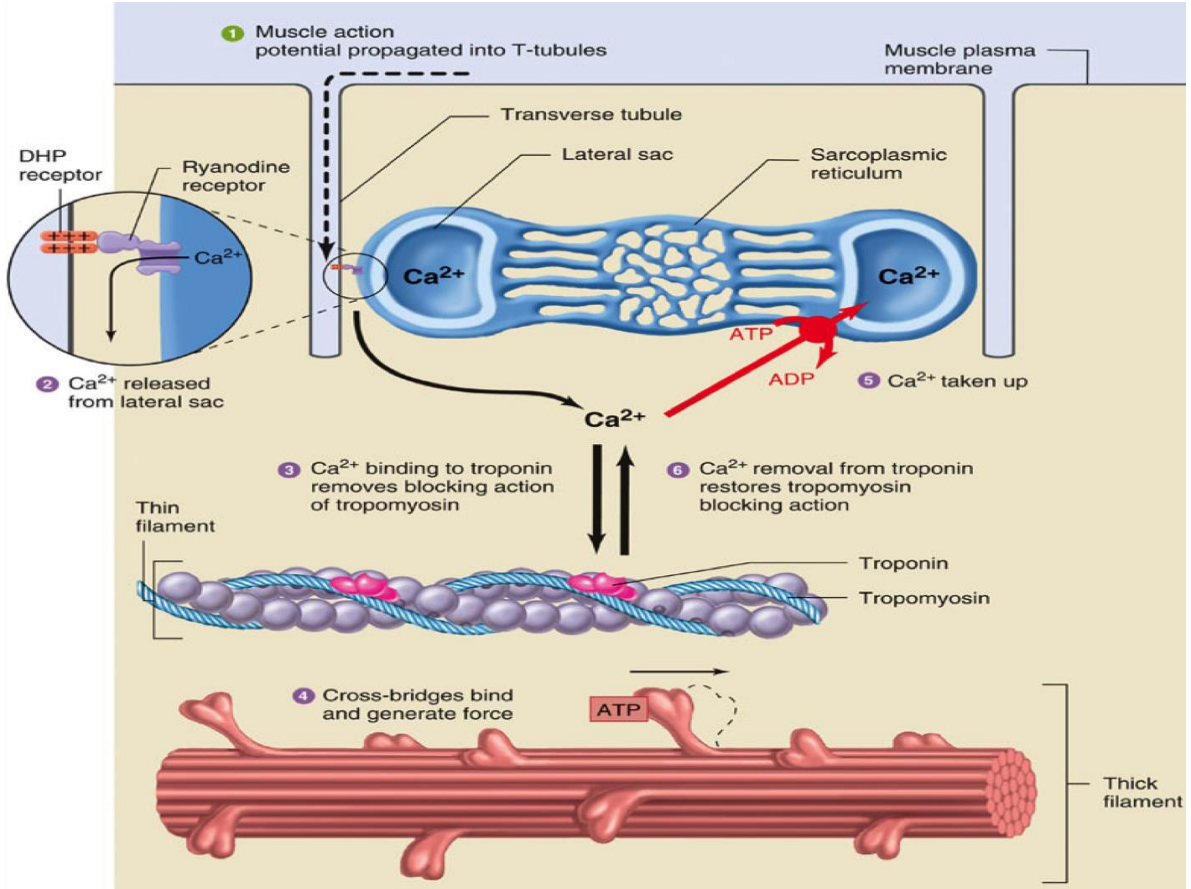
Steps

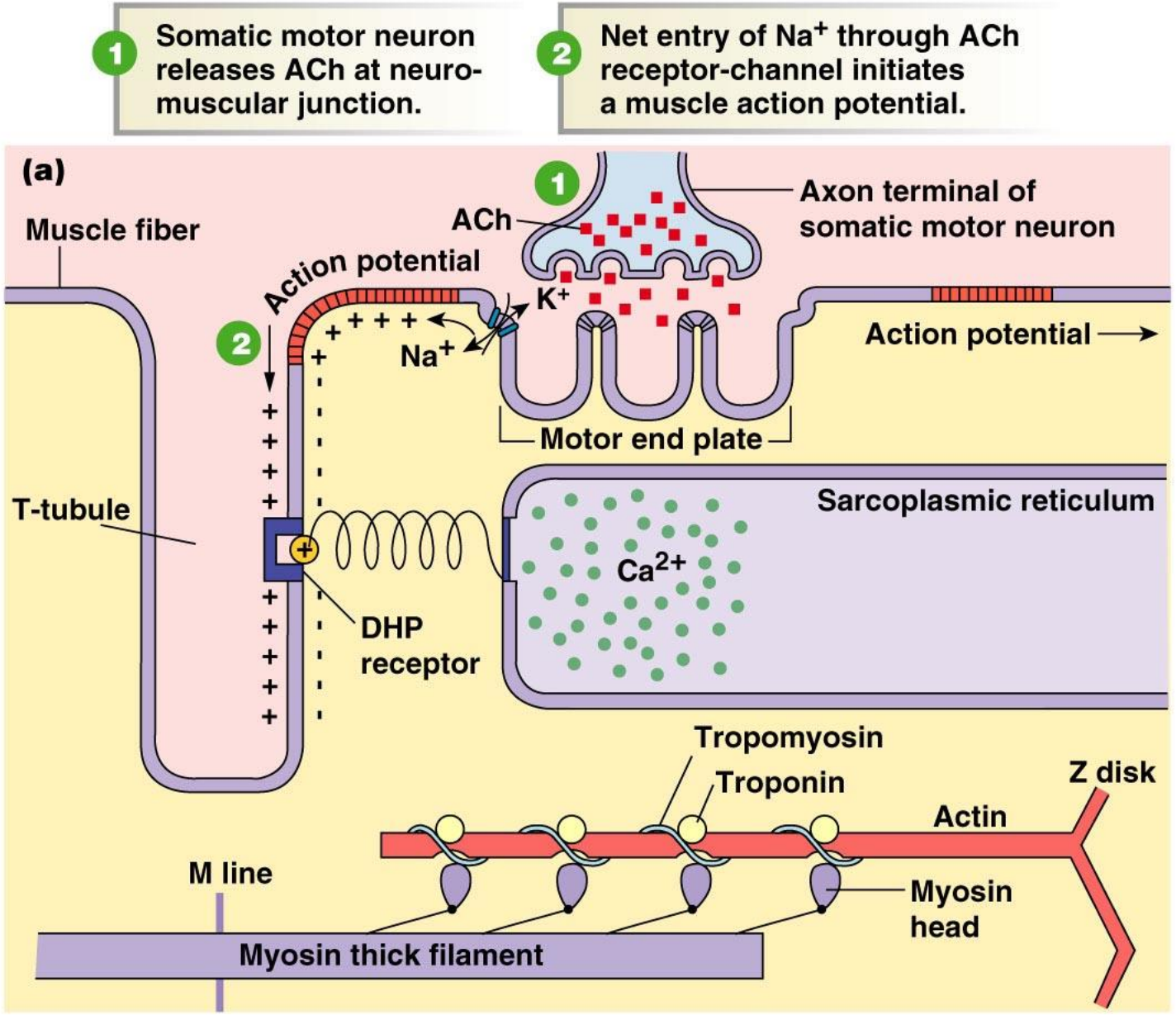
5. Ca^{2+} taken back up

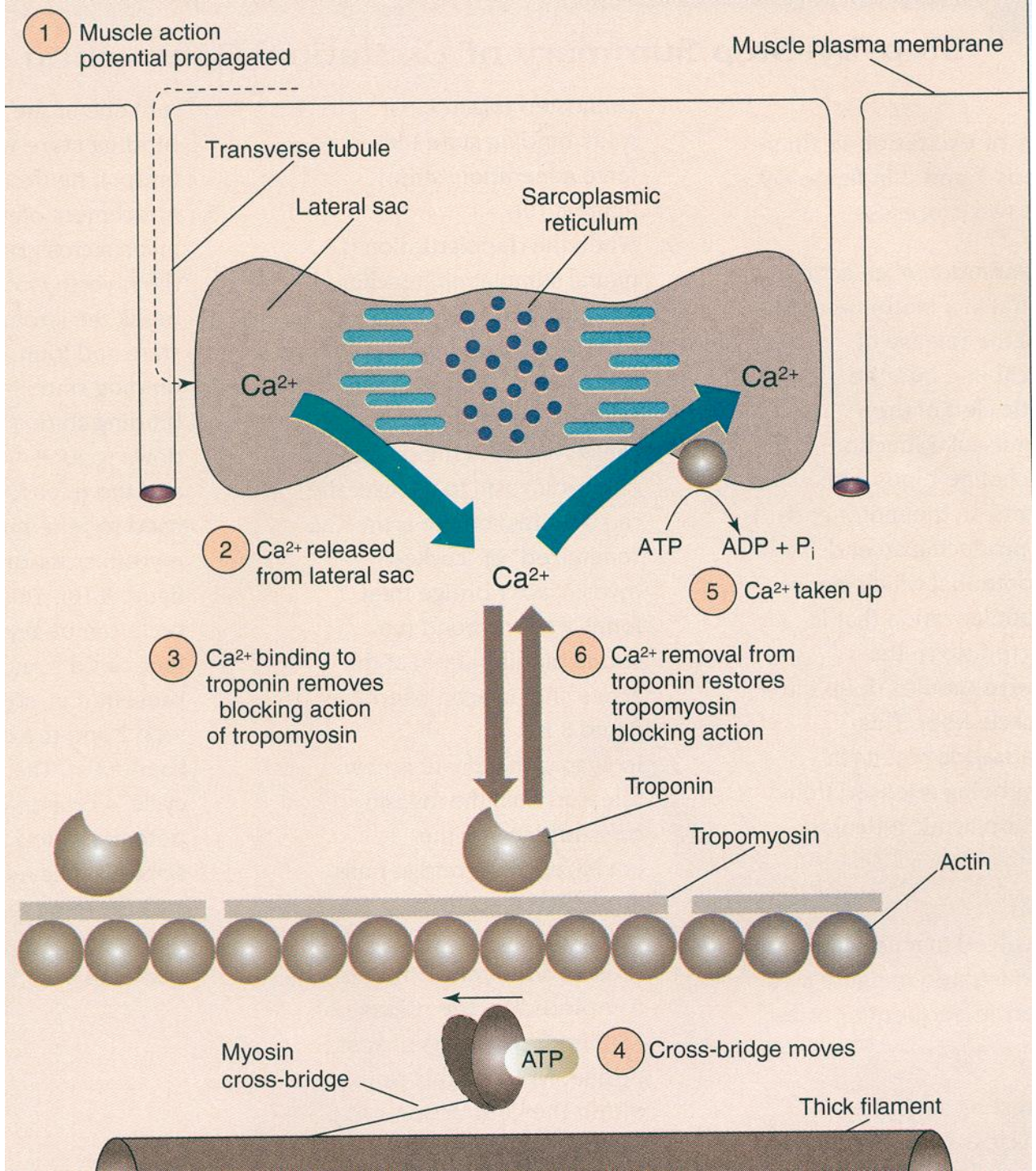


Steps

6, Ca^{2+} removal from troponin restores tropomyosin blocking agent.





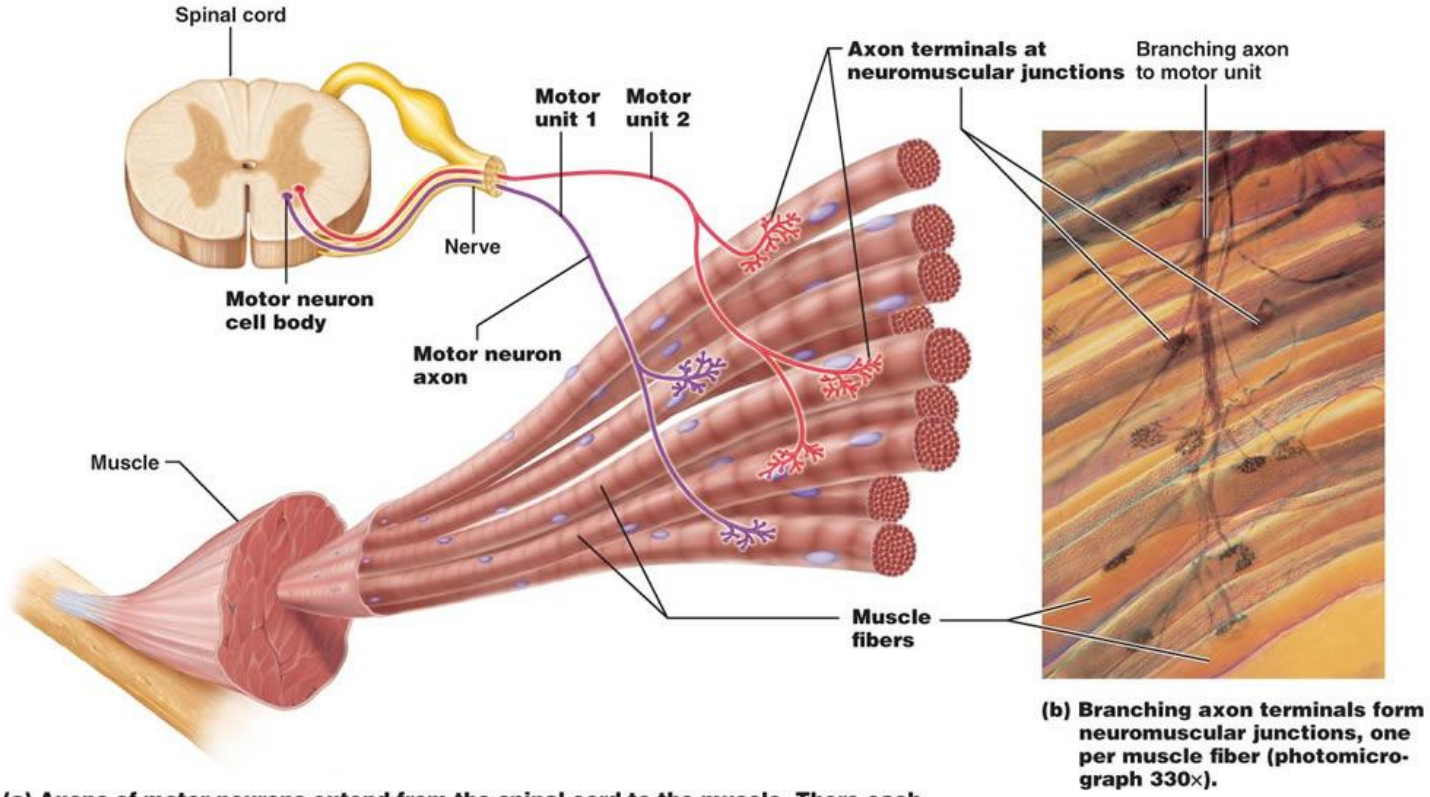


STEPS IN EXCITATION-CONTRACTION (RELAXATION) COUPLING

- Sites of peripheral fatigue (i.e. beyond the neuromuscular junction and in the muscle itself

Motor Unit

- **A motor unit consists of a motor neuron, axon, and the muscle fibres it stimulates**



(a) Axons of motor neurons extend from the spinal cord to the muscle. There each axon divides into a number of axon terminals that form neuromuscular junctions with muscle fibers scattered throughout the muscle.

(b) Branching axon terminals form neuromuscular junctions, one per muscle fiber (photomicrograph 330×).

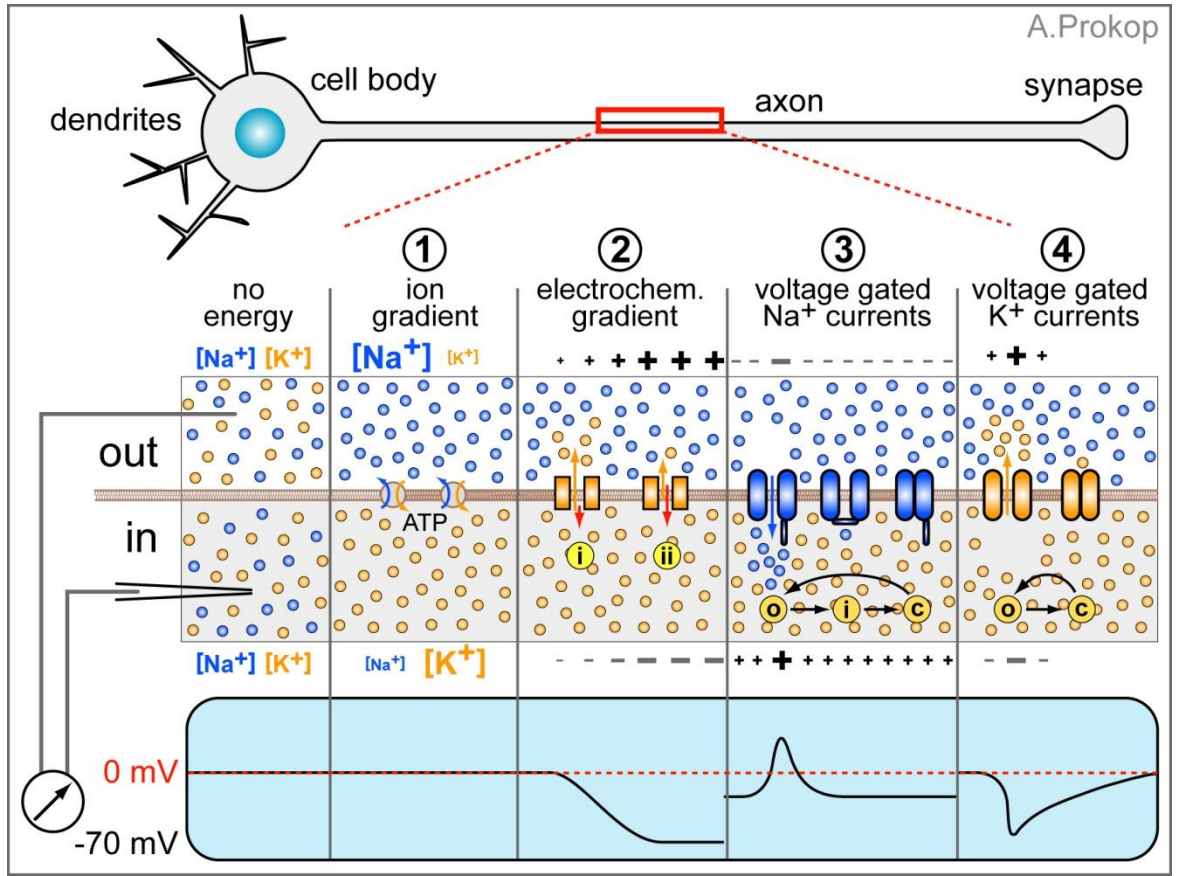
Motor unit

- Some motor units are attached to just a few muscle fibres while others in large muscles are attached to 100’s

- In order to do a one rep max, all motor units must be recruited.

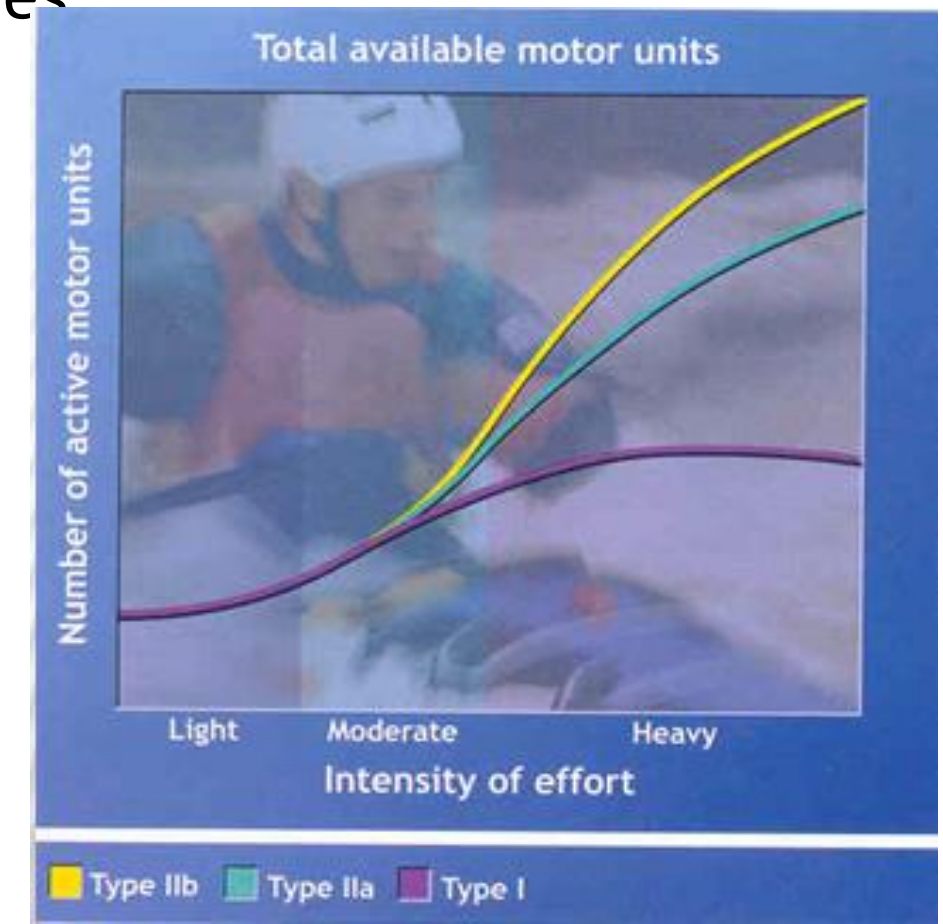
Motor Unit

- Nerve impulses come in waves.
  - **Single wave and muscle contraction is called a twitch**



Motor Units

- Slow twitch muscle motor units generally are smaller as they have fewer muscle fibres

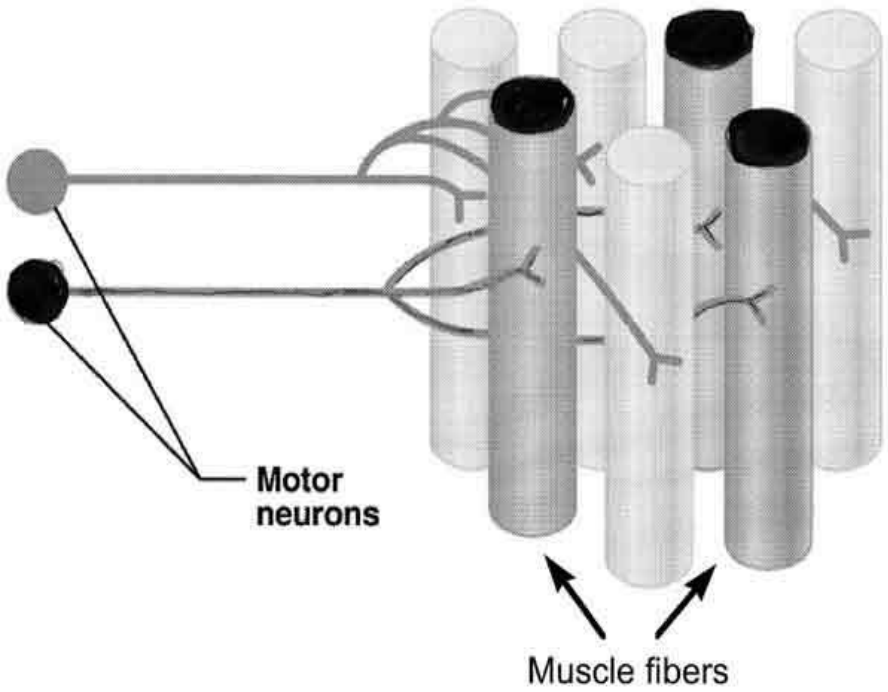


All-or-none Principle

- When a motor unit is stimulated to contract, all the muscle fibres will contract to their fullest potential. Either they all fire or they all don’t fire.

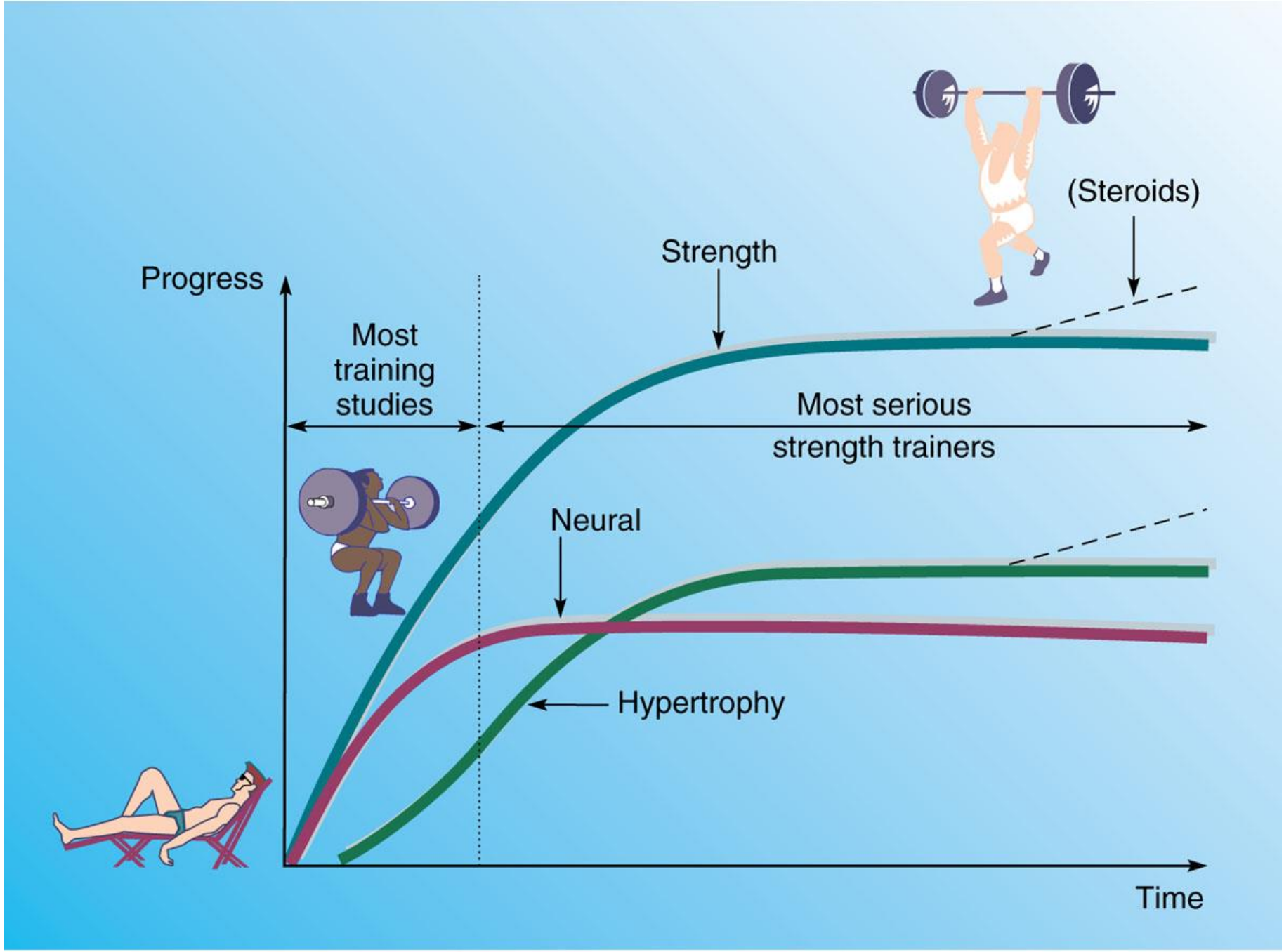
Motor Unit

- motor neuron and the muscle fibers it innervates
- smallest amount of muscle that can be activated voluntarily



- recruitment of motor units is the most important means of controlling muscle force

- To increase force:
  - Recruit more motor units
  - Increase frequency



- **Neural factors**
  - -Increased ability to activate motor units
  - -Strength gains in initial 4-20 weeks

- **Muscular enlargement**
  - -Mainly due enlargement of fibers (hypertrophy)
  - -Long-term strength training

High intensity – short duration
Training

- Nerve–muscle connections
  - Increased recruitment of additional motor units, which respond in a simultaneous fashion to improve force production
  - There is an increased activation of synergistic muscles to assist force production for strength, power, speed and hypertrophy.

High intensity – short duration
Training

- Nerve–muscle connections
  - Neural pathways linking to target muscles become more efficient at transmitting the message (stimulus).

High intensity – short duration
Training

- ✖ Timing of Neural Stimulus
  - The timing of contractions becomes more co-ordinated, especially with power, speed and strength training, in order to meet the force generation required to move loads.

High intensity – short duration Training

- Summation of motor units
- The ability to summate (fire a lot of impulses in target muscles all at once) is improved with strength and power training because they require maximum activation of target muscles to create maximum force.

Longer Duration Training

- No real Neural changes

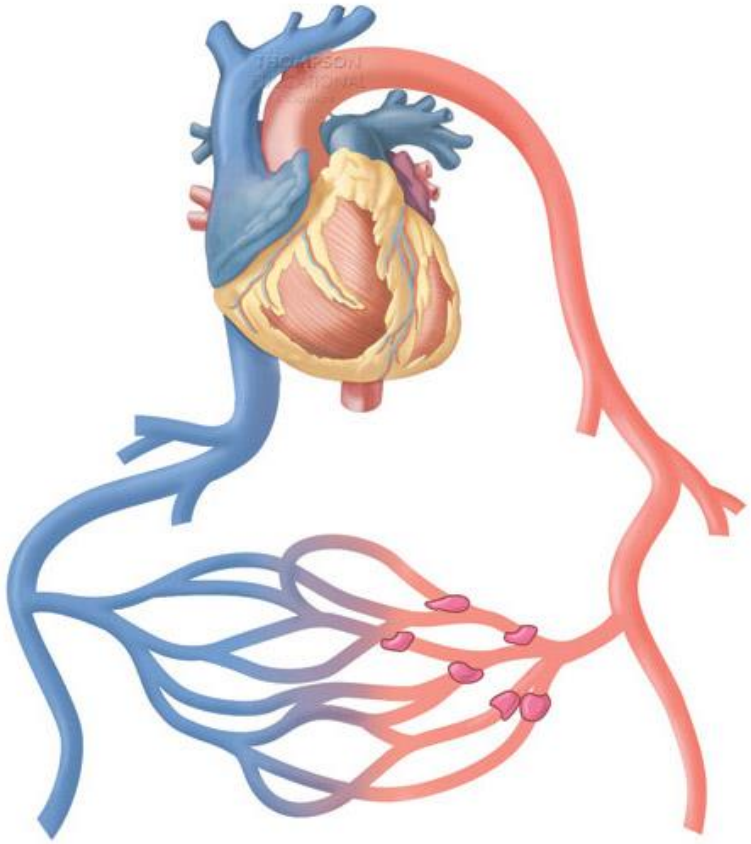
✖ As the duration of training lengthens slow twitch (endurance) fibres become increasingly dominant. Aerobic fitness, anaerobic fitness and muscular endurance training all improve the function of slow twitch fibres.

The Cardiovascular System

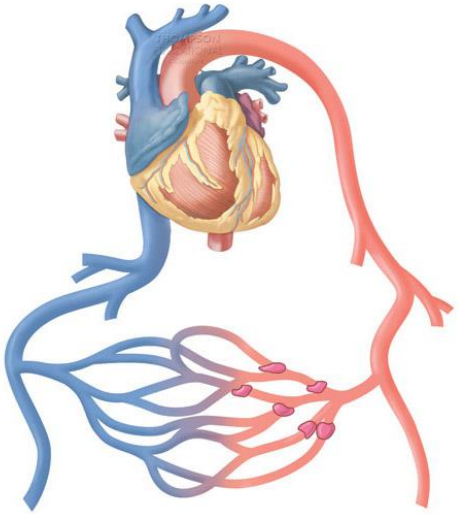
"related to the heart"

Cardiovascular System

- Composed of:
  - Heart
  - Blood vessels
  - Blood

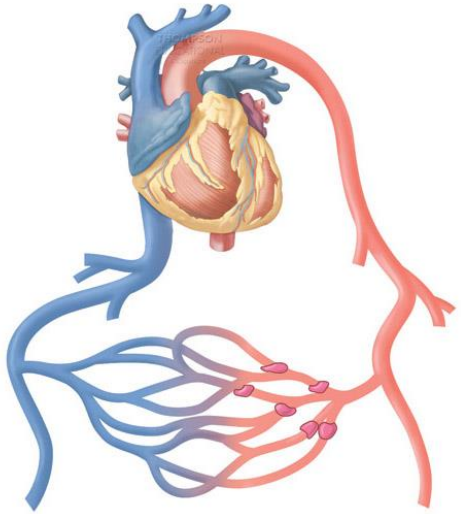


Cardiovascular System

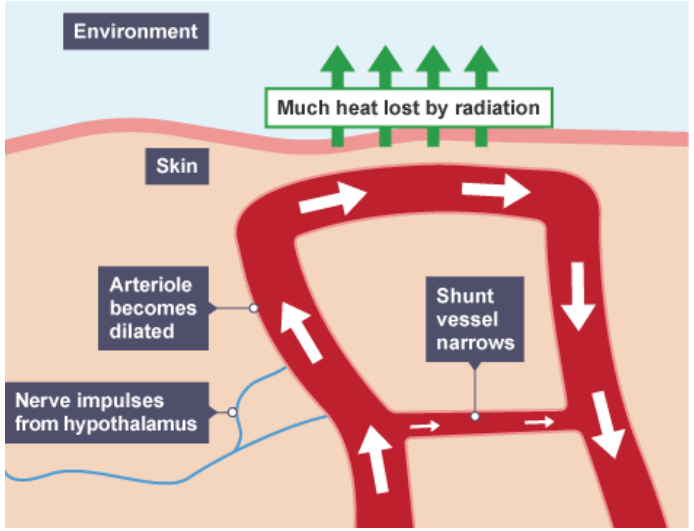


- Functions:
  - Delivery of O_2, fuel, and nutrients to the tissues of the body
  - Removal of CO_2 and waste products from the tissues

Cardiovascular System

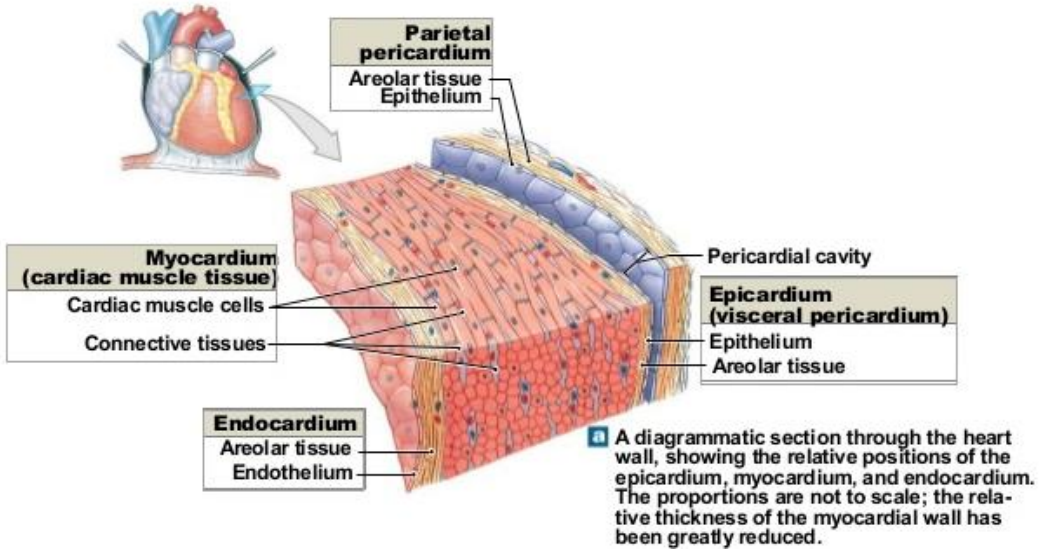


- Functions:
  - Maintenance of a constant body temperature (thermoregulation)
  - Prevention of infection (immune function)



The Heart

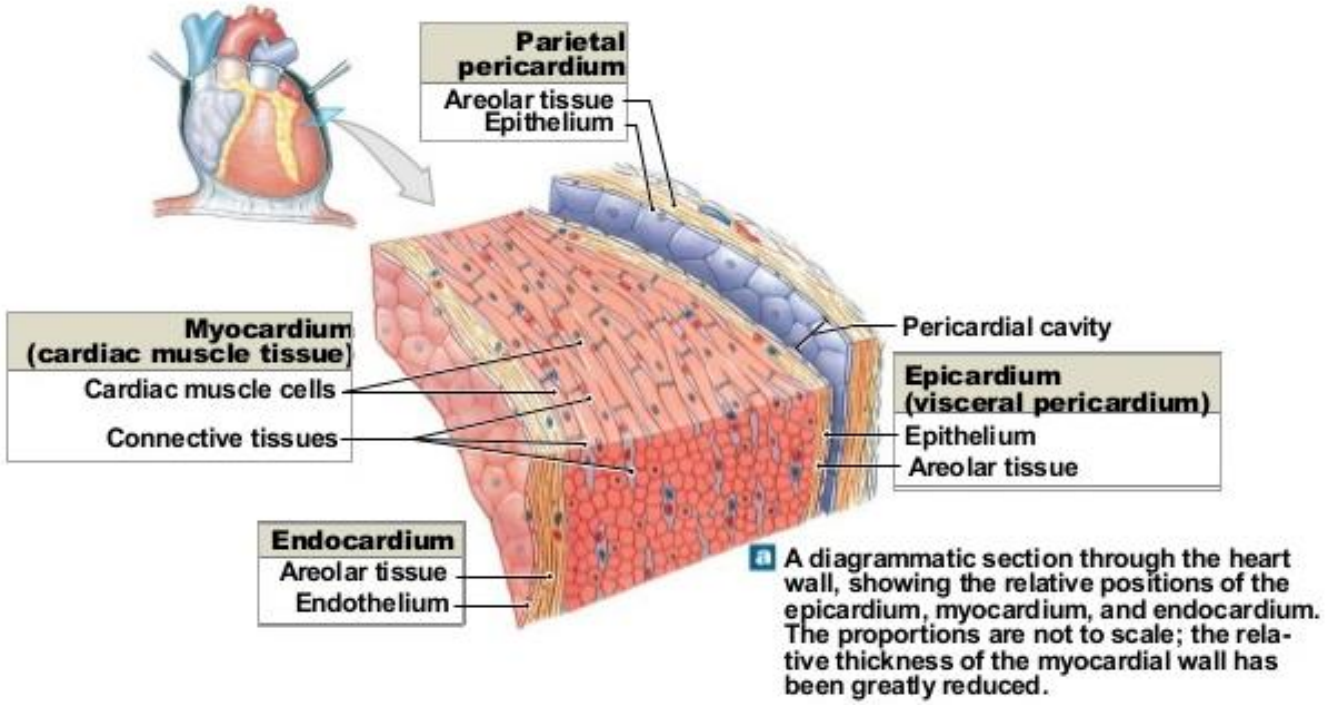
- Formed from *myocardium*, a specialized muscle tissue
- Surrounded by **pericardium** (tough protective sac); allows heart to expand and contract



A diagrammatic section through the heart wall, showing the relative positions of the epicardium, myocardium, and endocardium. The proportions are not to scale; the relative thickness of the myocardial wall has been greatly reduced.

The Heart

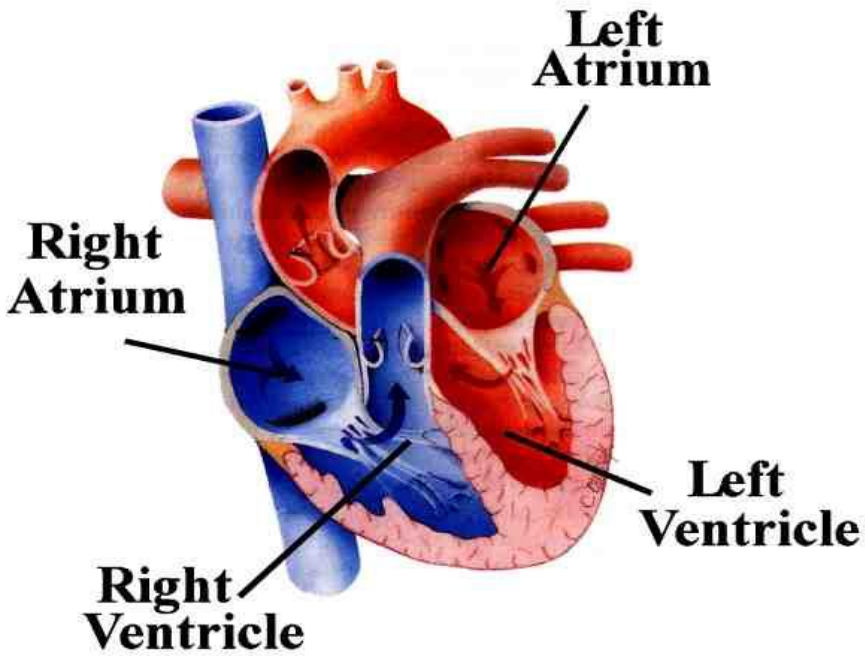
- **Epicardium** lines outside of heart; **endocardium** lines inside of heart



A diagrammatic section through the heart wall, showing the relative positions of the epicardium, myocardium, and endocardium. The proportions are not to scale; the relative thickness of the myocardial wall has been greatly reduced.

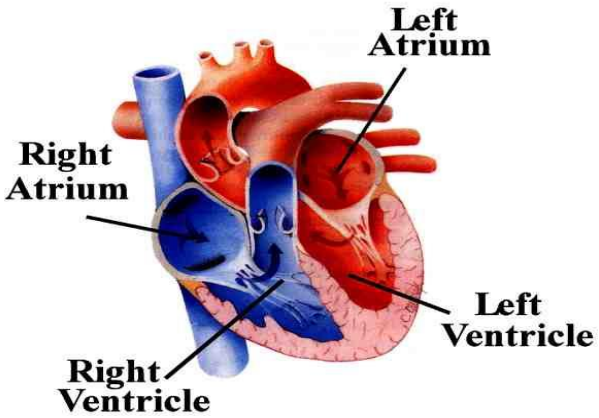
The Heart

- Made up of four separate chambers: atria (upper chambers) and ventricles (lower chambers)

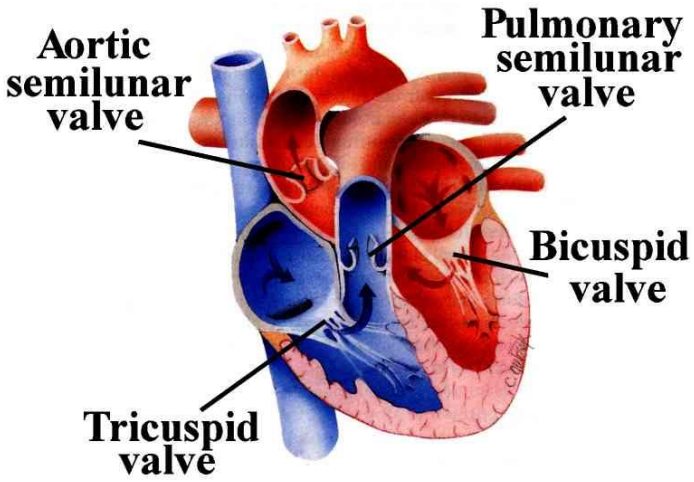


The Heart

- Ventricles are separated from atria by specialized valves that allow blood to flow only from atria into ventricles
  - Called Atrioventricular (AV) valves
  - Right side-Tricuspid valve-3 flaps
  - Left side-Bicuspid (Mitral) valve-2 flaps
  - Attached to papillary muscles by chordae tendinae
    - Prevent inversion

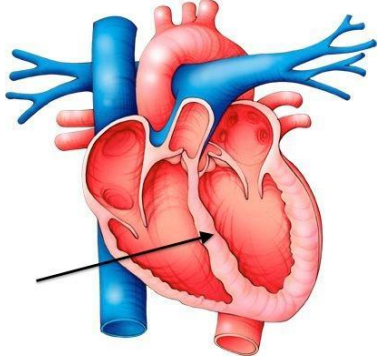


The Heart



- Semilunar valves-blood leaves the ventricles
  - Pulmonary Semilunar Valve
    - Right side of heart
    - Prevents blood from flowing back from the pulmonary arteries into the right ventricle
  - Aortic Semilunar Valve
    - Left side of the heart
    - Separates the aorta from the left ventricle

The Heart

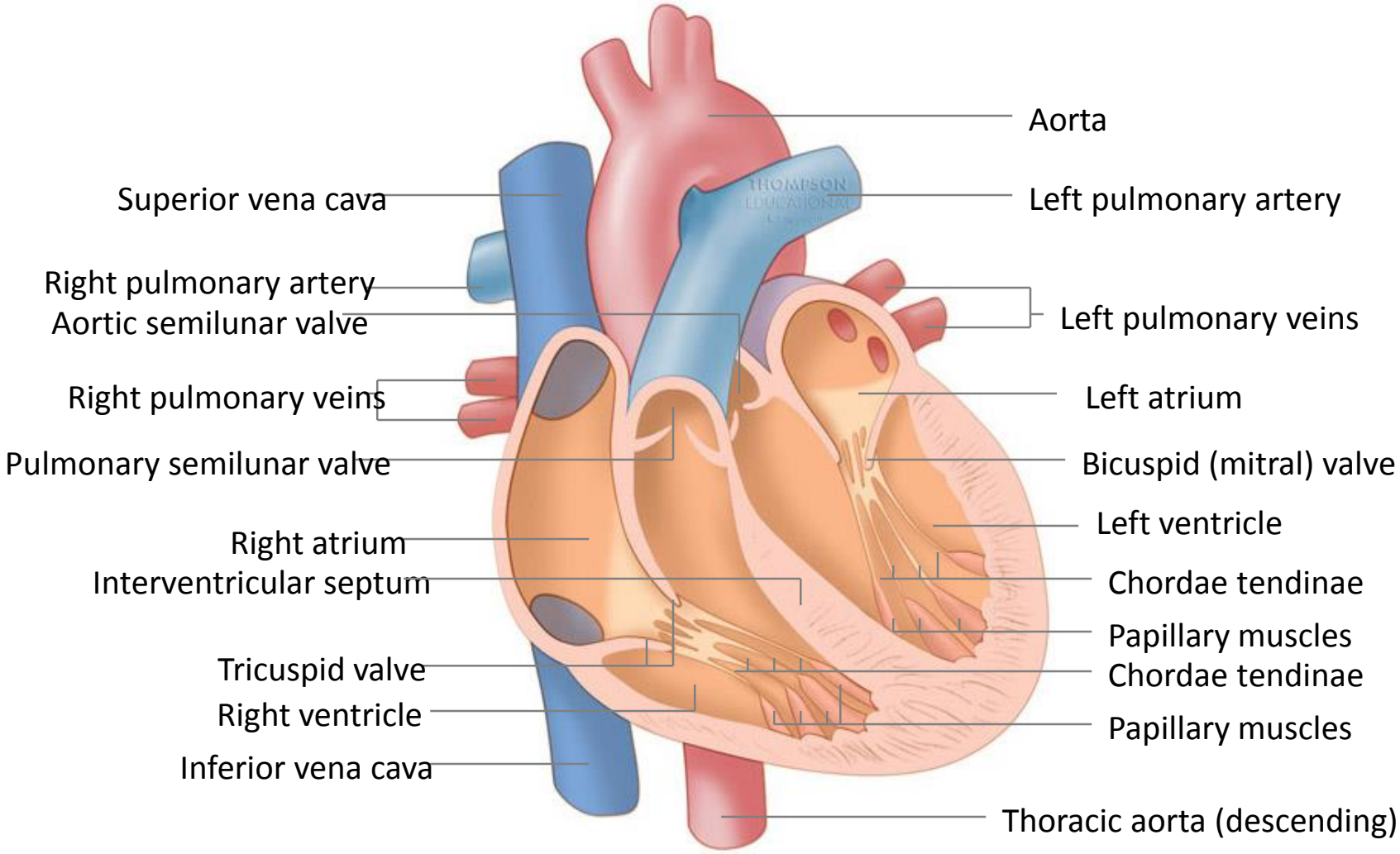


- Considered a “double-pump” and is divided into the right and left heart; separated by the interventricular septum
  - ❖Right heart:
    - pumps deoxygenated blood to the lungs (*pulmonary circulation*)
      - Very dark red, depicted as blue
  - ❖Left heart:
    - Pumps oxygenated blood to the rest of the body (*systemic circulation*)
      - Bright red

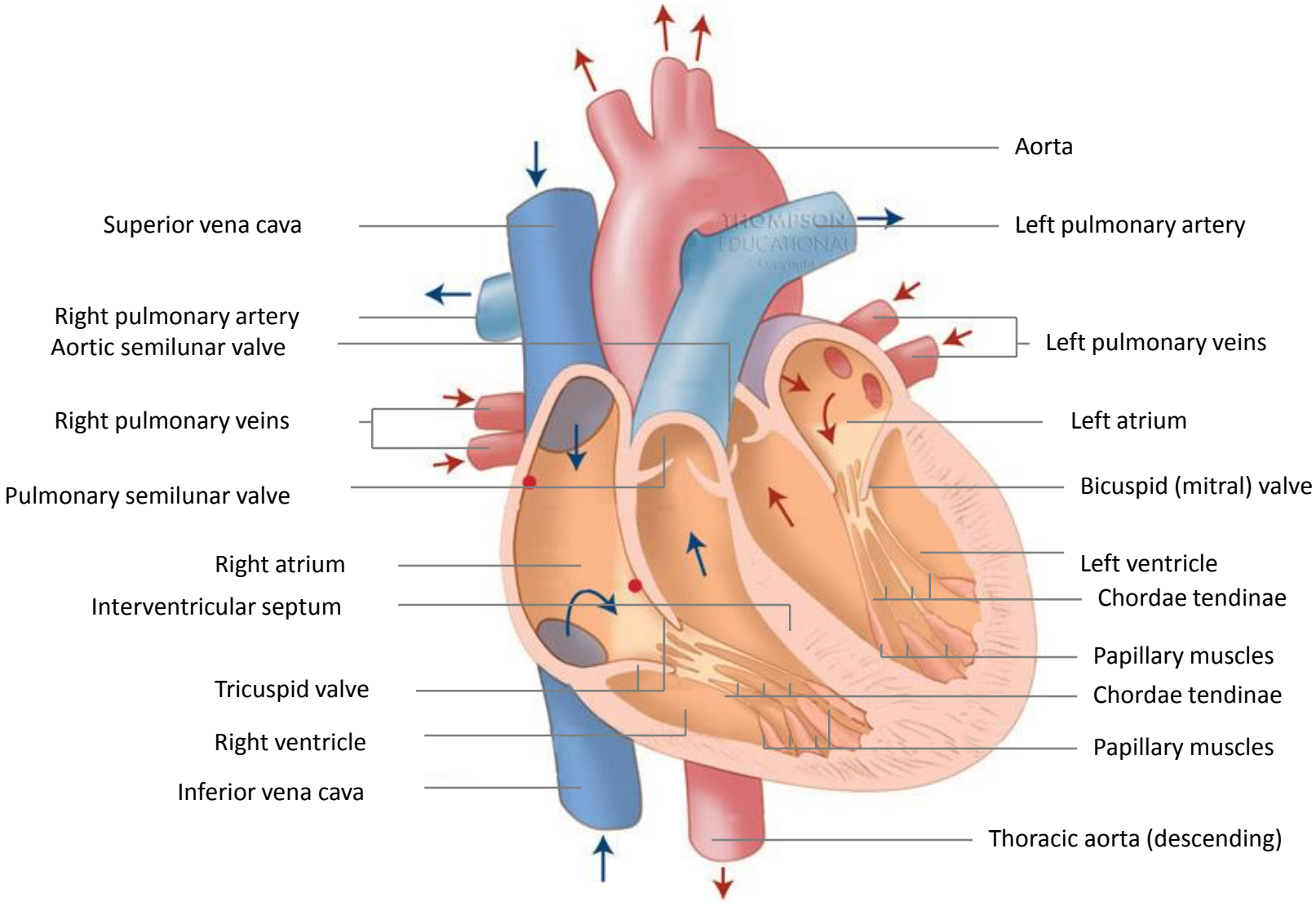
Structures of the Heart

Common Structures	Structure of right side	Structure of left side
Chordae tendinae	Superior and inferior vena cava	Aorta and thoracic (descending aorta)
Papillary muscles	Right atrium	Left atrium
Interventricular septum	Right ventricle	Left ventricle
	Pulmonary artery	Pulmonary vein
	Tricuspid valve	Bicuspid (mitral) valve
	Pulmonary valve	Aortic valve

The Internal Anatomy of the Heart



Path of Blood Through the Heart



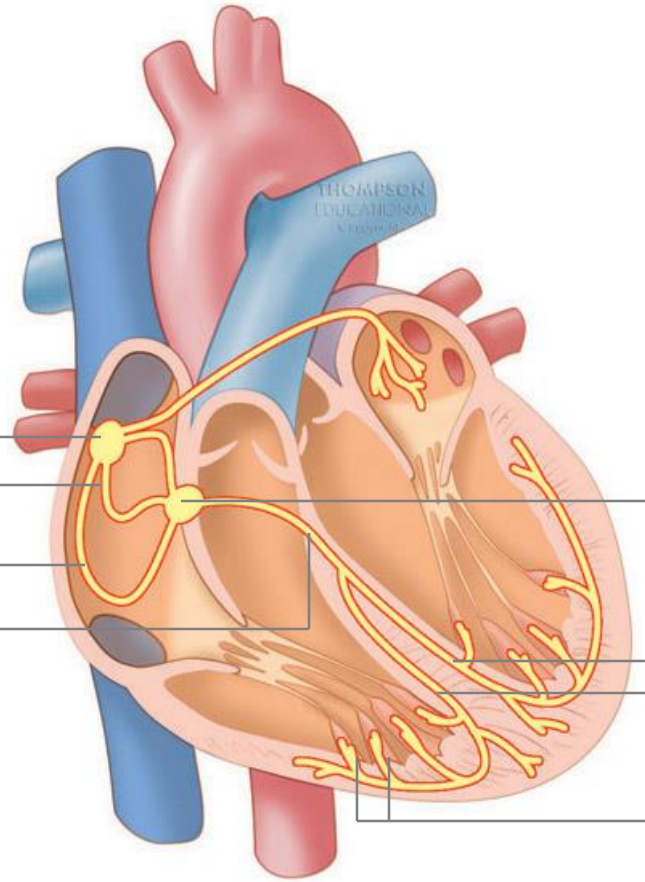
Systemic vs Pulmonary Circulation

- Arteries carry blood away from the heart
  - Systemic circulation (vast majority of body's blood vessels)
    - Carry oxygenated blood from heart to the tissues
  - Pulmonary circulation
    - Carry deoxygenated blood from heart to lungs
- Veins carry blood toward the heart
  - Systemic circulation
    - Carry deoxygenated blood from tissues back to heart
  - Pulmonary circulation
    - Carry oxygenated blood from lungs back to heart

Cardiac Muscle

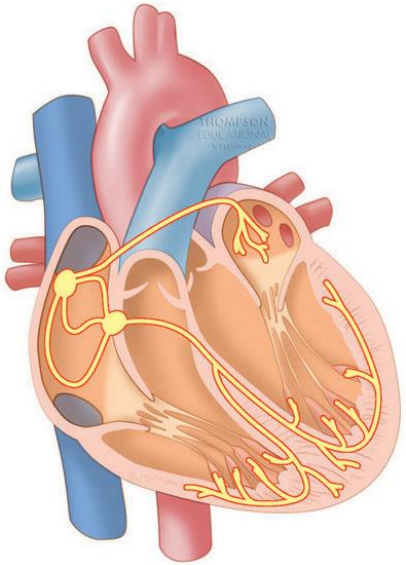
- Similar in structure to skeletal muscle
- Interconnected and excitable
  - Allow passage of electrical signals
  - Allows the myocardium to contract as a unit
  - When a single cell is stimulated to contract it causes all other cardiac muscles to contract
  - SYNCYTIUM
- Contraction of the heart leads to pumping of blood

The Heart – Electrical Conduction System



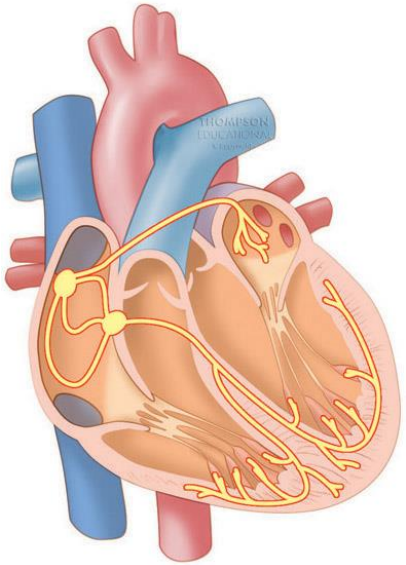
Excitation of the Heart

- *Sinoatrial node (SA node)*:
  - Specialized region of tissue found in wall of right atrium
  - Location where electrical signals are initiated (“pacemaker”)
  - Sets the basic rate of contraction
  - Modulated by the autonomic nervous system
  - Electrical signals are spread through both atria by internodal pathways (top to bottom)



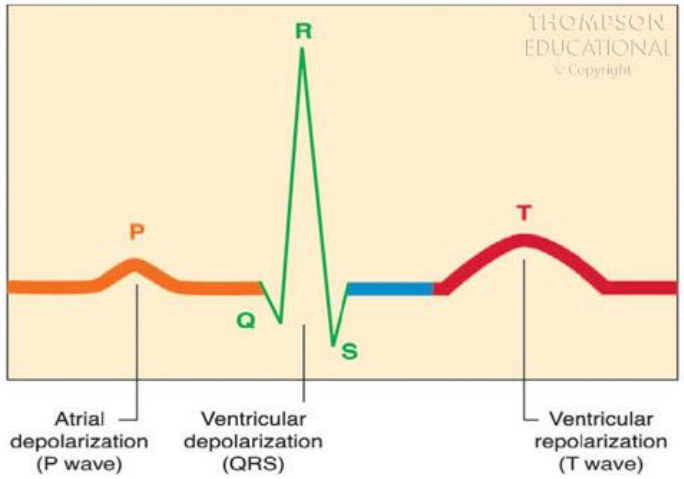
Excitation of the Heart

- *Atrioventricular node (AV node)*:
  - Passes electrical signal from atria into ventricles
  - Passes electrical signal to the bundle of His (*atrioventricular bundle*)
- Bundle of His pass electrical signal to the *Purkinje fibres*
- Purkinje fibres pass electrical signal to the *myocardium*
- The myocardium of ventricles contract (bottom to top)
  - Leads to contraction of the heart
  - Leads to the pumping of blood



The Electrical Activity of the Heart

- Measured using an *electrocardiogram* (ECG)
  - Graphical representation of electrical sequence of events occurring with each contraction of the heart
  - Each wave generated during contraction is named:
    - **P wave**: represents depolarization through the atria
      - Spreading of the electrical signal to contract through the atria
      - Atria is immediately repolarized – not visible in ECG
    - **QRS complex**: represents depolarization of the ventricle
    - **T wave**: represents repolarization of the ventricle

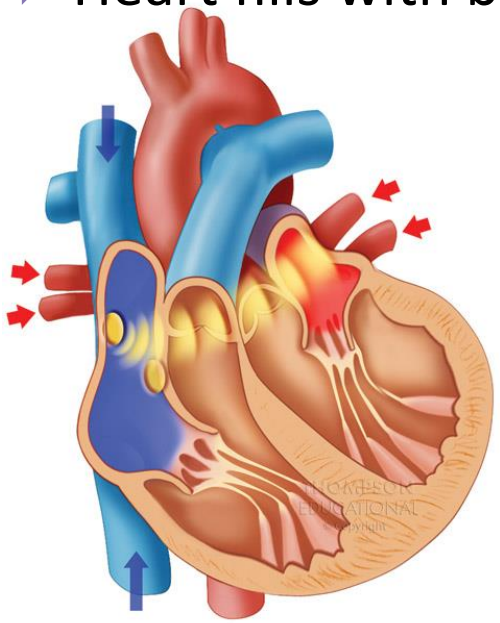


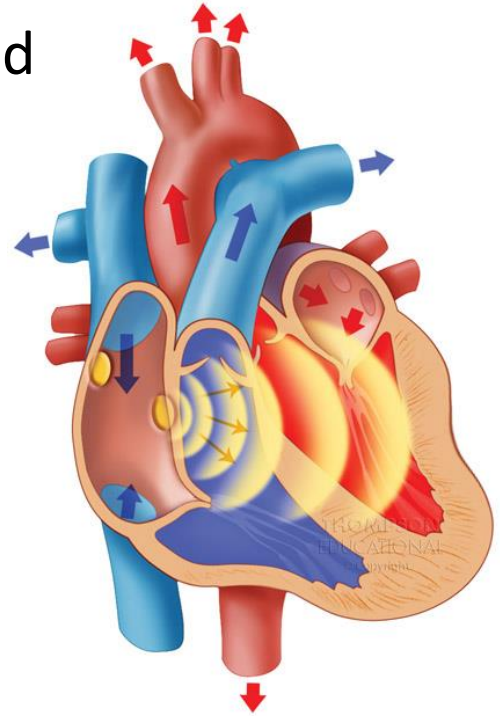
Coronary Circulation

- Heart requires constant supply of O_2, fuel and nutrients
- Myocardial infarction
  - Blood supply to a region of the myocardium is cut off for a prolonged period of time or blood flow is reduced
    - Myocardium will die or become damaged
  - HEART ATTACK

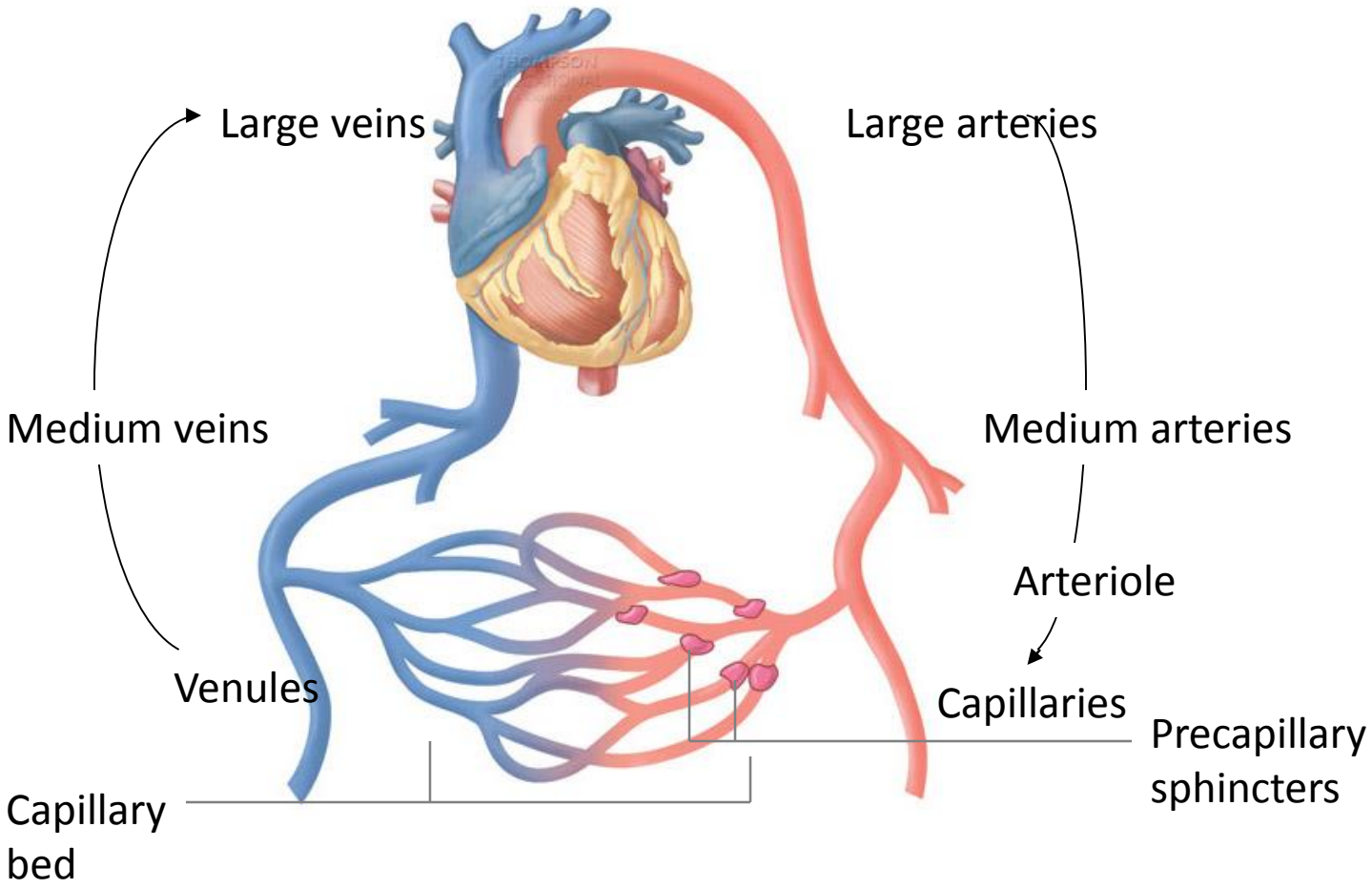
Cardiac Cycle

- *Cardiac cycle*: series of events occurring through one heartbeat
- Dramatic changes in pressure in the heart-measure in arteries
- Involves two phases:
  - Diastole phase (relaxation)
    - Heart fills with blood
  - Systole phase (contraction)
    - Heart contracts and ejects blood



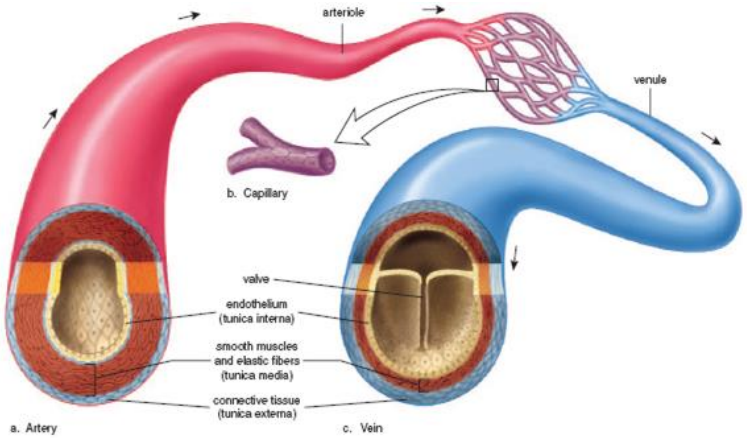


Summary of the Vascular System



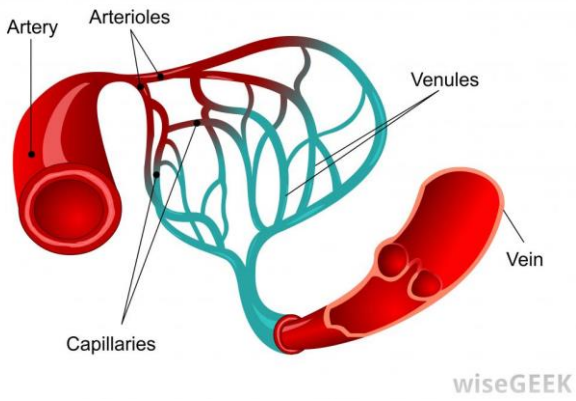
The Vascular System and Blood

- *Vascular System*:
  - A network of vessels that transport blood throughout the body
  - Endothelium lines the inside of all vessels
  - Vessels divided into four main categories:
    - *Arteries*
      - carry blood away from the heart to different organs
      - Thick muscular walls, elastic-stretch and return
      - Systolic Blood Pressure vs Diastolic Blood Pressure

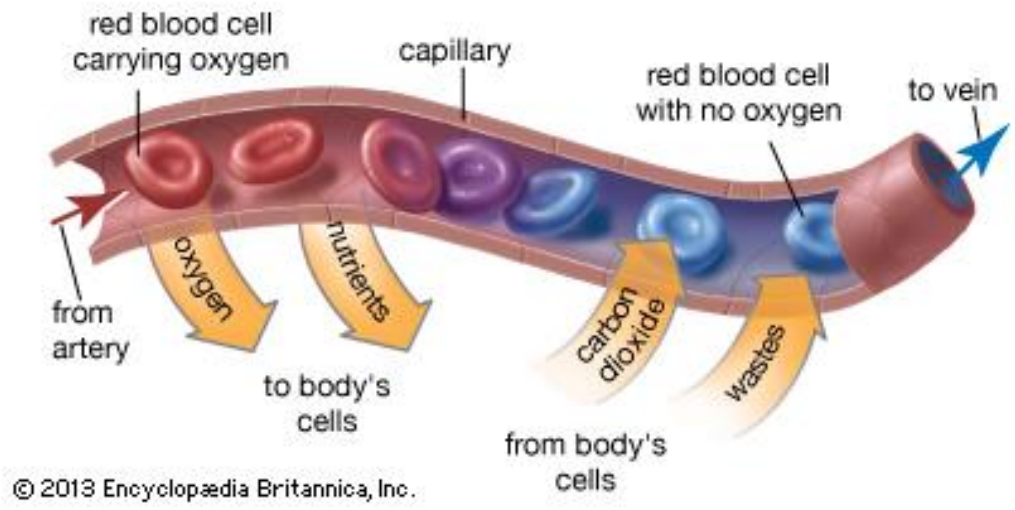


The Vascular System and Blood

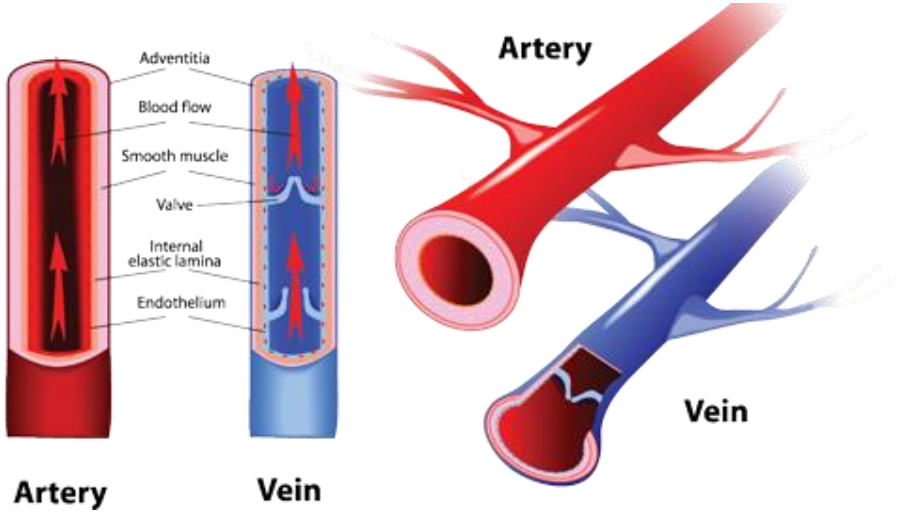
- *Arterioles*
  - regulate blood distribution to various tissues of the body
  - Surrounded by rings of smooth muscle
    - Regulate blood flow
    - Controlled by nervous system and local chemical factors released by surrounding tissues
    - AUTOREGULATION-effects of locally produced chemicals on blood

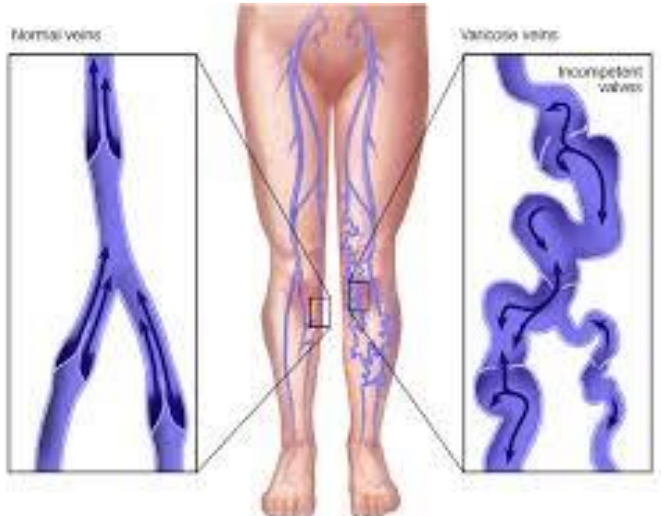


- *Capillaries*
  - responsible for the exchange of gases and nutrients with the tissues
  - Smallest vessel but most important function
  - RBCs barely fit through
  - Thin walls
  - All body tissues have extensive supply
  - Exchange depends on diffusion



- *Veins* (venules)
  - Return blood to the heart
  - Become larger as they move away from capillaries
  - Eventually come to an end at the vena cava
    - Drain deoxygenated (venous) blood in right atrium
  - Wall of veins contain smooth muscle
    - Ability to dilate and contract
    - Enough blood return to heart
    - Usually carry deoxygenated blood
    - One way valves-ensure one way blood flow

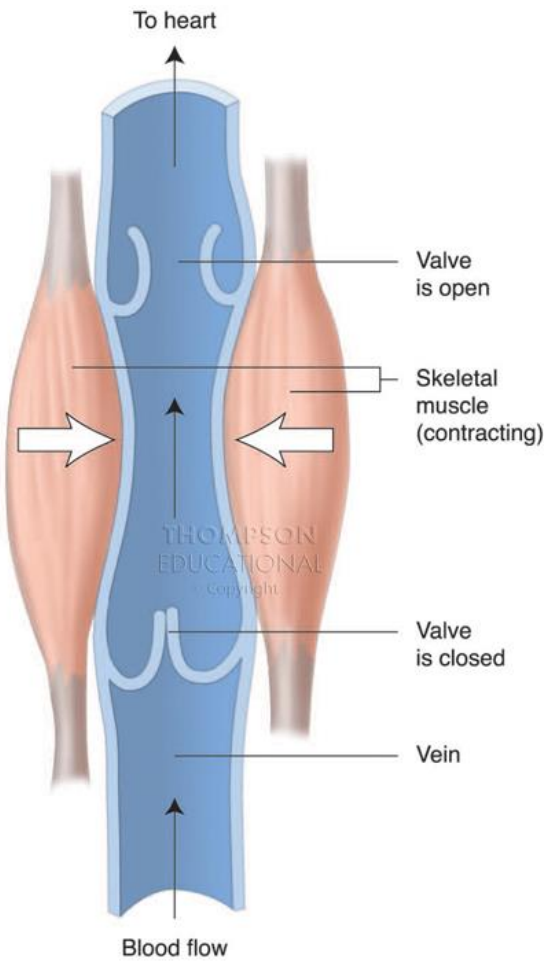




The Return of Blood from the Veins

-compensate for low pressure

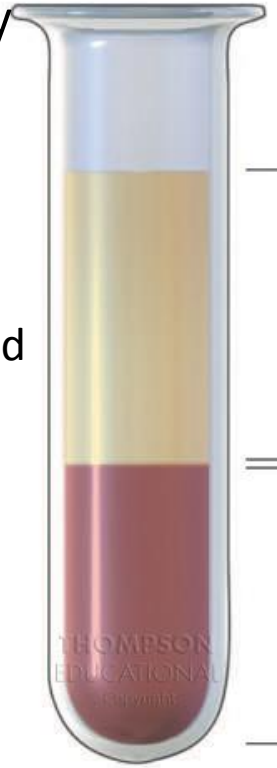
- The *skeletal muscle pump*:
  - Upon contraction of skeletal muscle, blood is pushed/
    massaged back to the heart
  - Compresses the vein and increases pressure
- The *thoracic pump*:
  - Pressure in veins (in the chest) decrease while pressure in veins (in the abdominal cavity) increase upon intake of breath
  - Difference in pressure pushes blood from veins in the abdominal cavity into veins in the thoracic cavity
- The nervous system:
  - Sends a signal to veins
  - Veins constrict allowing more blood back to the heart



The skeletal muscle pump

Properties of Blood
-transport medium

- Two main components:
  - Plasma
    - Fluid component of blood (mostly water)
  - Blood cells
    - *Red blood cells* (erythrocytes)
      - Made in bone marrow
      - Transport O_2 and CO_2 in the blood
      - Transport nutrients and waste
      - Contain *hemoglobin*
    - *White blood cells* (leukocytes)
      - Destroy foreign elements
      - Critical in the function of the immune system
    - *Platelets*
      - Regulate blood clotting



Plasma 55%
90% water
7% plasma proteins
3% other (acids, salts)

Formed elements 45%
>99% red blood cells
<1% white blood cells and platelets

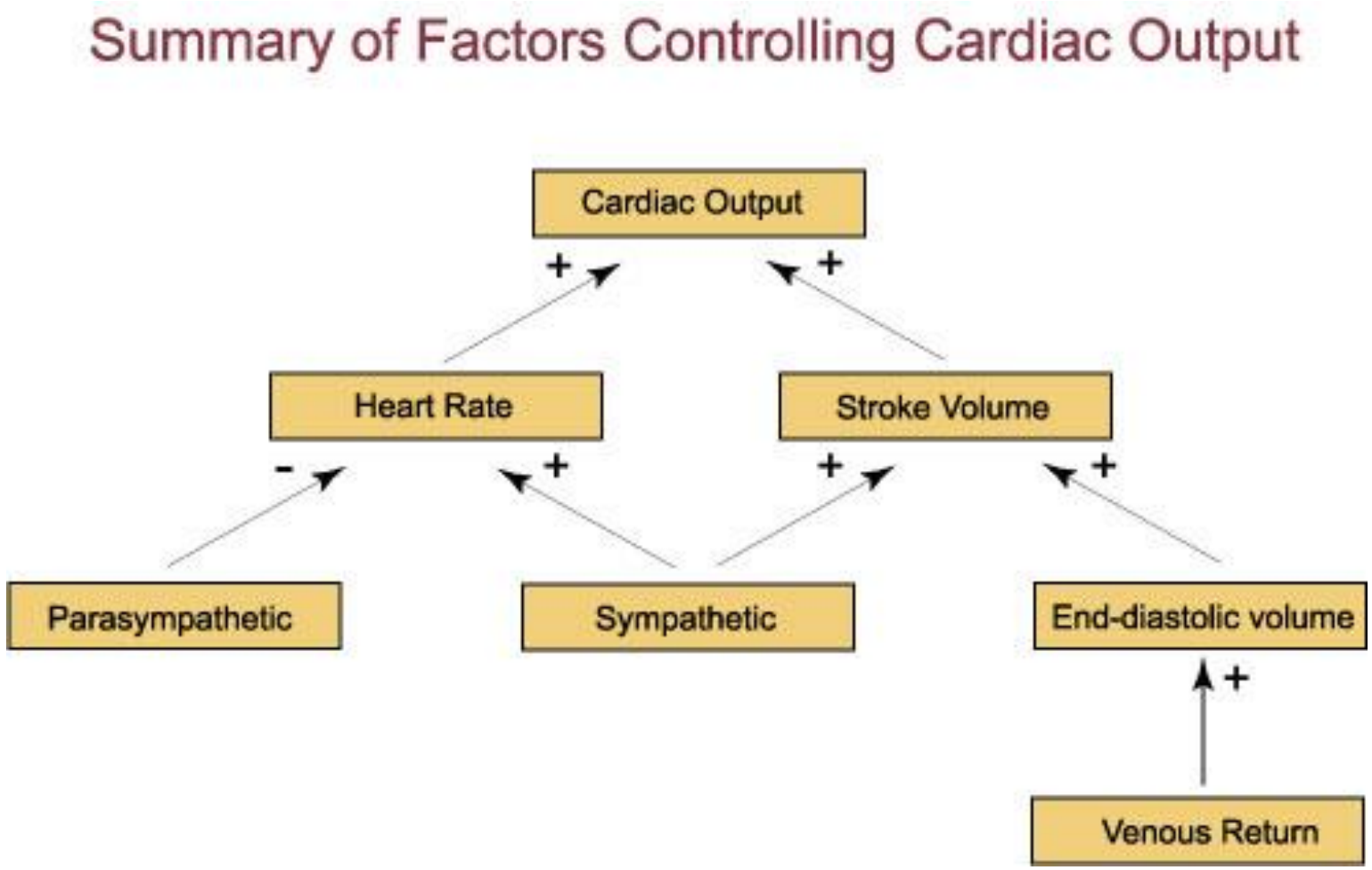
Cardiovascular Dynamics

- Cardiovascular system adapts to meet the demands that are placed on it
- Heart adjusts amount of blood pumped by altering:
  - *Heart rate (HR)*
    - duration of each cardiac cycle
  - *Stroke volume(SV)*
  - *Cardiac output (Q)*
- *Frank-Starling Law*:
  - Ability of the heart to stretch and increase the force of contraction
- *Ejection fraction*
  - Measure of stroke volume calculated by use of a formula

Cardiac Output

- Volume of blood pumped out of left ventricle in 1 minute
- L/min
- 5-6L/min at rest
- Approximately 30 L/min during exercise
- Two factors contribute to Q
  - Stroke volume and heart rate
  - HR × SV = Q

Cardiac Output

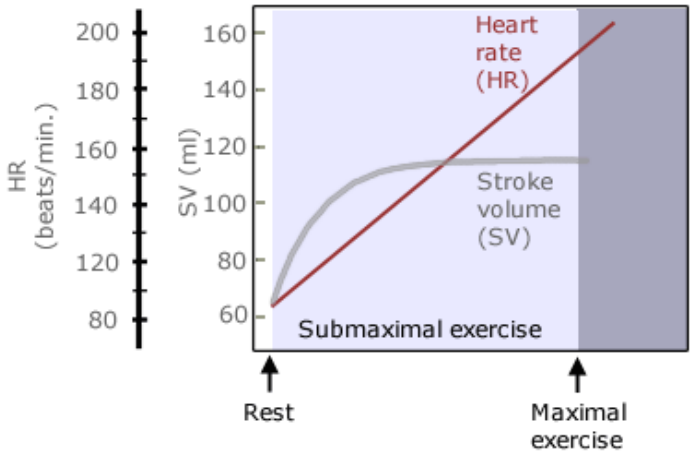


Stroke Volume

- volume of blood ejected by ventricles
  - Left ventricle in a single beat
- Measured in mL
- Calculated by subtracting the
  - LVESV-left ventricular end systolic volume
    - Amount of blood remaining in the left ventricle after it contracts
  - LVEDS-left ventricular end diastolic volume
    - Amount of blood in the left ventricle before it contracts (after atria contracts)
    - Capacity to stretch

Stroke Volume

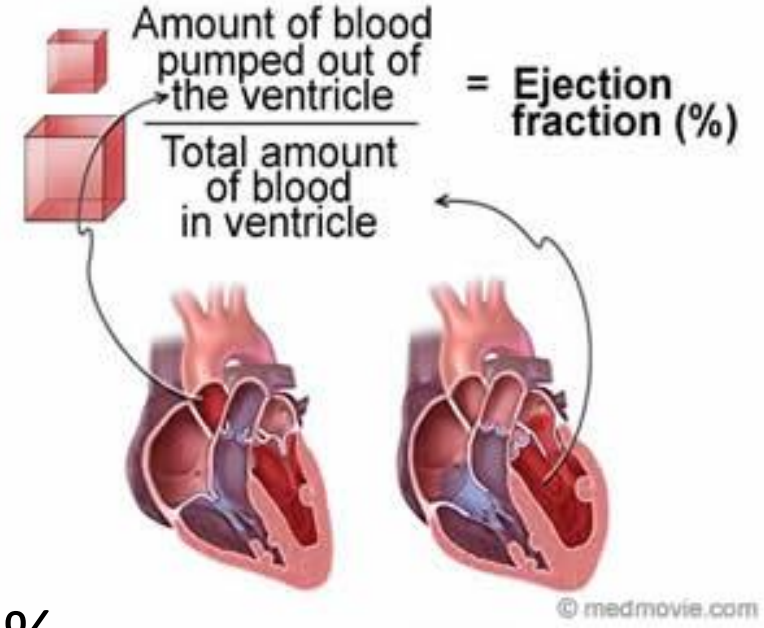
- SV = LVEDS – LVESV
- Regulate by 3 main factors
  - LVEDV-ability of heart to stretch allows this to increase
  - Aortic blood pressure
  - Strength/Force of ventricular contraction
    - Due to stretching of ventricle and therefore more forceful contraction
- Frank Starling Law-Ability of the heart to stretch and increase the force of contraction



Stroke Volume

- During exercise venous return increases as the result of 4 factors
  1. Constriction of the veins
     - Smooth muscle in walls of veins is stimulated during exercise
     - Contracts reducing diameter
     - Reducing blood volume in veins and directing it to the heart
  2. Skeletal muscle pump
  3. Thoracic pump
  4. Nervous stimulation
     - Increases heart rate
     - Increase in force of contraction
     - Increase in SV

Ejection Fraction

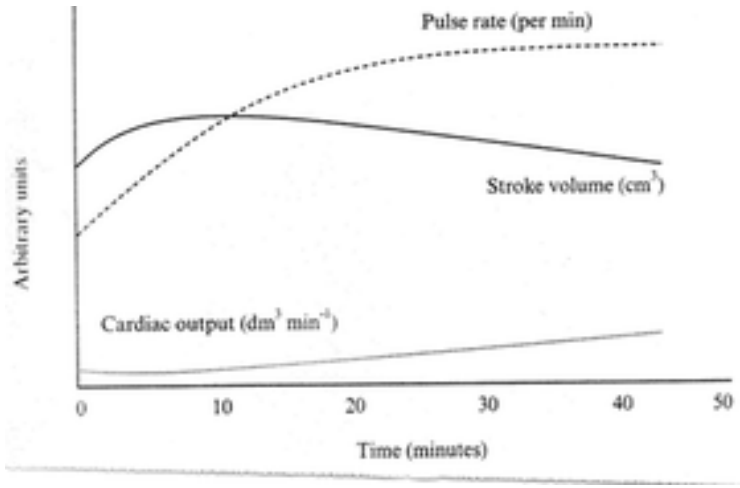


- Efficiency of SV
- Average EF at rest is 50-60 %
- Increases during exercise, up towards 85%
- Proportion of blood that is ejected from the left ventricle during a single heart beat
  - $EF(\%) = \frac{SV\ (ml)}{LVEDV\ (ml)} \times 100$

Heart Rate and Cardiac Output

- Number of times a heart contracts in one minute
  - Beats per minute
- Can calculate cardiac output using heart rate
  - $Q_{(L/min)} = SV_{(ml)} \times HR_{(beats/min)}$
  - At rest
    - HR = 72 beats per min
    - SV = 71 ml
    - Q = 5040 ml/min = 5.04L/min
  - During exercise, Q=15-20 L/min
    - Increase occurs early in exercise and the remains at that level
    - Due to an increase in SV and HR
    - Increase in Q is related to the intensity of the exercise

Cardiovascular Drift



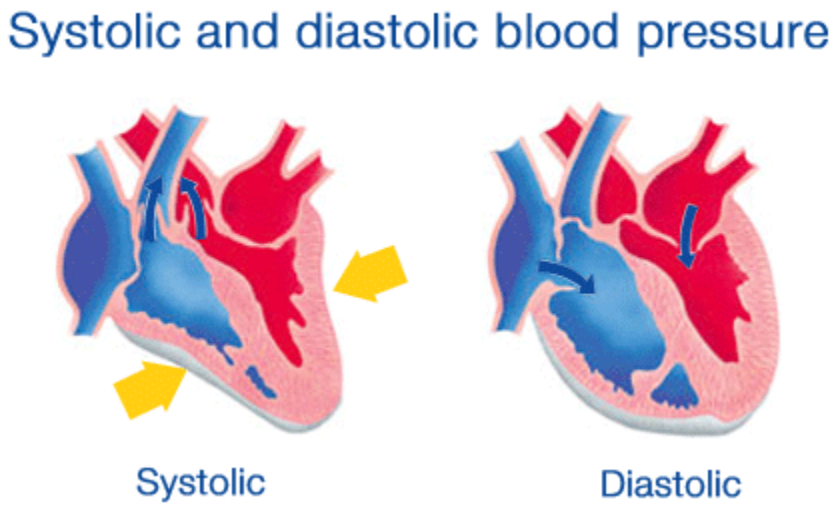
- Prolonged exercise
  - SV may begin decline
    - Due to increase in body temp
      - Excessive fluid loss due to sweating
      - Decrease in plasma volume
      - Redistribution of blood flow to the skin
      - Dehydration
    - Lower the venous return, therefore SV may decline
  - HR begins to increase to compensate for decline in SV
  - Q stays constant

Blood Pressure

- *Blood Pressure* is the force exerted by the blood against the walls of the arteries
- Measuring blood pressure: systolic pressure over diastolic pressure

Blood Pressure

- *Systolic blood pressure*:
  - Pressure observed in the arteries during contraction phase
- *Diastolic blood pressure*:
  - Pressure observed in the arteries during relaxation phase of the heart



Blood Pressure

- Blood pressure changes during exercise
  - Aerobic activity
    - Sustained increase in systolic pressure but no change in diastolic
  - Resistance Training
    - Short, large increase in both systolic and diastolic
  - Post-exercise
    - BP drops below resting level – **Post Exercise Hypotension** - not for all people

Normal Blood Pressure

- Normal blood pressure (BP)
  - Old Standard 120mmHg over 80mmHg
  - New Standard-doctors want it lower

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)
Normal	less than 120	and	less than 80
Prehypertension	120 – 139	or	80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or	90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	or	Higher than 110

Normal Blood Pressure

- *Hypertension*
  - BP greater than 140mmHg over 90mmHg
  - Major risk factor for cardiovascular disease
  - Modifiable-aerobic exercise and diet low in saturated fats and cholesterol as well as high in fibre and complex carbs
  - May need medication

Normal Blood Pressure

- Factors affecting BP
  - Diet
  - Aerobic exercise

Blood Flow Distribution

Vascular region	At rest (6%)	Light exercise (30%)	Heavy exercise (75%)	Maximal Exercise (100%)
Cerebral	720 mL (12%)	720 mL (6%)	720 mL (3%)	720 mL (2%)
Myocardial	240 mL (4%)	480 mL (4%)	960 mL (4%)	1,200 mL (4%)
Muscle	1,260 mL (21%)	5,760 mL (48%)	17,280 mL (72%)	26,400 mL (88%)
Renal	1,320 mL (22%)	1,200 mL (10%)	720 mL (3%)	300 mL (1%)
Digestive	1,560 mL (26%)	1,440 mL (12%)	960 mL (4%)	300 mL (1%)
Skin	540 mL (9%)	1,920 mL (16%)	2,640 mL (11%)	900 mL (3%)
Other	360 mL (6%)	480 mL (4%)	720 mL (3%)	180 mL (1%)
TOTAL	**6,000 mL**	**12,000 mL**	**24,000 mL**	**30,000 mL**

Meet the skeletal muscle demand for O_2

-increase Q

-redistribute blood

Effects of Training (Aerobic)

- Alterations to heart structure
  - Increase in mass and dimension
    - Increase in ventricular volume and thickness of ventricular walls
      - Due to increase in venous return
    - Both contribute to an increase in SV and hence Q
  - Increase in capillary number that deliver blood to myocardium
    - Due to increase in oxygen demand
  - Increase in diameter of coronary arteries

Effects of Training (Aerobic)

- Increase in blood volume
  - Contribute to increase venous return and therefore SV and Q
- Increase in RBCs
- Training causes Q to increase during exercise but remain unchanged at rest
  - SV increase during rest and decrease in HR-BRADYCARDIA

Effects of Training

	Q	=	SV (mL)	x	HR (beats/ min)
Untrained					
Rest	5.00	=	70	x	72
Exercise					
Light	9.35	=	85	x	110
Moderate	14.25	=	95	x	150
Maximal	22.00	=	110	x	200
Trained					
Rest	5.00	=	100	x	50
Exercise					
Light	9.40	=	125	x	75
Moderate	14.85	=	135	x	110
Maximal	34.2	=	180	x	190