


# NEUROMUSCULAR PHYSIOLOGY



“I WANT A CONTRACT”

# NEUROLOGICAL CONTROL

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# Central Nervous System

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- ❑ Involves the BRAIN and SPINAL CORD
- ❑ PARASYMPATHETIC system
  - Controls the craniosacral divisions
- ❑ SYMPATHETIC system
  - Controls the thoracolumbar divisions

# Inhibitory Neurotransmitters

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- GABA: brain; causes an influx of chloride
- GLYCINE: spinal cord; causes an influx of chloride

# PARASYMPATHETIC SYSTEM

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- ❑ Uses acetylcholine for preganglionic fibers and postganglionic fibers
- ❑ DEPOLARIZES the head and neck as well as below the belt
- ❑ HYPERPOLARIZES the thoracolumbar areas
- ❑ Has long preganglionic fibers, short postganglionic fibers

# SYMPATHETIC SYSTEM

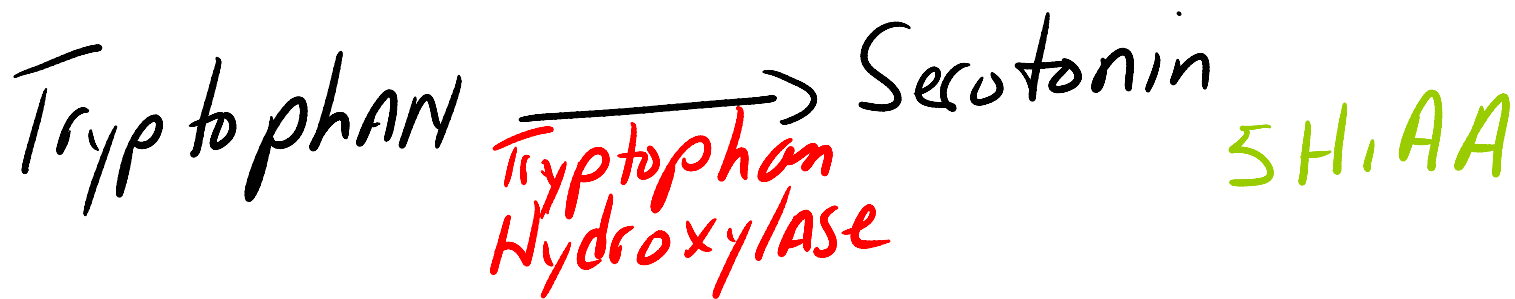
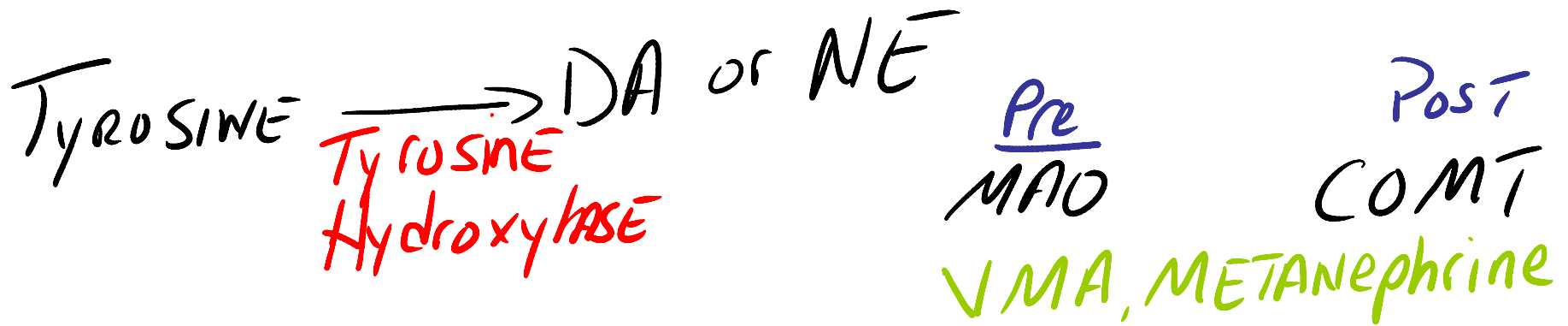
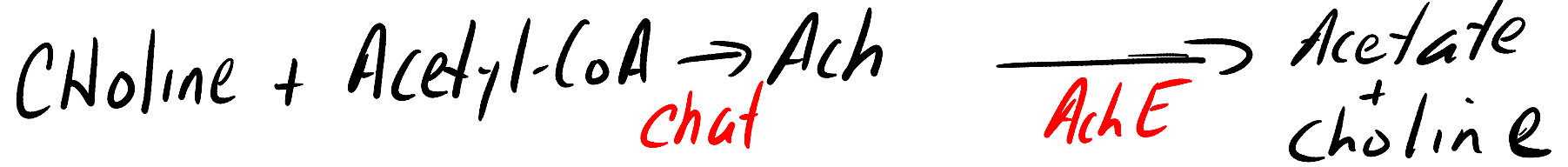
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- ❑ Uses acetylcholine for preganglionic fibers; uses primarily NE for postganglionic fibers
- ❑ Some pathways use DA or SEROTONIN
- ❑ DEPOLARIZES the brain and the thoracolumbar areas
- ❑ HYPERPOLARIZES the sacral area
- ❑ Has short preganglionic fibers, long postganglionic fibers

# Second Messengers

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- ❑ **PARASYMPATHETIC: c-GMP**
- ❑ **SYMPATHETIC: c-AMP**
  
- ❑ Smooth muscle contraction by neurotransmitter or hormone: IP3/DAG
- ❑ Smooth muscle contraction by distention: calcium-calmodulin





# Parasympathetic Receptors

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- Most are MUSCARINIC except at ganglia or neuromuscular junctions which are NICOTINIC

# Sympathetic Receptors

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- Many are NICOTINIC, except for sweat glands which are muscarinic or...

# Alpha 1 Receptors

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- Arteries: vasoconstriction
- Sphincters: tighten
- Radial muscles of the eyes: mydriasis w/o cycloplegia

# Alpha 2 Receptors

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- All presynaptic sympathetic fibers: inhibit NE release
- Islet cells of pancreas: inhibit insulin secretion

# Beta 1 Receptors

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- ❑ CNS: increased activity
- ❑ SA NODE: increase heart rate and contractility
- ❑ JG Apparatus: increased renin release
- ❑ Alpha cells of pancreas: increased glucagon release

# Beta 2 Receptors

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- ❑ CNS: increased activity
- ❑ Ventricles: increased contractility but NOT rate
- ❑ Lungs: bronchodilation
- ❑ Arterioles: vasodilation
- ❑ Islet cells of pancreas: increased insulin
- ❑ Uterus and Bladder: relaxation

# If you want to stimulate...

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- You want to depolarize
- Make the cell more positive
- Make Na move INTO the cell
- Make Ca move into SA node

# If you want to inhibit...

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- CNS: make CL move into cell
- PNS: make K move out of cells
  
- In either case, cells become more NEGATIVE and are less likely to depolarize



**NOW FOR THE MUSCLES!**

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# TYPES of MUSCLES

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- CARDIAC muscle
- SKELETAL muscle
- SMOOTH muscle

# STRIATED MUSCLES

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- Cardiac muscle
- Skeletal muscle
  
- Striations due to sarcomeres

# Smooth Muscle

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- Appear smooth due to lack of striations

# Skeletal Muscle

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- Use intracellular calcium for contraction
- 100% electrochemically coupled
- Function as motor units( one nerve fiber and all the muscle fibers it innervates
- Demonstrate RECRUITMENT
- NO AUTONOMICS
- NO SYNCYTIAL activity

# Cardiac Muscle

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- ❑ Uses intracellular calcium for contraction
- ❑ Needs extracellular calcium to trigger off intracellular calcium release
- ❑ Complete SYNCYTIAL activity
- ❑ The most gap junctions
- ❑ Complete AUTONOMICS
- ❑ Can function without innervation, neurotransmitters or hormones

# Smooth Muscle

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- ❑ Uses intracellular calcium for contraction
- ❑ Needs extracellular calcium for its second messenger system ( when it flows inside the cell)
- ❑ Has AUTONOMICS
- ❑ Has partial SYNCYTIAL activity
- ❑ Can function without innervation, neurotransmitters or hormones

# NEUROMUSCULAR TRANSMISSION

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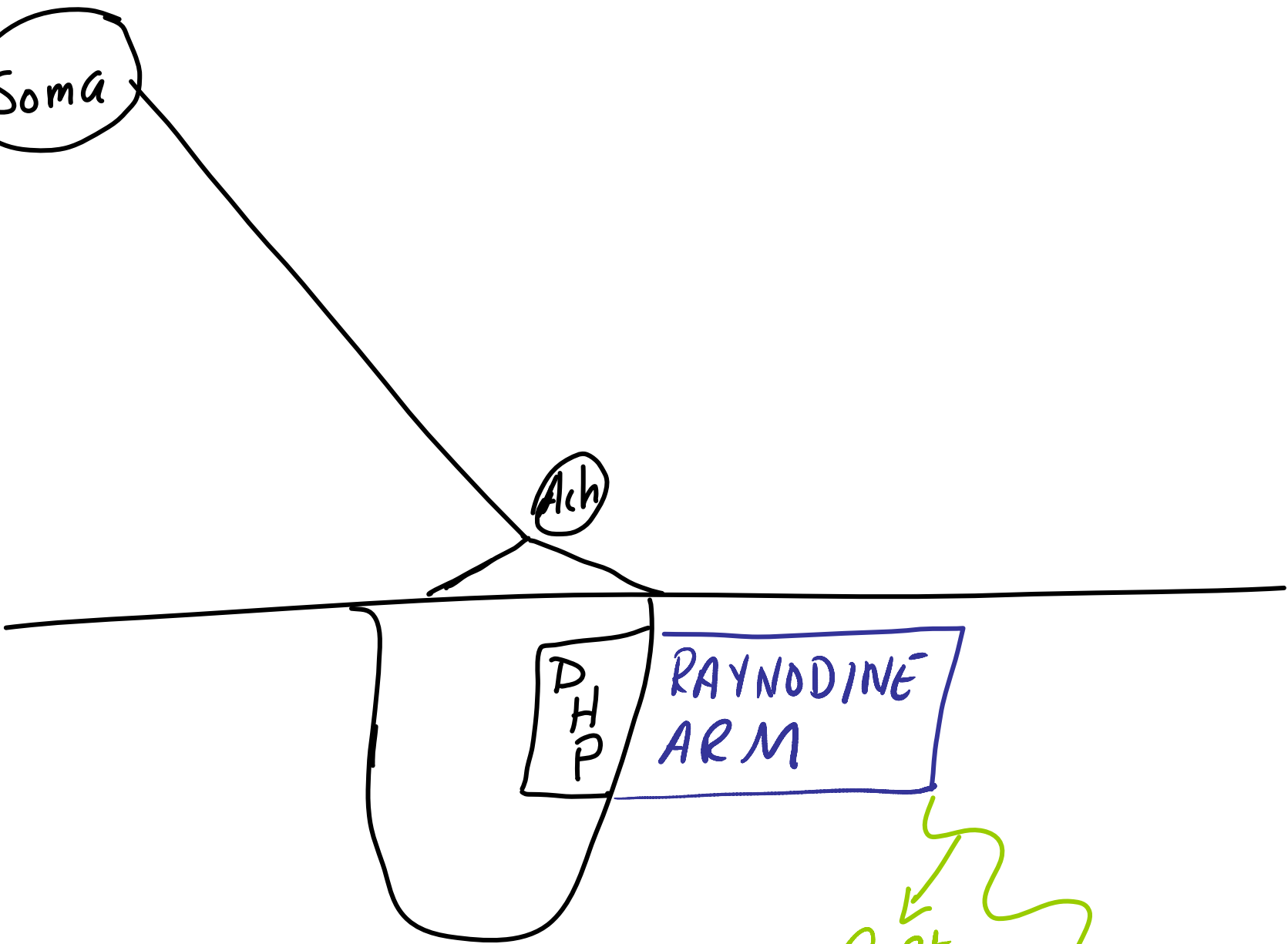
Soma

Ach

DHP

RAYNODINE ARM

Ca<sup>2+</sup>  
SR



# MUSCLE CONTRACTION

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- ❑ Calcium binds trop-C
- ❑ Trop-C releases trop-I
- ❑ Trop-I releases tropomyosin
- ❑ Tropomyosin releases actin binding sites
- ❑ Myosin heads bind actin
- ❑ CONTRACTION occurs
- ❑ Myosin heads release ADP from previous rd
- ❑ Myosin heads bind new ATP
- ❑ Myosin heads hydrolyze ATP
- ❑ RELEASE occurs
- ❑ Myosin heads return to start position

# MUSCLE CONTRACTION, cont

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- Tropomyosin binds actin
- Trop-I binds tropomyosin
- Trop-C binds trop-I
- Ca-ATPase pumps Ca back into SR
- Phospholambin inhibits Ca-ATPase when it is done pumping

# Clinical Application

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# Diagnosis of a Myocardial Infarction

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- **EKG**: Na-K pump stops > peaked T-wave > ST-wave depression > ST-wave elevation > T-wave depression, then inversion > Q-wave
- **Troponin I**: rises at 2 hours > peaks in 2days > positive up to 7 days
- **CK-mb**: rises in 6 hours > peaks in 12 hours > gone in 24 to 36 hours
- **LDH 1**: rises in 24 hours > peaks in 48hours > gone in 72 hours

# Management of an MI

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- 24 hour hospitalization
- Check EKG Q6
- Check CIE's Q6
- Monitor for arrhythmias
- Discharge after 24 hours IF asymptomatic
- Re-evaluate in 6 weeks

# In 6 Weeks...

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## ❑ **Exercise stress test**

- Positive IF: chest pain is reproduced; ST-wave changes; drop in BP

## ❑ **Stress Thallium test**

- A perfusion test; looking for a COLD spot

## ❑ **Dobutamine or Dipyridamole stress test**

- Use when patient unable to exercise


## ❑ **Calcium Pyrophosphate scan**

- Taken up by DEAD tissue; looking for HOT spot

## ❑ **2-D echo**

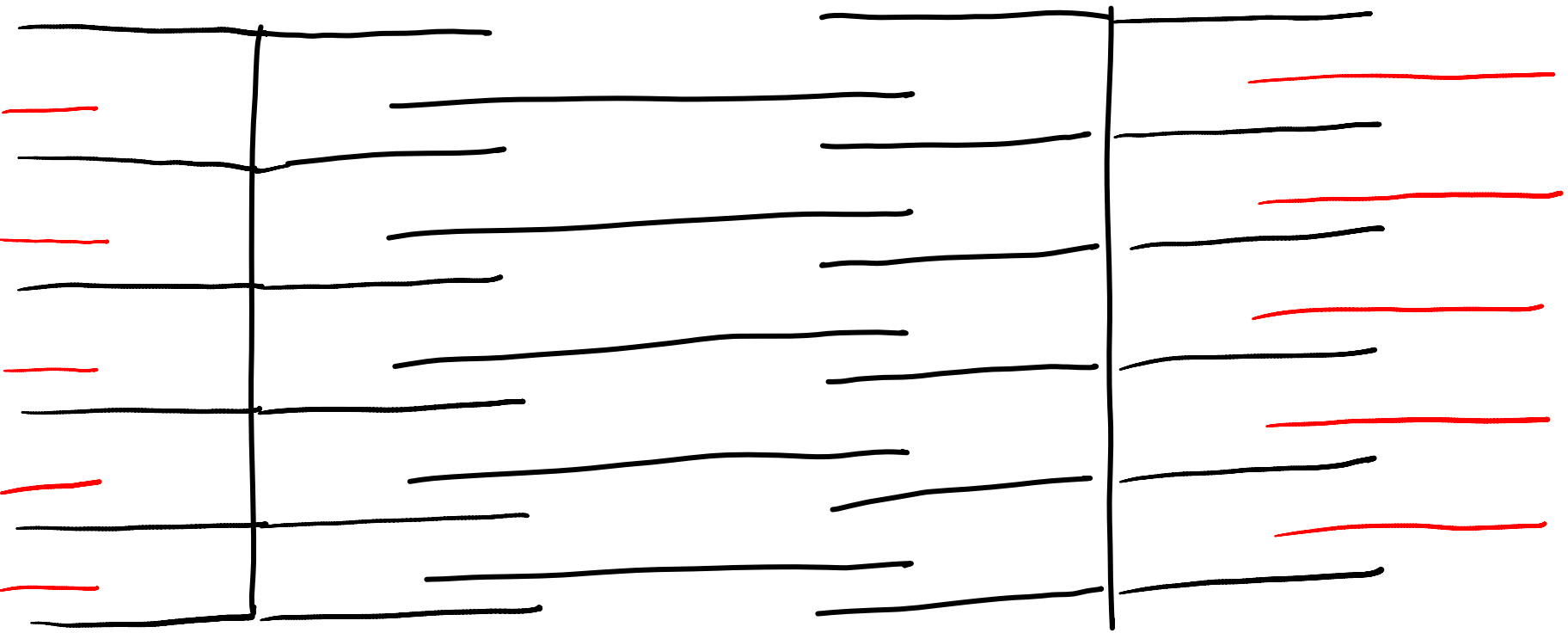
- Evaluates anatomy of heart; measures SV and CO

# The Functional Unit of Muscles



THE SARCOMERE





# MUSCLE DIFFERENCES

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# CARDIAC MUSCLE

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- ❑ In addition to wave of depolarization, calcium MUST flow into the T-tubules during phase 2 for contraction to occur
- ❑ Ventricle depends on EXTRACELLULAR calcium to trigger its contraction

# Smooth Muscle

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- Has NO sarcomeres
- Contains NO troponin > actin and myosin are always bound ( LATCHING)
- Contains BASAL BODIES
- Has NO myosin ATPase activity
  - Has MLCK and MLCP working together



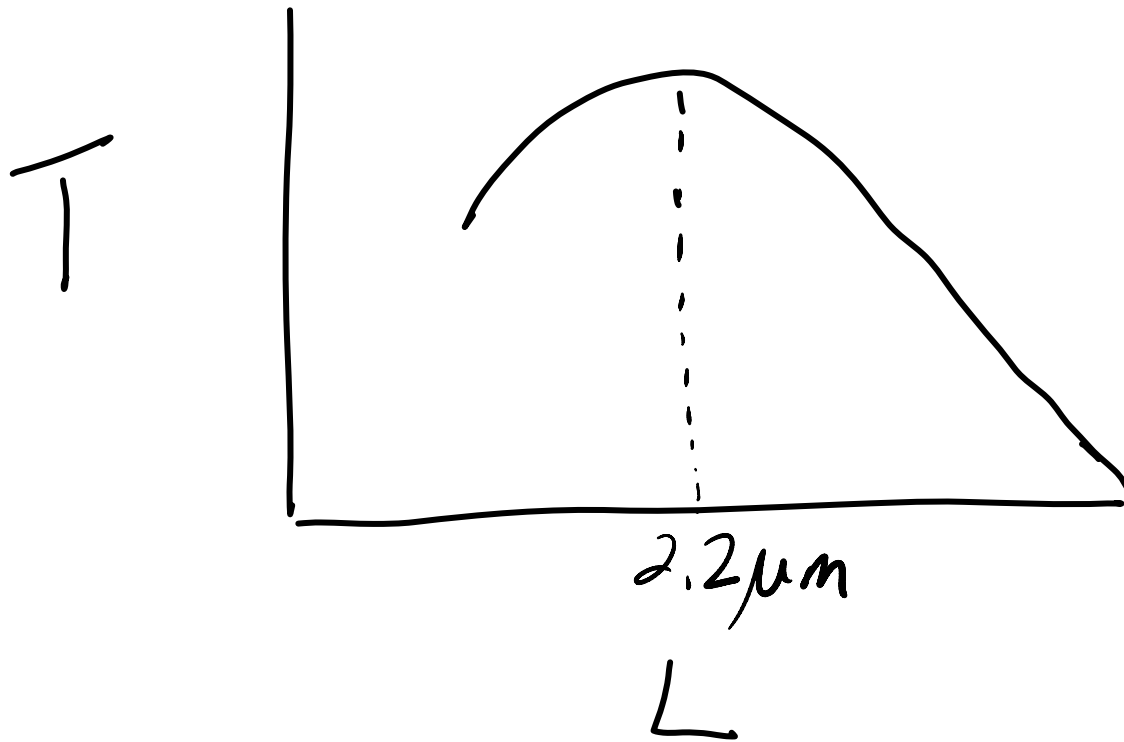
# As Muscle Contracts...

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- LENGTH decreases
- FORCE and TENSION increase
- A band stays the same
- Amount of OVERLAP increases
- The H band and I band therefore shrink

# Length/Tension Curve

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# Golgi Tendon Organs

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- ❑ Located at muscle insertions
- ❑ Monitor the force of muscle contractions
- ❑ Allows muscle to hold MAXIMUM muscle contraction force for only one second
- ❑ Once it fires, muscle fibers MUST relax
- ❑ Prevents destruction of sarcomeres

# Muscle Strain

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- ❑ Overstretching or tearing a muscle
- ❑ When a muscle is torn, it goes into spasm to keep the fibers together for proper healing
  - Tx: rest it > apply heat > NSAIDS > muscle relaxants



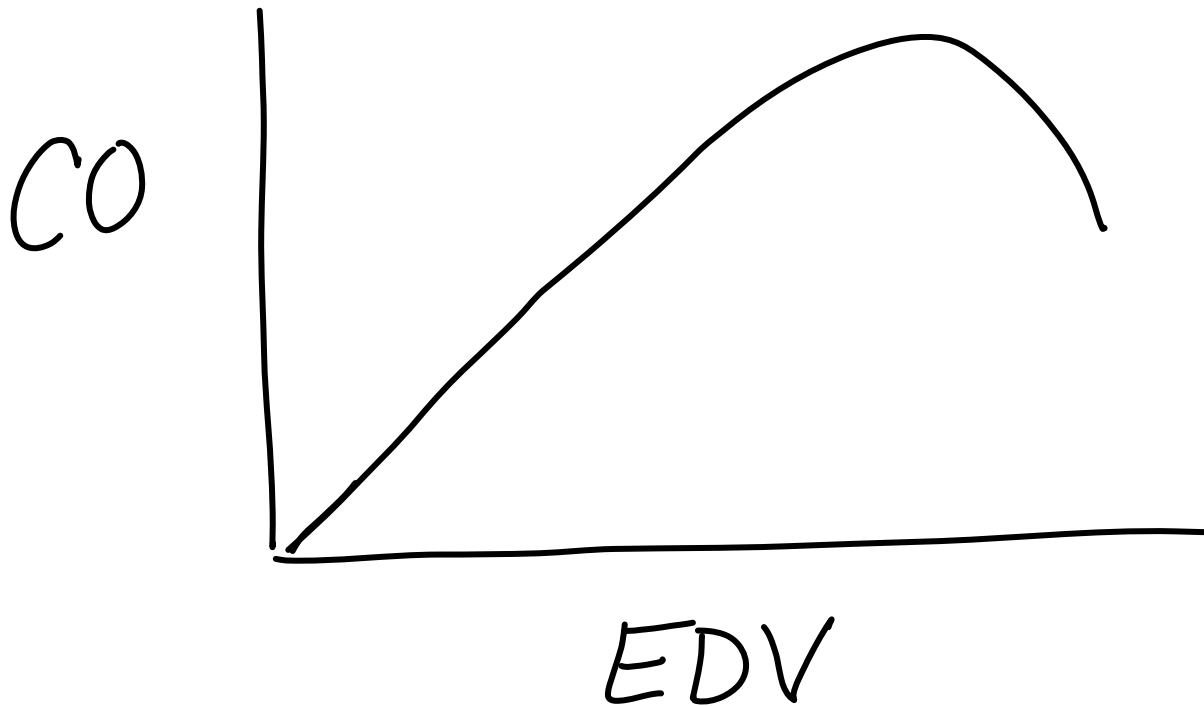
# JOINT SPRAIN

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- TORN tendon or ligament
- Tx: Rest it > Ice Compression > Elevate the extremity

# Frank-Starling Curve

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# Congestive Heart Failure

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- ❑ Over 50% mortality in 5 years
- ❑ Most common medicare diagnosis
- ❑ Muscle fibers are overstretched
- ❑ Dilated ventricle
- ❑ Increased EDV and ESV
- ❑ Decreased contractility > decreased CO and EF

# Congestive Heart Failure after a myocardial infarction

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- ❑ AT LEAST 40% of myocardium lost
- ❑ EJECTION FRACTION is less than 45%
- ❑ Due to left coronary artery infarcts 90% of time

# Treating CHF: Applying Frank-Starling Curve

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- Decrease volume
  - Restrict sodium intake
  - Restrict volume intake
- Increase contractility
  - Digitalis
  - Dobutamine
  - Dopamine
- Decrease TPR
  - Ace inhibitors

# NEUROMUSCULAR PROFILE

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**ALL YOU NEED NOW IS**

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**THE CLUE...**

# Inflammatory Myopathies

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- **Myositis**
  - **Polymyositis**
  - **Dermatomyositis**
  - **Fibrositis**
  - **Fibromyalgia**
  - **Polymyalgia rheumatica**
  - **Temporal Arteritis**
- ALL HAVE:
    - High ESR
    - High WBC count
    - Myoglobinemia
    - High AST, ALT and Aldolase



# Muscular Dystrophies

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## □ Duchenne's

- Gower's sign
- Waddling gait
- Pseudohypertrophy of the calf
- Dystrophin protein
- X-linked recessive; onset BEFORE age 5

## □ Becker's

- Onset AFTER age 5

## □ Myotonic

# Neuropathies

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- ❑ **Guillian Barre**
- ❑ **Diabetes mellitus**
- ❑ **Syphilis**
- ❑ **Myesthenia Gravis / Myesthenic or "Eaton Lambert" syndrome**

# Acetylcholinesterase inhibitors: reversible

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- **Edrophonium**
- **Neostigmine**
- **Pyridostigmine**
- **Physostigmine**

# Acetylcholinesterase inhibitors: irreversible

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## □ AKA **Organophosphates**

- End in ....**phate** ( diflorophate; echothiophate)
- End in ....**thion** ( malathion; nalathion; parathion)

# If they come back complaining about more weakness...

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- Myasthenia Gravis has gotten worse or...

- Cholinergic crisis

- **REPEAT EDREPHONIUM TEST!!**

- IF patient gets better > disease is worse

- Increase neostigmine

- IF patient gets worse > cholinergic crisis

- Hold neostigmine > give atropine > decrease neostigmine

# Anticholinergic Drugs

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- ❑ Side effects are sympathetic except for...
- ❑ HOT, DRY SKIN!
  
- ❑ **Atropine**
- ❑ **Glycopyrrolate**
- ❑ **Benztropine**
- ❑ **Trihexyphenidyl**
- ❑ **Ipratropium**
- ❑ **Tiotropium**

# Neoplastic Associations

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- Myasthenia Gravis: **THYMOMA**
  
- Myasthenic syndrome: **SMALL CELL CARCINOMA**; a paraneoplastic syndrome
  - Sarcoplasmic reticulum is slow to sequester calcium; cancer blocks some calcium channels

# Neuropathies, cont

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- **Multiple sclerosis**
- **Metachromatic leukodystrophy**



# Treatment of MS

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- **STEROIDS**
- **IV GAMMGLOBULINS**
- **PLASMAPHARESIS**

# Lower Motor Neuron Disease

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- ❑ **Amyotrophic lateral sclerosis**
- ❑ **Werdnig-Hoffman Disease**
- ❑ **Polio**

# Cerebellar Disease in 5 to 10 Y/O children

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- **Ataxia Telangiectasia**
- **Fredrick's Ataxia**
- **Adrenoleukodystrophy**

# Cerebral Palsy

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- Any permanent neurological damage suffered PRIOR to age 21 years
- **Spastic Diplegia**
  - Midline cortical problem
- **Spastic Hemiplegia**
  - Cortical problem on ONE SIDE of the brain
- **Choreoathetosis**
  - BASAL GANGLIA is involved: kernicterus
- **Atonic**
  - FRONTAL CORTEX: involves the CST

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**THE END**

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