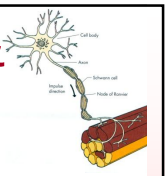
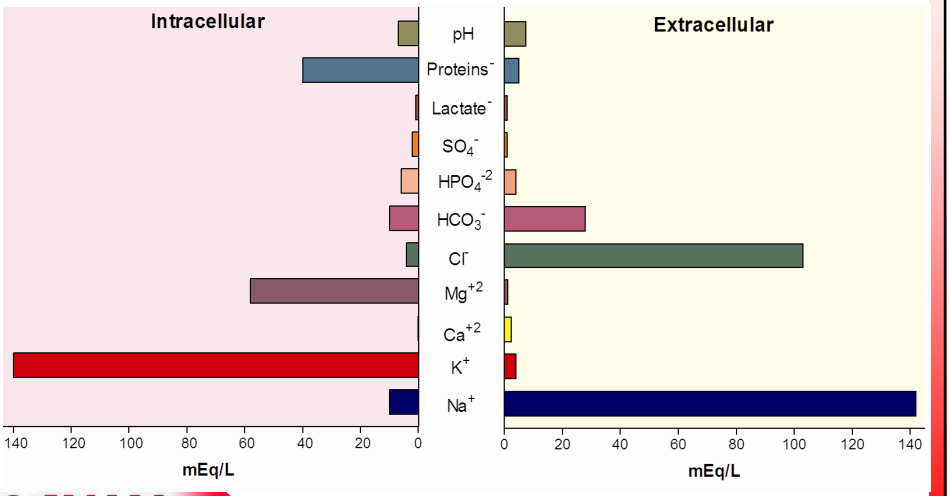
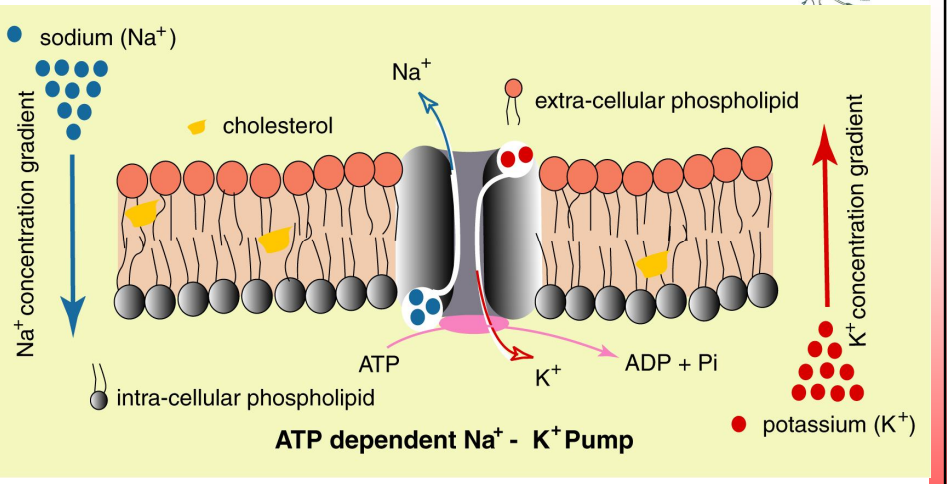
Action Potentials, Synapses & Motor Units



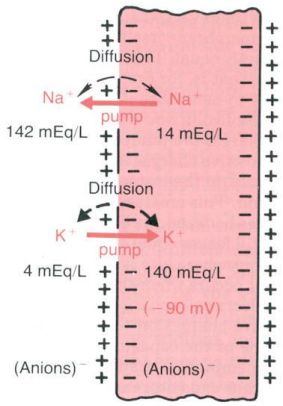


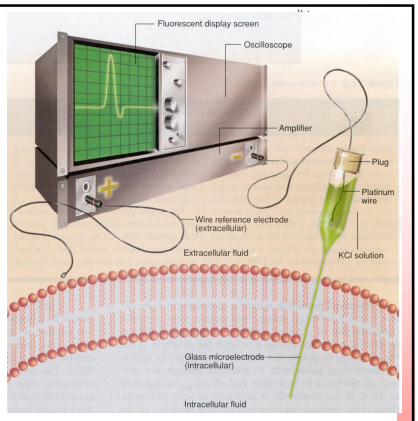
UNM

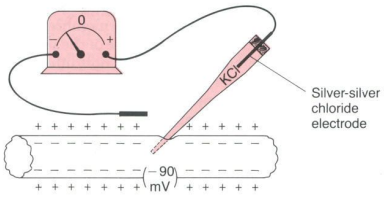


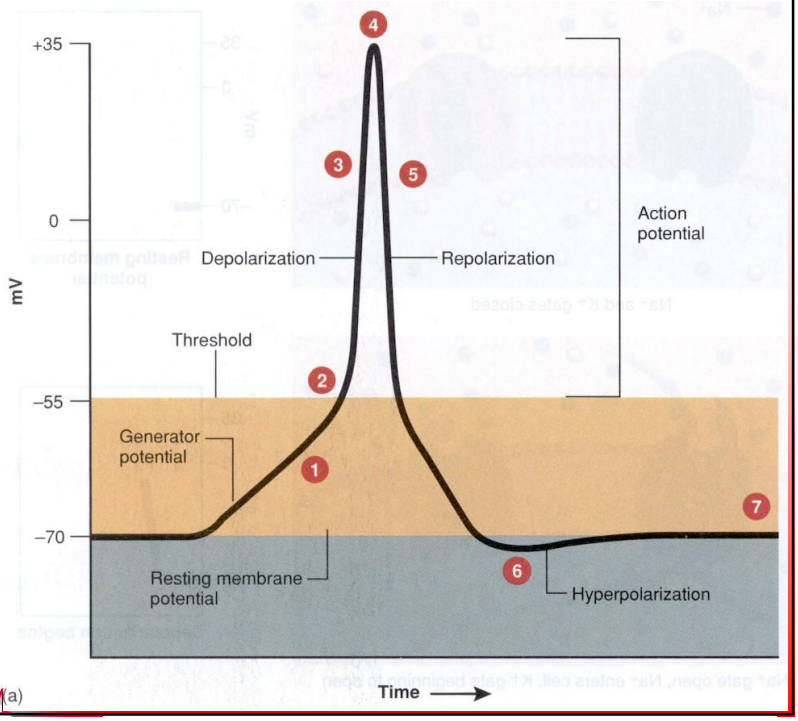
UNM

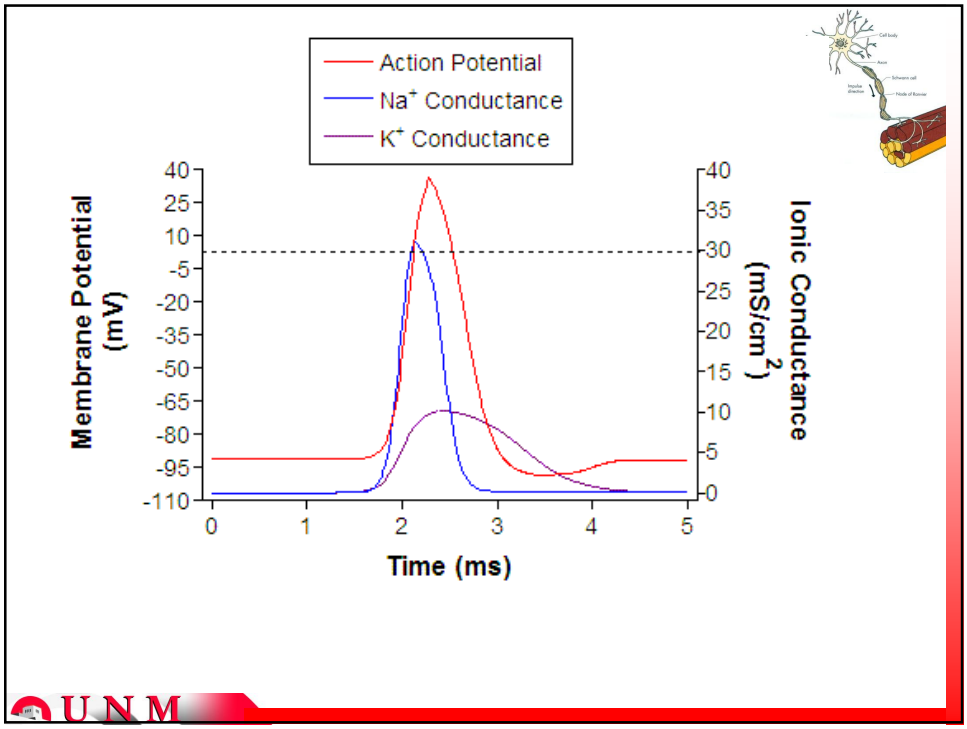
Nerves Function by Generating Action Potentials

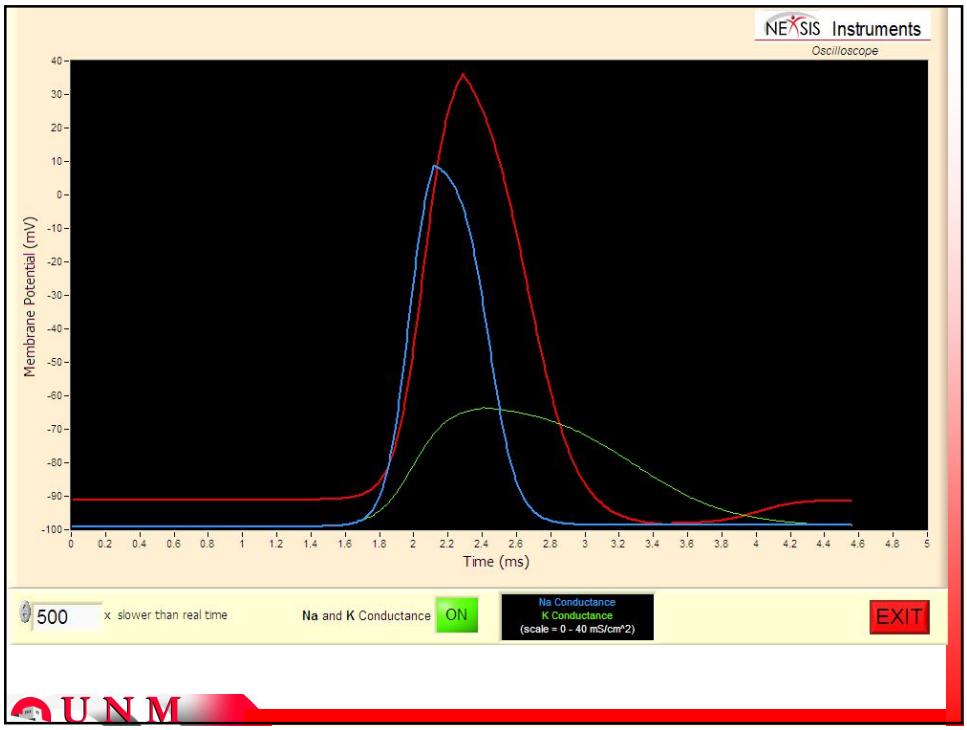


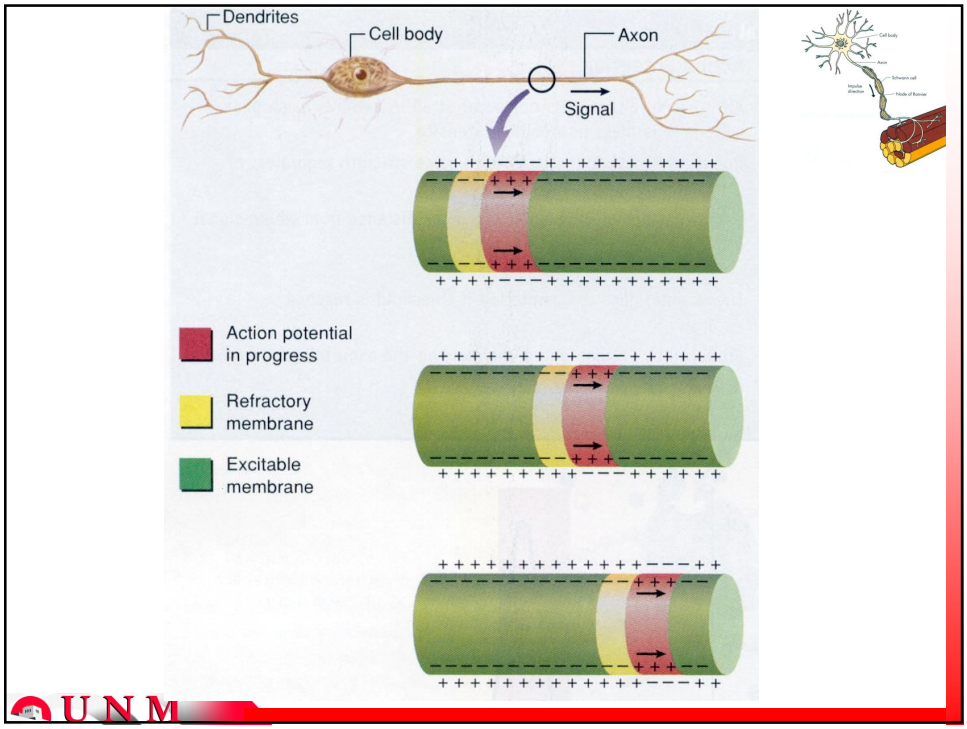


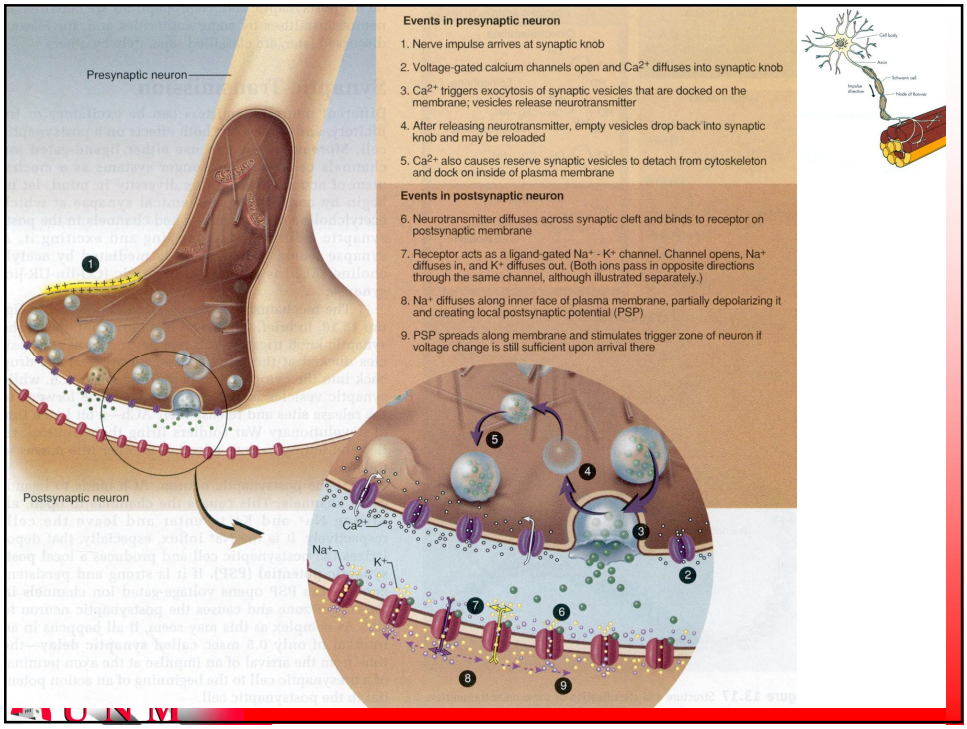


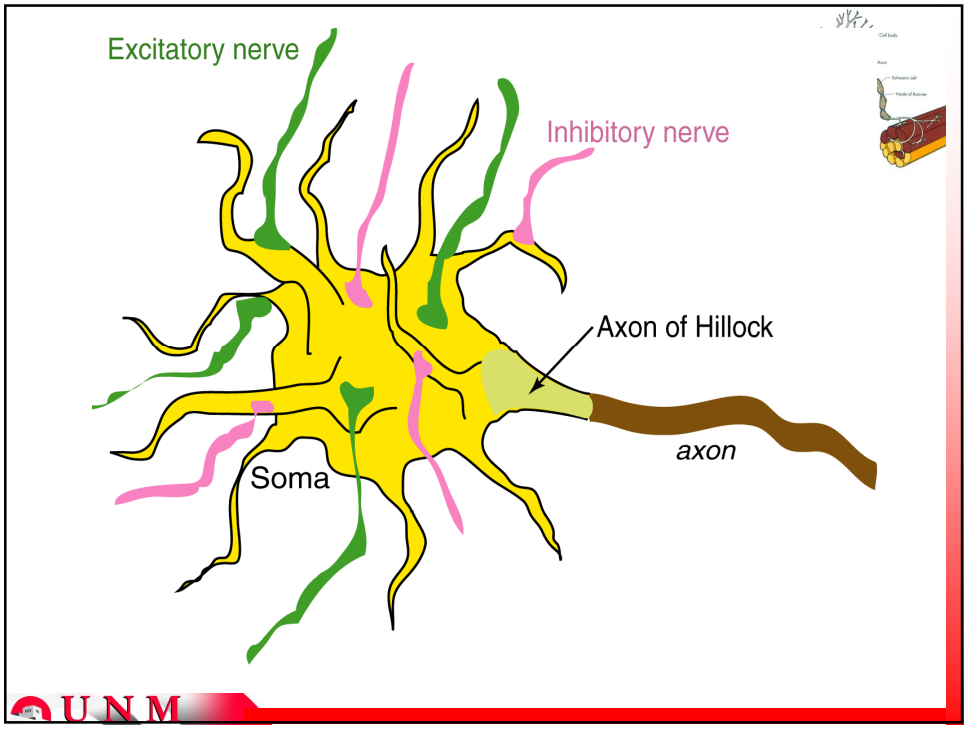


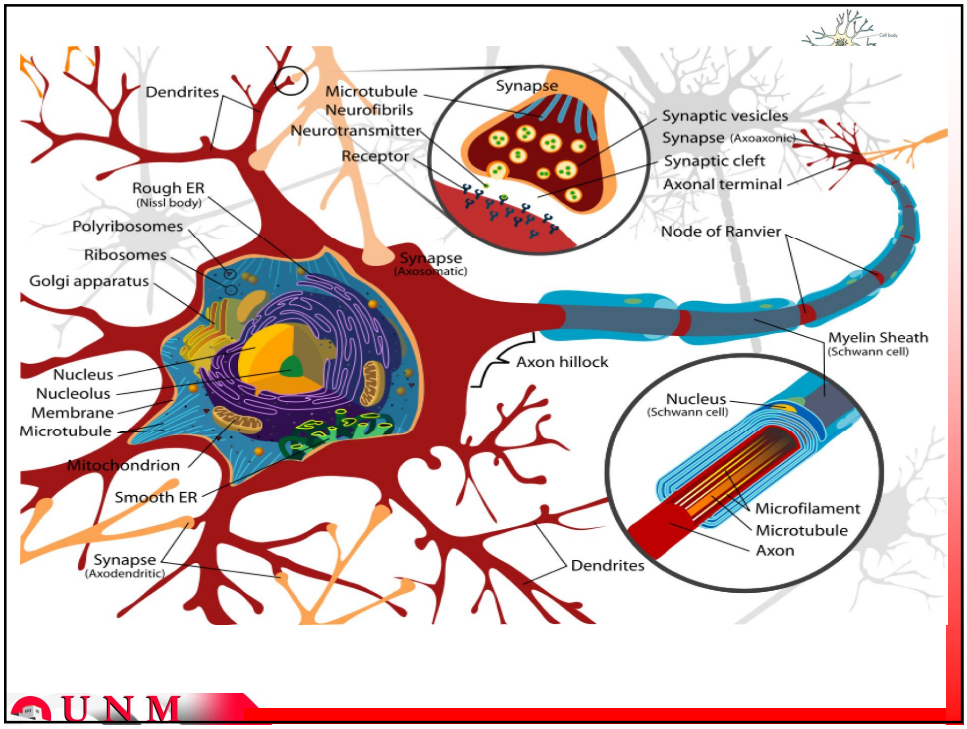

Action Potential
Na+ Conductance
K+ Conductance
Membrane Potential (mV)
Ionic Conductance (mS/cm2)
Time (ms)
UNM

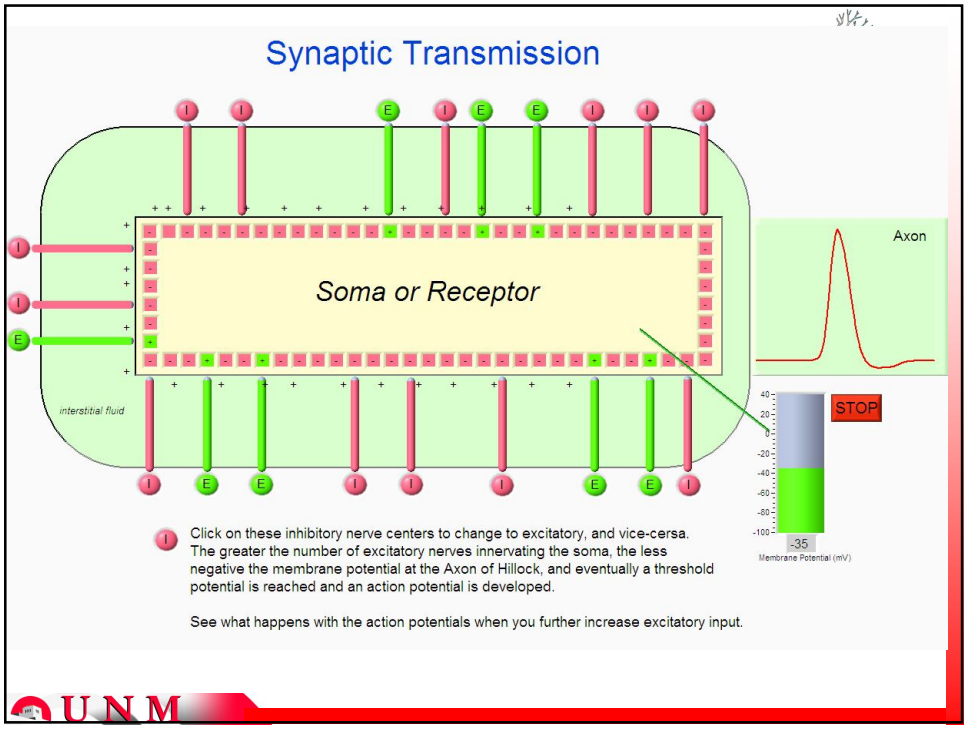

NEXSIS Instruments
Oscilloscope
Membrane Potential (mV)
Time (ms)
500
x slower than real time
Na and K Conductance
ON
Na Conductance
K Conductance
(scale = 0 - 40 mS/cm^2)
EXIT
UNM

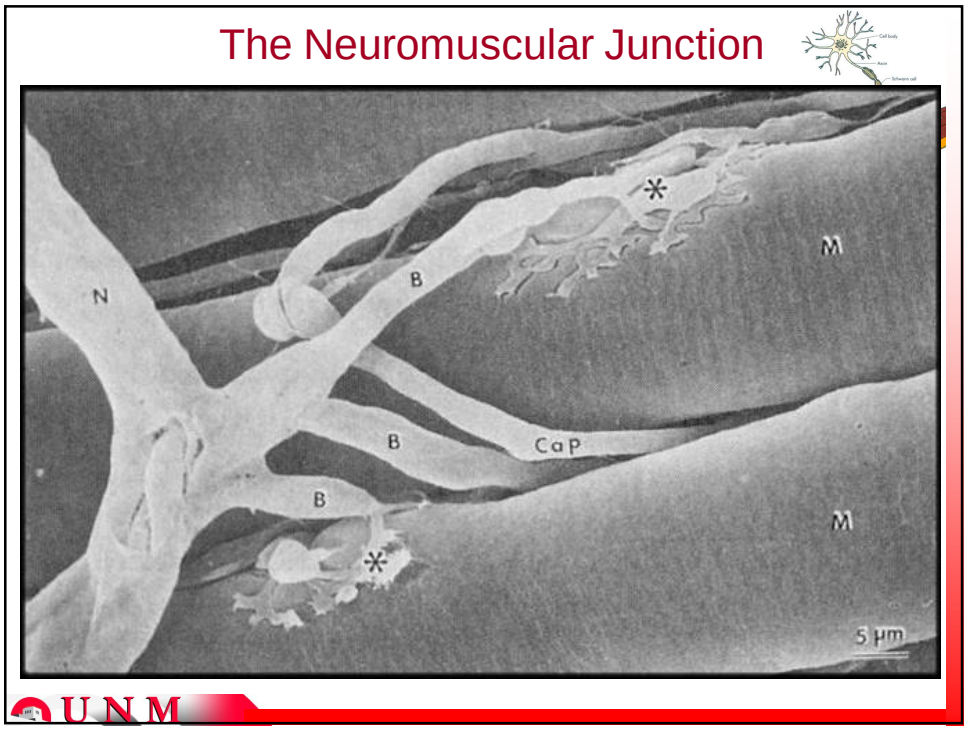

Dendrites
Cell body
Axon
Signal
Action potential in progress
Refractory membrane
Excitable membrane


Presynaptic neuron
Postsynaptic neuron
Events in presynaptic neuron
1. Nerve impulse arrives at synaptic knob
2. Voltage-gated calcium channels open and Ca^{2+} diffuses into synaptic knob
3. Ca^{2+} triggers exocytosis of synaptic vesicles that are docked on the membrane; vesicles release neurotransmitter
4. After releasing neurotransmitter, empty vesicles drop back into synaptic knob and may be reloaded
5. Ca^{2+} also causes reserve synaptic vesicles to detach from cytoskeleton and dock on inside of plasma membrane
Events in postsynaptic neuron
6. Neurotransmitter diffuses across synaptic cleft and binds to receptor on postsynaptic membrane
7. Receptor acts as a ligand-gated Na^+ - K^+ channel. Channel opens, Na^+ diffuses in, and K^+ diffuses out. (Both ions pass in opposite directions through the same channel, although illustrated separately.)
8. Na^+ diffuses along inner face of plasma membrane, partially depolarizing it and creating local postsynaptic potential (PSP)
9. PSP spreads along membrane and stimulates trigger zone of neuron if voltage change is still sufficient upon arrival there
Ca^{2+}
Na^+
K^+

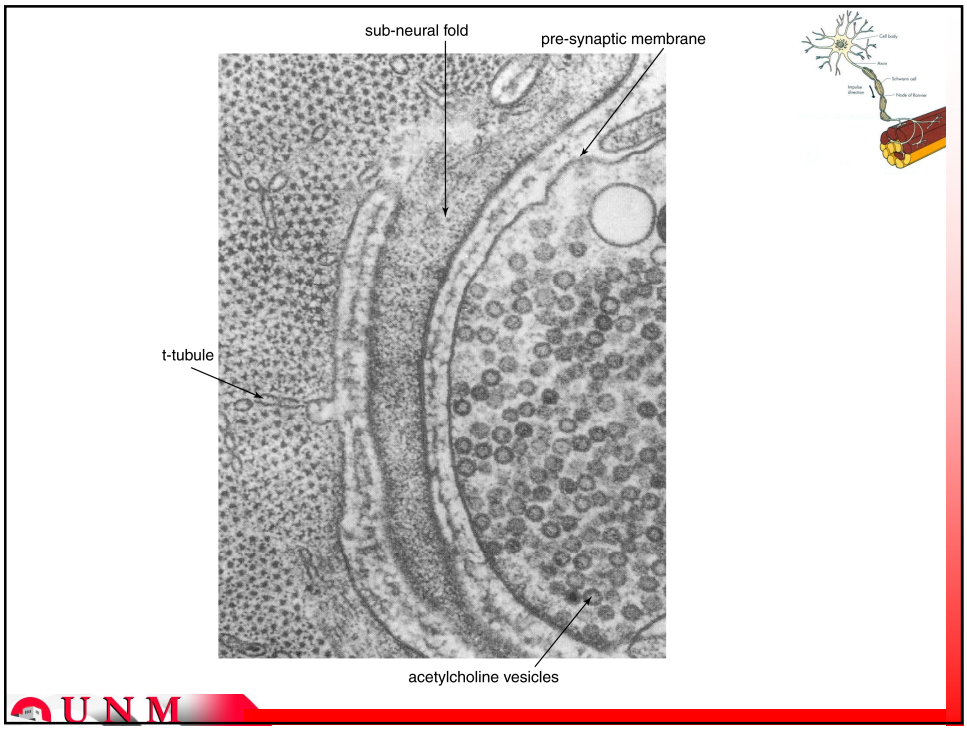

Excitatory nerve
Inhibitory nerve
Axon of Hillock
axon
Soma
UNM

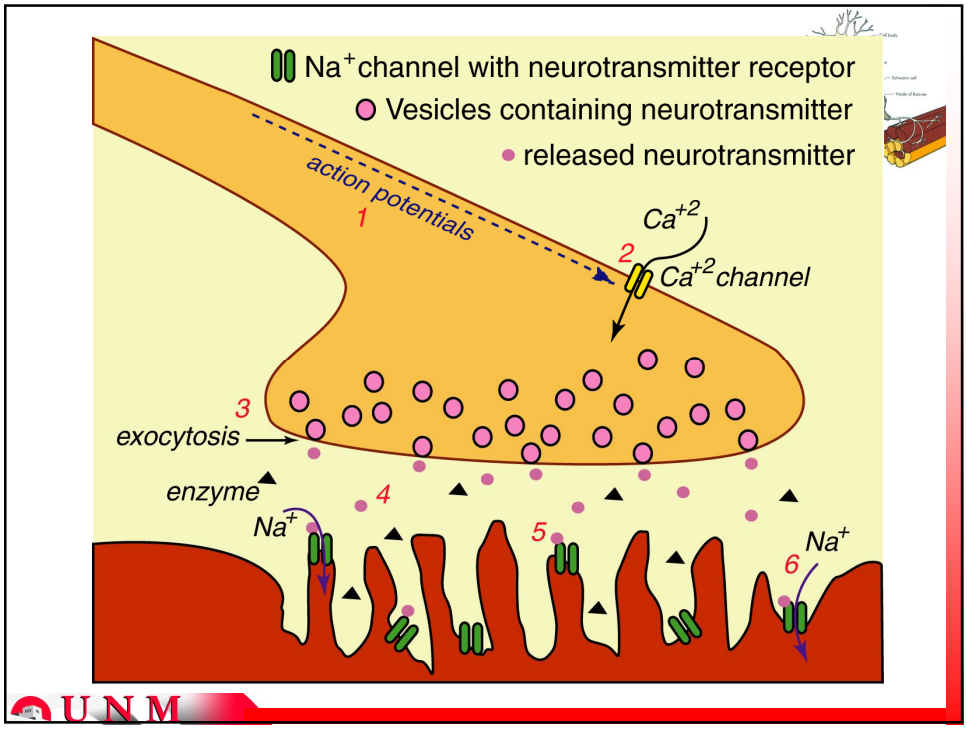

Dendrites
Microtubule
Neurofibrils
Neurotransmitter
Receptor
Synapse
Synaptic vesicles
Synapse (Axoaxonic)
Synaptic cleft
Axonal terminal
Rough ER
(Nissl body)
Polyribosomes
Ribosomes
Golgi apparatus
Synapse
(Axosomatic)
Node of Ranvier
Myelin Sheath
(Schwann cell)
Axon hillock
Nucleus
Nucleolus
Membrane
Microtubule
Mitochondrion
Smooth ER
Synapse
(Axodendritic)
Nucleus
(Schwann cell)
Microfilament
Microtubule
Axon
Dendrites
UNM

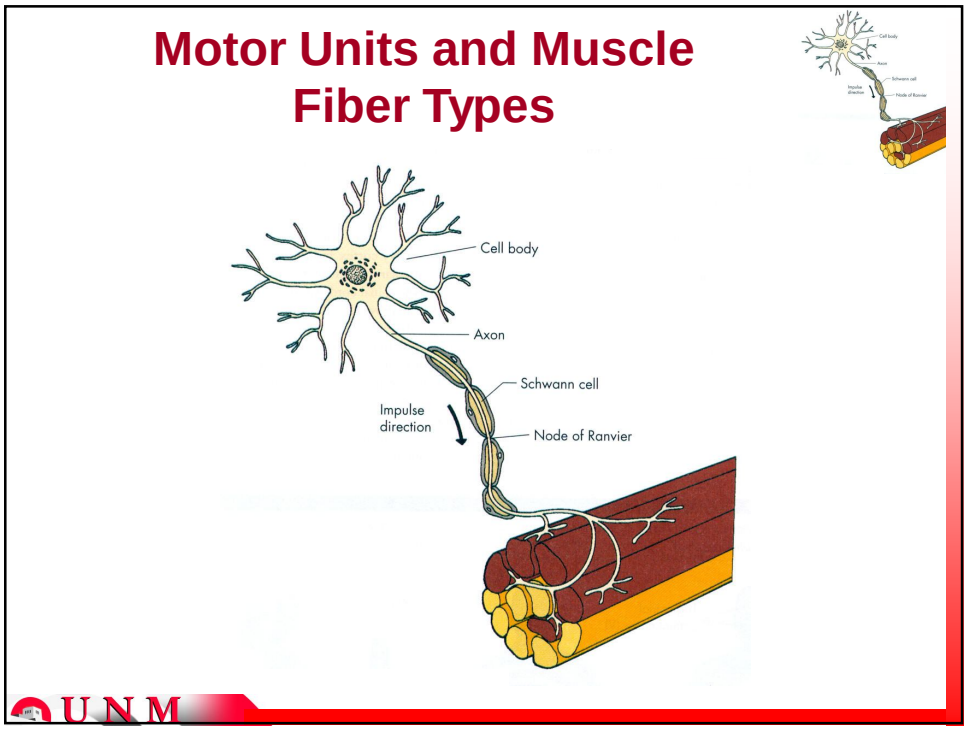

Synaptic Transmission
Soma or Receptor
Axon
interstitial fluid
STOP
-35
Membrane Potential (mV)
Click on these inhibitory nerve centers to change to excitatory, and vice-cersa.
The greater the number of excitatory nerves innervating the soma, the less negative the membrane potential at the Axon of Hillock, and eventually a threshold potential is reached and an action potential is developed.
See what happens with the action potentials when you further increase excitatory input.
UNM

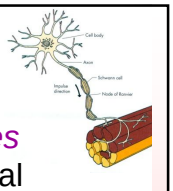

The Neuromuscular Junction
N
B
B
B
CaP
M
M
5 µm
UNM


T
M
3T
M
UNM


sub-neural fold
pre-synaptic membrane
t-tubule
acetylcholine vesicles
UNM


Na+ channel with neurotransmitter receptor
Vesicles containing neurotransmitter
released neurotransmitter
action potentials
1
Ca+2
2
Ca+2 channel
3
exocytosis
enzyme
4
Na+
5
Na+
6
UNM


Motor Units and Muscle Fiber Types
Cell body
Axon
Schwann cell
Impulse direction
Node of Ranvier
UNM

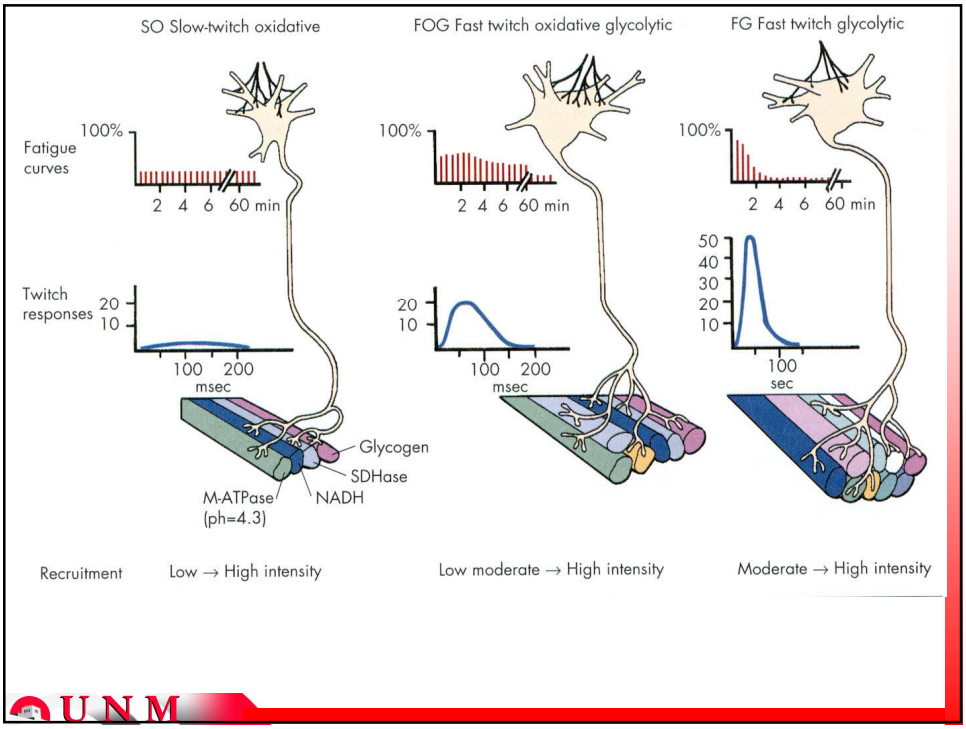


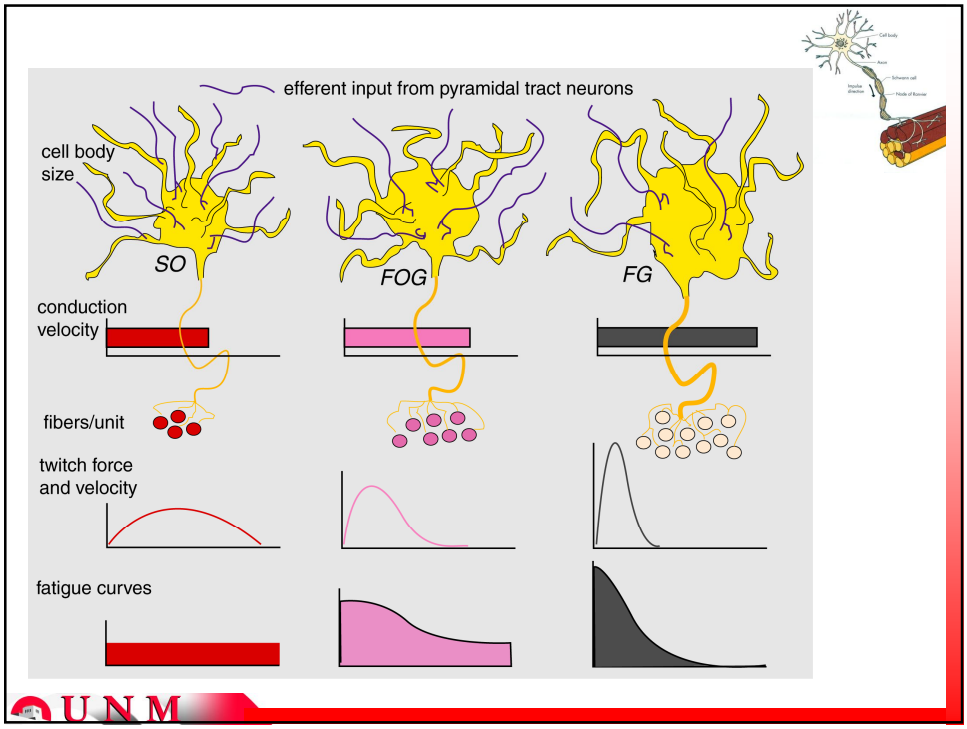
Based on research of animals (cat, dog, rat):

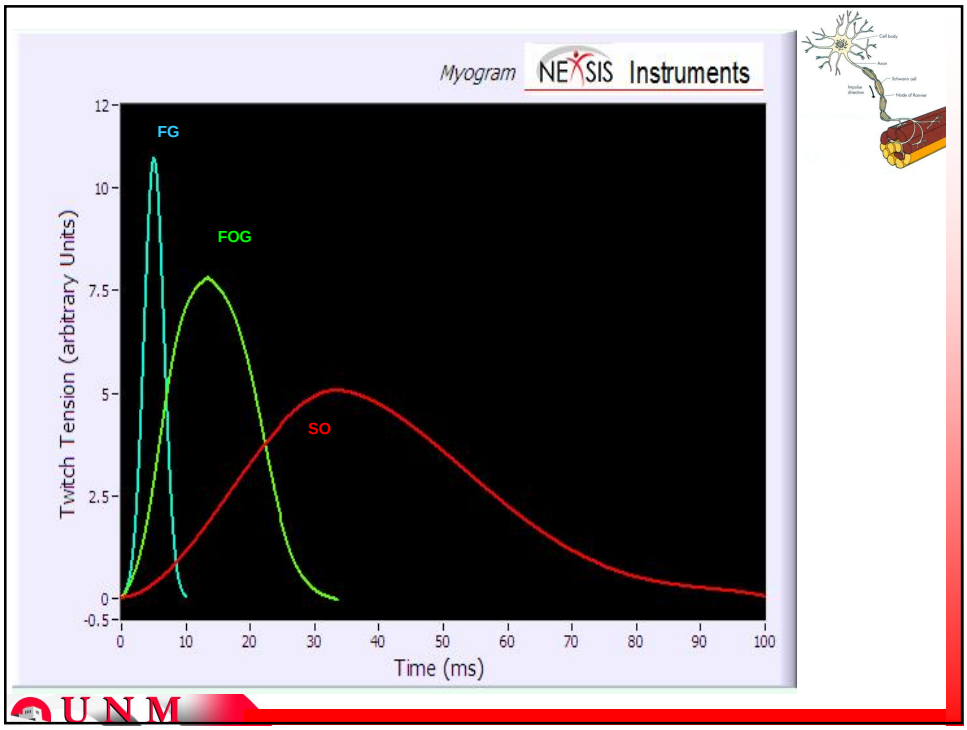
1. There are *numerous differences* between the *nerves* and *muscle fiber metabolic* characteristics of skeletal muscle motor units:
   - Number & Size of Muscle Fibers
   - Size and Excitability of the Motor Nerve
   - Enzyme and Glycogen Levels
   - Protein Composition

2. For a given motor unit, all muscle fibers have similar metabolic profiles.

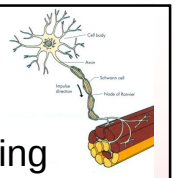
3. Both the nerve and muscle characteristics combine to differentiate motor unit types.




efferent input from pyramidal tract neurons
cell body size
SO
FOG
FG
conduction velocity
fibers/unit
twitch force and velocity
fatigue curves
UNM


Myogram
NEXSIS Instruments
FG
FOG
SO
Twitch Tension (arbitrary Units)
Time (ms)
12
10
7.5
5
2.5
0
-0.5
0
10
20
30
40
50
60
70
80
90
100
UNM

Human Muscle Biopsy and Histology

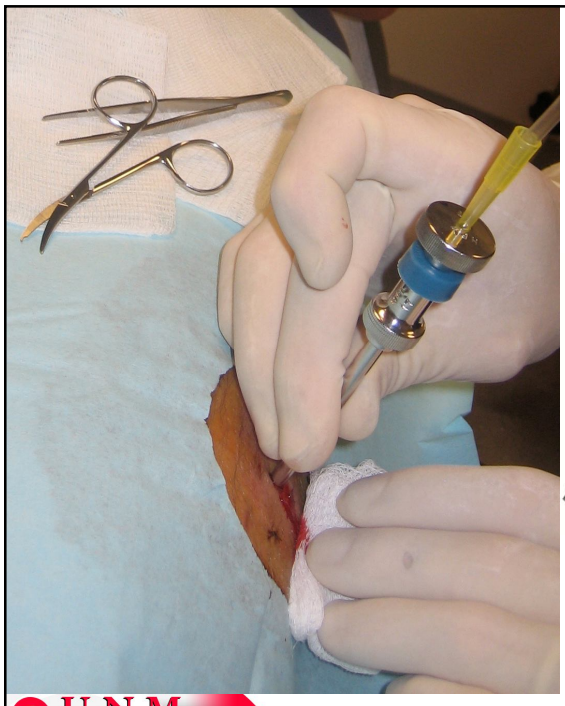


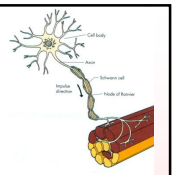
Morphological and metabolic characteristics of human muscle fibers have been researched using the method of *percutaneous needle biopsy*.

The information gained from biopsy research of human skeletal muscle includes:

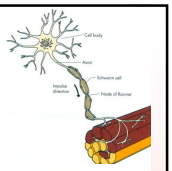
1. ***Muscle enzyme activities***
2. ***Muscle metabolite/substrate concentrations***
3. ***Muscle fiber types (myosin ATPase, structural protein)***
4. ***Muscle fiber glycogen content (PAS stain)***
5. ***Muscle capillary density***
6. ***Muscle damage***

UNM



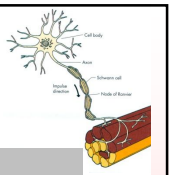


UNM



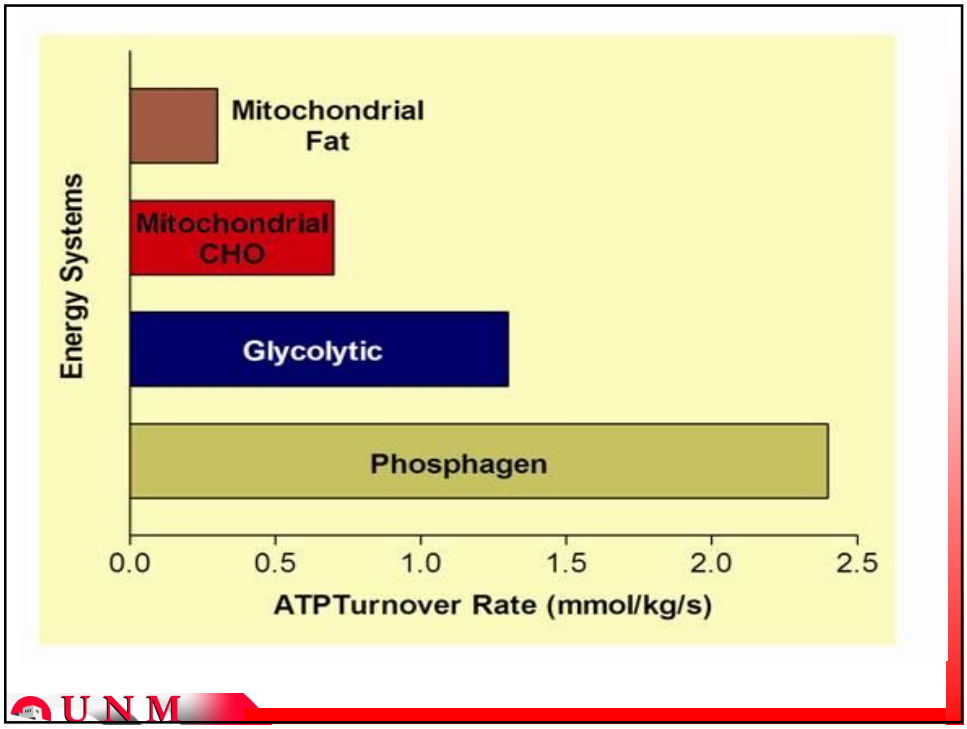
UNM

Classification nomenclature of mammalian motor units

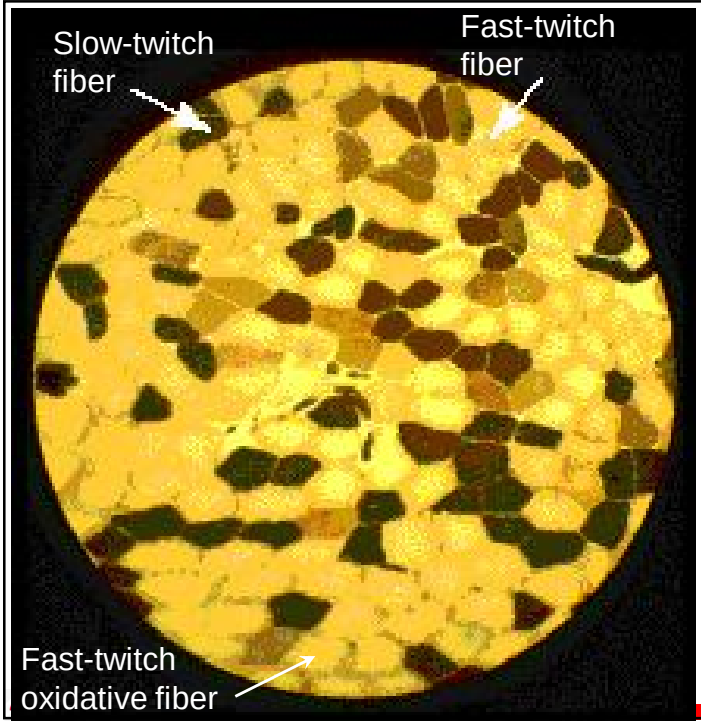


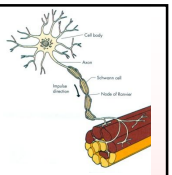
Classification Method	*Nomenclature*			
Visual	**Red**	**White**		
Contractile Velocity	**Slow-twitch**	**Fast-twitch**		
Contractile Velocity and Metabolism	**I** Slow-twitch	**IIab** Fast-twitch intermediate	**IIa** Fast-twitch fatigue resistant	**IIb** Fast-twitch fatigable
Contractile Velocity and Metabolism	**S** Slow-twitch	**F(int)** Fast-twitch intermediate	**FR** Fast-twitch fatigue resistant	**FF** Fast-twitch fatigable
Contractile Velocity and Metabolism	**SO** Slow-twitch oxidative		**FOG** Fast-twitch oxidative glycolytic	**FG** Fast-twitch glycolytic

UNM



UNM

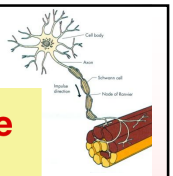




myosin-ATPase stain

preincubation pH=4.6

Fiber Typing

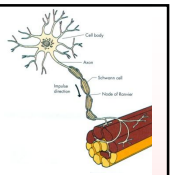


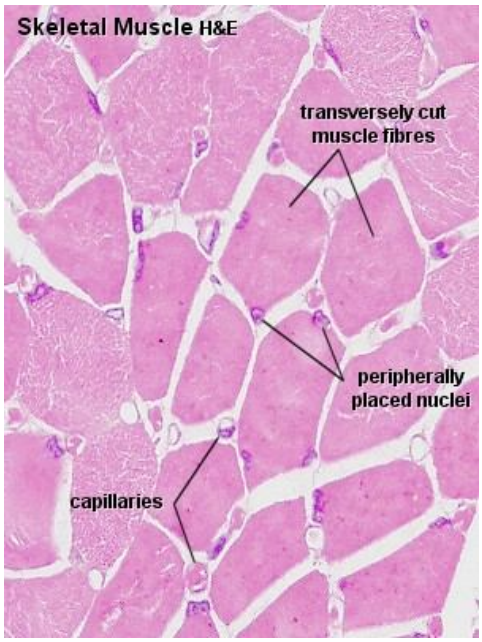
Myosin ATPase Staining of Skeletal Muscle

pre-incubation pH =	4.3	4.6	10.3
Slow Twitch Oxidative (SO)	●	●	○
Fast twitch oxidative glycolytic (FOG)	○	◉	●
Fast twitch glycolytic (FG)	○	○	●

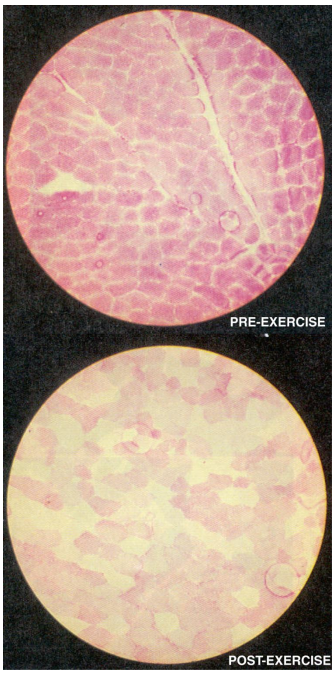
● stain from active myosin ATPase enzyme
○ no stain from inactive myosin ATPase enzyme
◉ intermediate stain from partially active myosin ATPase enzyme

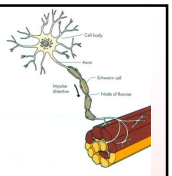
UNM

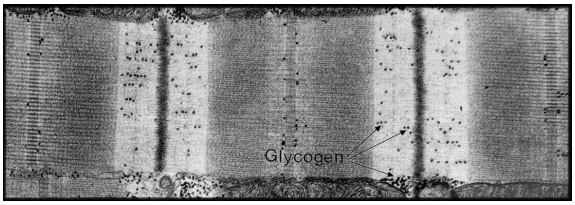




UNM

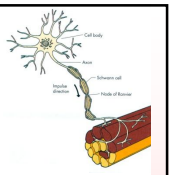






UNM

Fiber Types, Motor Units and Exercise Performance



UNM