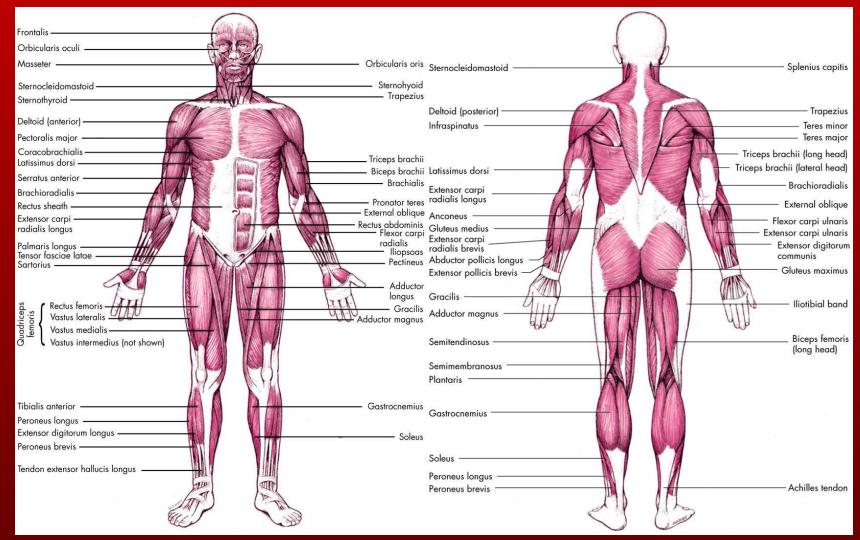
Skeletal Muscles

- Responsible for movement of body and all of its joints
- Muscle contraction produces force that causes joint movement
- Muscles also provide
 - protection
 - posture and support
 - produce a major portion of total body heat

Skeletal Muscles



Manual of Structural Kinesiology

Neuromuscular Fundamentals

Skeletal Muscles

- Over 600 skeletal muscles comprise approximately 40 to 50% of body weight
- 215 pairs of skeletal muscles usually work in cooperation with each other to perform opposite actions at the joints which they cross
- Aggregate muscle action muscles work in groups rather than independently to achieve a given joint motion

Muscle Nomenclature

- Muscles are usually named due to
 - visual appearance
 - anatomical location
 - function
- Shape deltoid, rhomboid
- Size gluteus maximus, teres minor
- Number of divisions triceps brachii
- Direction of its fibers external oblique

Muscle Nomenclature

- Action & size adductor magnus
- Shape & location serratus anterior
- Location & attachment brachioradialis
- Location & number of divisions biceps femoris

Muscle Tissue Properties

- Skeletal muscle tissue has 4 properties related to its ability to produce force & movement about joints
 - Irritability
 - Contractility
 - Extensibility
 - Elasticity

Muscle Tissue Properties

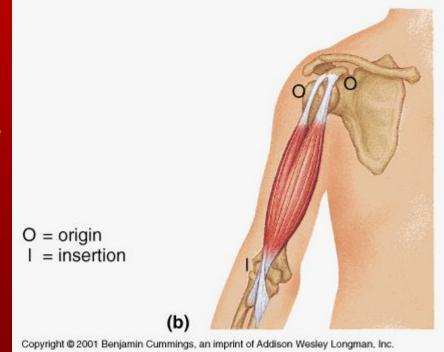
- Irritability property of muscle being sensitive or responsive to chemical, electrical, or mechanical stimuli
- Contractility ability of muscle to contract & develop tension or internal force against resistance when stimulated

Muscle Tissue Properties

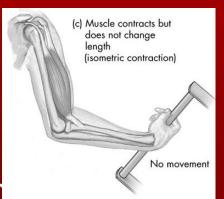
- Extensibility ability of muscle to be stretched back to its original length following contraction
- *Elasticity* ability of muscle to return to its original length following stretching

Muscle Terminology

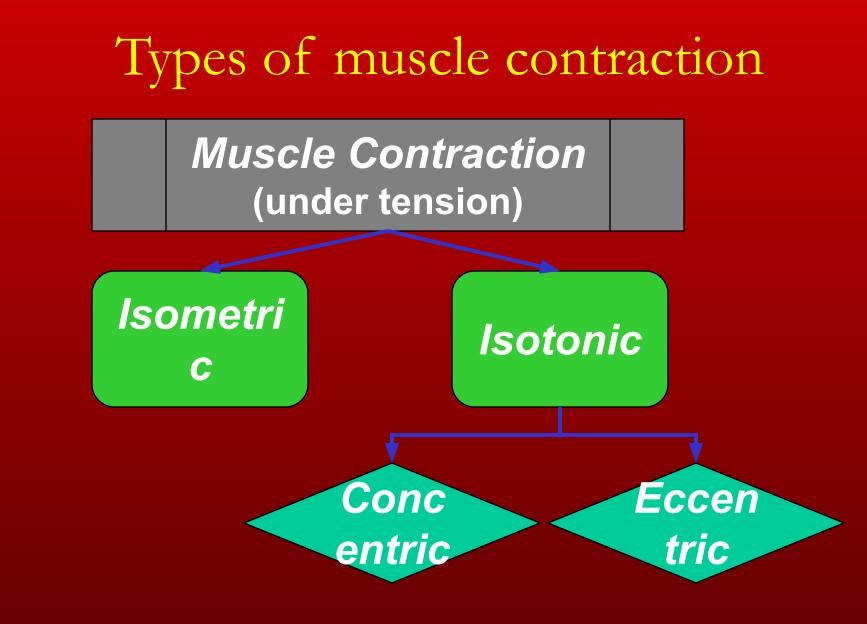
- Origin proximal attachment, generally considered the least movable part or the part that attaches closest to the midline or center of the body
- Insertion distal attachment, generally considered the most movable part or the part that attaches farthest from the midline or center of the body



- All muscle contractions are either isometric or isotonic
- Isometric contraction
 - tension is developed within muscle but joint angles remain constant
 - static contractions
 - significant amount of tension may be developed in muscle to maintain joint angle in relatively static or stable position



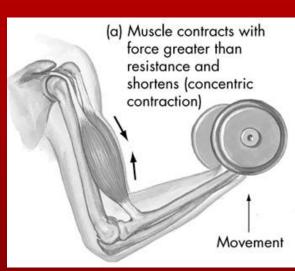
Manual of Structural Kinesiology



- Isotonic contractions involve muscle developing tension to either cause or control joint movement
 - dynamic contractions
 - the varying degrees of tension in muscles are causing joint angles to change
- Isotonic contractions are either concentric or eccentric on basis of whether shortening or lengthening occurs

- Concentric contractions involve muscle developing tension as it shortens
- Eccentric contractions involve the muscle lengthening under tension
 - Contraction is contradictory regarding eccentric muscle activity, since the muscle is really lengthening while maintaining considerable tension
 - Eccentric muscle action is perhaps more correct

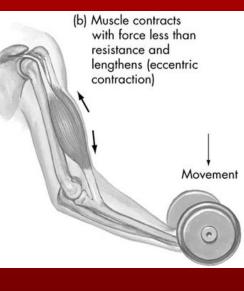
- Concentric contraction
 - muscle develops tension as it shortens
 - occurs when muscle develops enough force to overcome applied resistance



- causes movement against gravity or resistance
- described as being a positive contraction

- Concentric contraction
 - force developed by the muscle is greater than that of the resistance
 - results in joint angle changing in the direction of the applied muscle force
 - causes body part to move against gravity or external forces

- Eccentric contraction (muscle action)
 - muscle lengthens under tension
 - occurs when muscle gradually lessens in tension to control the descent of resistance
 - weight or resistance overcomes muscle contraction but not to the point that muscle cannot control descending movement

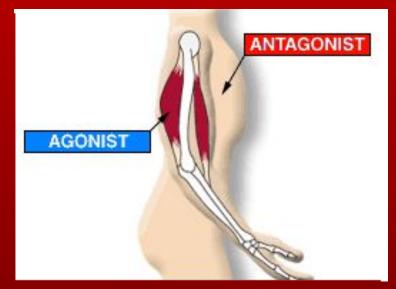


- Eccentric contraction (muscle action)
 - controls movement with gravity or resistance
 - described as a negative contraction
 - force developed by the muscle is less than that of the resistance
 - results in the joint angle changing in the direction of the resistance or external force
 - causes body part to move with gravity or external forces (resistance)

- Eccentric contraction (muscle action)
 - Some refer to this as a muscle action instead of a contraction since the muscle is lengthening as opposed to shortening
- Various exercises may use any one or all of these contraction types for muscle development

- Isokinetics a type of dynamic exercise using concentric and/or eccentric muscle contractions
 - the speed (or velocity) of movement is constant
 - muscular contraction (ideally maximum contraction) occurs throughout movement
 - not another type of contraction, as some have described
 - Ex. Biodex, Cybex, Lido

- Agonist muscles
 - cause joint motion through a specified plane of motion when contracting concentrically
 - known as primary or prime movers, or muscles most involved



Manual of Structural Kinesiology

- Antagonist muscles
 - located on opposite side of joint from agonist
 - have the opposite concentric action
 - known as contralateral muscles
 - work in cooperation with agonist muscles by relaxing & allowing movement
 - when contracting concentrically perform the opposite joint motion of agonist

- Stabilizers
 - surround joint or body part
 - contract to fixate or stabilize the area to enable another limb or body segment to exert force & move
 - known as fixators
 - essential in establishing a relatively firm base for the more distal joints to work from when carrying out movements

- Synergist
 - assist in action of agonists
 - not necessarily prime movers for the action
 - known as guiding muscles
 - assist in refined movement & rule out undesired motions

Neutralizers

 Counteract or neutralize the action of another muscle to prevent undesirable movements such as inappropriate muscle substitutions

- referred to as neutralizing
- contract to resist specific actions of other muscles

Manual of Structural Kinesiology

- Muscles with multiple agonist actions
 - attempt to perform all of their actions when contracting
 - cannot determine which actions are appropriate for the task at hand
- Actions actually performed depend upon several factors
 - the motor units activated
 - joint position
 - muscle length
 - relative contraction or relaxation of other muscles acting on the joint

 Two muscles may work in synergy by counteracting their opposing actions to accomplish a common action

- Example of muscle roles in kicking a ball
 - Muscles primarily responsible for hip flexion
 & knee extension are agonists
 - Hamstrings are antagonistic & relax to allow the kick to occur
 - Preciseness of the kick depends upon the involvement of many other muscles

• Example of muscle roles in kicking a ball

 The lower extremity route & subsequent angle at the point of contact (during the forward swing) depend upon a certain amount of relative contraction or relaxation in the hip abductors, adductors, internal rotators & external rotators (acting in a synergistic fashion to guide lower extremity precisely)

- Example of muscle roles in kicking a ball
 - These synergistic muscles are not primarily responsible for knee extension & hip flexion but contribute to accuracy of the total movement
 - They assist in refining the kick & preventing extraneous motions

- Example of muscle roles in kicking a ball
 - These synergistic muscles in contralateral hip & pelvic area must be under relative tension to help fixate or stabilize the pelvis on that side to provide a relatively stable base for the hip flexors on the involved side to contract against
 - Pectineus & tensor fascia latae are adductors and abductors, respectively, in addition to flexors

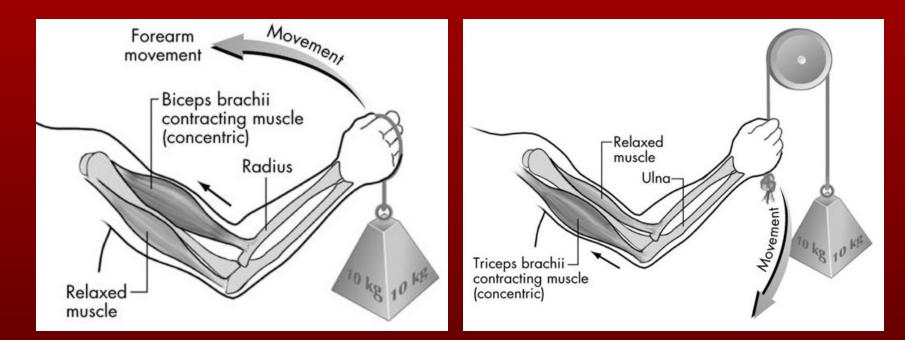
- Example of muscle roles in kicking a ball
 - Abduction & adduction actions are neutralized by each other
 - Common action of the two muscles results in hip flexion

- Antagonistic muscles produce actions opposite those of the agonist
 - Ex. elbow extensors are antagonistic to elbow flexors
 - Elbow movement in returning to hanging position after chinning is extension, but triceps & anconeus are not being strengthened
 - Elbow joint flexors contract concentrically followed by eccentric contraction of same muscles

- Antagonistic muscles produce actions opposite those of the agonist
 - Specific exercises are needed for each antagonistic muscle group

Reversal of Muscle Function

 A muscle group described to perform a given function can contract to control the exact opposite motion



Manual of Structural Kinesiology

Neuromuscular Fundamentals

Neural control of voluntary movement

- Muscle contraction result from stimulation by the nervous system
- Every muscle fiber is innervated by a somatic motor neuron which, when an appropriate stimulus is provided, results in a muscle contraction

Neural control of voluntary movement

- Sensory neurons transmit impulses to spinal cord & brain from all parts of body
- Motor neurons transmit impulses away from the brain & spinal cord to muscle & glandular tissue
- Interneurons are central or connecting neurons that conduct impulses from sensory neurons to motor neurons

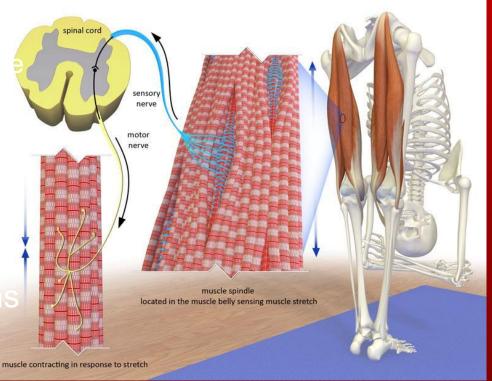
- Activity performance is significantly dependent upon neurological feedback from the body
- We use various senses to determine a response to our environment
 - Seeing when to lift our hand to catch a fly ball

- Taken for granted are sensations associated with neuromuscular activity through proprioception
- Proprioceptors internal receptors located in skin, joints, muscles, & tendons which provide feedback relative to tension, length, & contraction state of muscle, position of body & limbs, and movements of joints

- Proprioceptors work in combination with other sense organs to accomplish kinesthesis
- Kinesthesis awareness of position & movement of the body in space
- Proprioceptors specific to muscles
 - Muscles spindles
 - Golgi tendon organs (GTO)

<u>Muscle spindles</u>

- concentrated primarily in muse belly between the fibers
- sensitive to stretch & rate of stretch
- 1. Muscle stretch occurs
- 2. Impulse is sent to the CNS
- CNS activates motor neuror of muscle and causes it to contract

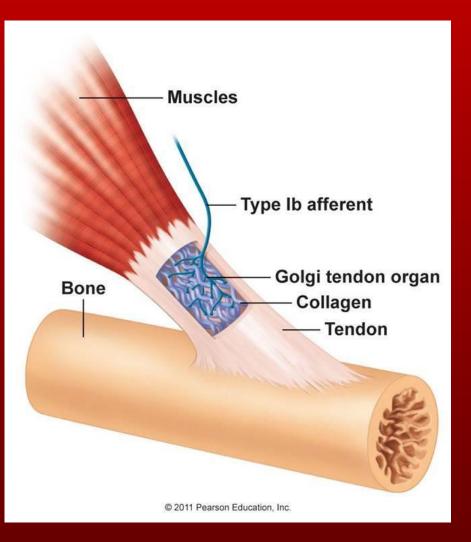


- Ex. Knee jerk or patella tendon reflex
 - Reflex hammer strikes patella tendon
 - Causes a quick stretch to musculotendonis unit of quadriceps
 - In response quadriceps fires & the knee extends
- More sudden the tap, the more significant the reflexive contraction

- Stretch reflex may be utilized to facilitate a greater response
 - Ex. Quick short squat before attempting a jump
 - Quick stretch placed on muscles in the squat enables the same muscles to generate more force in subsequently jumping off the floor

Golgi tendon organ

- found in the tendon close to muscle tendon junction
- sensitive to both muscle tension & active contraction
- much less sensitive to stretch than muscles spindles
- require a greater stretch to be activated



Manual of Structural Kinesiology

- Tension in tendons & GTO increases as muscle contract, which activates the GTO
 - 1. GTO stretch threshold is reached
 - 2. Impulse is sent to the CNS
 - 3. CNS causes the muscle to relax
 - 4. facilitates activation of the antagonists as a protective mechanism
- GTO protects us from an excessive contraction by causing it to relax

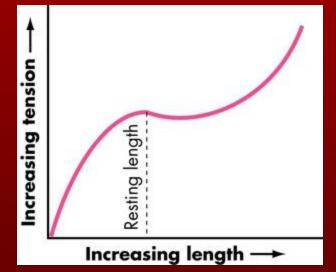
All or None Principle

- All or None Principle regardless of number, individual muscle fibers within a given motor unit will either fire & contract maximally or not at all
- difference between lifting a minimal vs. maximal resistance is the number of muscle fibers recruited

All or None Principle

- The number of muscle fibers recruited may be increased by
 - activating those motor units containing a greater number of muscle fibers
 - activating more motor units
 - increasing the frequency of motor unit activation

 Maximal ability of a muscle to develop tension & exert force varies depends upon the length of the muscle during



Manual of Structural Kinesiology

contraction

- Generally, depending upon muscle involved
 - Greatest amount of tension can be developed when a muscle is stretched between 100% to 130% of its resting length
 - Stretch beyond 100% to 130% of resting length significantly decreases the amount of force muscle can exert

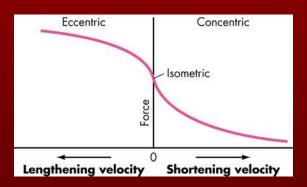
- Generally, depending upon muscle involved
 - A proportional decrease in ability to develop tension occurs as a muscle is shortened
 - When shortened to around 50% to 60% of resting length ability to develop contractile tension is essentially reduced to zero

- Ex. 1 Increasing ability to exert force

 squat slightly to stretch the calf, hamstrings, & quadriceps before contracting same muscles concentrically to jump
- Ex. 2. Reducing ability to exert force

 isolate the gluteus maximus by maximally shortening the hamstrings with knee flexion

- When muscle is contracting (concentrically or eccentrically) the rate of length change is significantly related to the amount of force potential
- When contracting concentrically against a light resistance muscle is able to contract at a high velocity



Manual of Structural Kinesiology

- As resistance increases, the maximal velocity at which muscle is able to contract decreases
- Eventually, as load increases, the velocity decreases to zero resulting in an isometric contraction
- As load increases beyond muscle's ability to maintain an isometric contraction, the muscle begins to lengthen resulting in an eccentric contraction

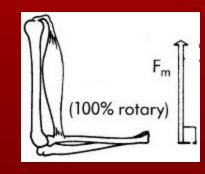
- Slight increases in load results in relatively low velocity of lengthening
- As load increases further the velocity of lengthening will increase as well
- Eventually, load may increase to point where muscle can no longer resist, resulting in uncontrollable lengthening or dropping of load
- Inverse relationship between concentric velocity and force production

- As force needed to cause movement of an object increases the velocity of concentric contraction decreases
- Somewhat proportional relationship between eccentric velocity and force production
- As force needed to control an object's movement increases, the velocity of eccentric lengthening increases, at least until when control is lost

- Angle between the line of pull of the muscle & the bone on which it inserts (angle of attachment facing away from joint as opposed to angle on side of joint)
- With every degree of joint motion, the angle of pull changes
- Joint movements & insertion angles involve mostly small angles of pull

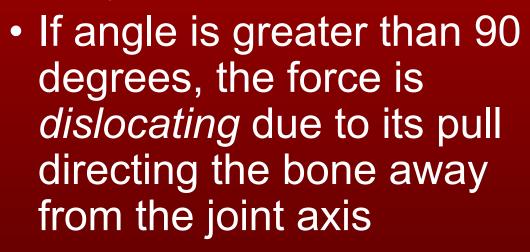
- Angle of pull decreases as bone moves away from its anatomical position through local muscle group's contraction
- Range of movement depends on type of joint & bony structure
- Most muscles work at angles of pull less than 50 degrees
- Amount of muscular force needed to cause joint movement is affected by angle of pull

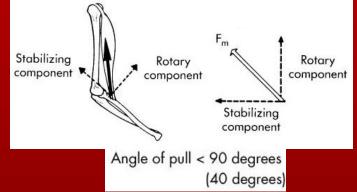
- Rotary component (vertical component) component of muscular force that acts perpendicular to long axis of bone (lever)
 - When the line of muscular force is at 90 degrees to bone on which it attaches, all of the muscular force is rotary force (100% of force is contributing to movement)
 - All of force is being used to rotate the lever about its axis
 - The closer the angle of pull to 90 degrees, the greater the rotary component

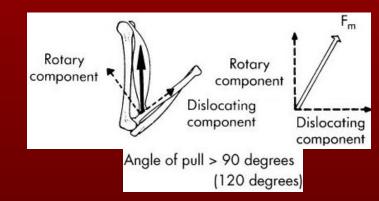


- At all other degrees of the angle of pull, one of the other two components of force are operating in addition to rotary component
 - Rotary component continues with less force, to rotate the lever about its axis
 - Second force component is the horizontal, or nonrotary component and is either a stabilizing component or a dislocating component, depending on whether the angle of pull is less than or greater than 90 degrees

 If angle is less than 90 degrees, the force is a stabilizing force because its pull directs the bone toward the joint axis







- Sometimes desirable to begin with the angle of pull is at 90 degrees
 - chin-up (pull-up)
 - angle makes the chin-up easier because of more advantageous angle of pull
 - compensate for lack of sufficient strength

- Biarticular muscles cross & act on two different joints
 - Depending, biarticular muscles may contract & cause motion at either one or both of its joints
 - Two advantages over uniarticular muscles
 - can cause and/or control motion at more than one joint
 - are able to maintain a relatively constant length due to "shortening" at one joint and "lengthening" at another joint

- Muscle does not actually shorten at one joint & lengthen at other
 - The concentric shortening of the muscle to move one joint is offset by motion of the other joint which moves its attachment of muscle farther away
 - This maintenance of a relatively constant length results in the muscle being able to continue its exertion of force

- Ex.1 Hip & knee biarticular muscles
 - Concurrent movement pattern occurs when both the knee & hip extend at the same time
 - If only knee extension occurs, rectus femoris shortens & loses tension as do other quadriceps muscles, but its relative length & subsequent tension may be maintained due to its relative lengthening at the hip joint during extension

Manual of Structural Kinesiology

- Ex. 2 Hip & knee biarticular muscles
 - Countercurrent movement pattern occurs in kicking
 - During the lower extremity forward movement phase the rectus femoris concentrically contracts to flex the hip & extend the knee
 - These two movements, when combined, increase the tension or stretch on the hamstring muscles both at the knee & hip

- Multiarticular muscles act on three or more joints due to the line of pull between their origin & insertion crossing multiple joints
- Principles relative to biarticular muscles apply similarly to multiarticular muscles

Reciprocal Inhibition or Innervation

- Antagonist muscles groups must relax & lengthen when the agonist muscle group contracts
 - This reciprocal innervation effect occurs through reciprocal inhibition of the antagonists
 - Activation of the motor units of the agonists causes a reciprocal neural inhibition of the motor units of the antagonists
 - This reduction in neural activity of the antagonists allows them to subsequently lengthen under less tension

Manual of Structural Kinesiology

Reciprocal Inhibition or Innervation

• Ex. Compare the ease of

 stretching hamstrings when simultaneously contracting the quadriceps

VS.

 stretching hamstrings without contracting quadriceps

Active & Passive Insufficiency

- As muscle shortens its ability to exert force diminishes
 - Active insufficiency is reached when the muscle becomes shortened to the point that it can not generate or maintain active tension
 - Passively insufficiency is reached when the opposing muscle becomes stretched to the point where it can no longer lengthen & allow movement

Active & Passive Insufficiency

- Easily observed in either biarticular or multiarticular muscles when full range of motion is attempted in all joints crossed by the muscle
 - Ex. Rectus femoris contracts concentrically to both flex the hip & extend the knee.
 - Can completely perform either action one at a time but actively insufficient to obtain full range at both joints simultaneously

Active & Passive Insufficiency

- Similarly, hamstrings can not usually stretch enough to allow both maximal hip flexion & maximal knee extension due passive insufficiency
- As a result, it is virtually impossible to actively extend the knee fully when beginning with the hip fully flexed or vice versa



Neurologic Exam: An anatomical approach

http://medlib.med.utah.edu/neurologicexam/home_exam.html

 A very thorough site regarding neurological exam including numerous movies with both normal & pathological results

Cranial Nerves: Review info

www.gwc.maricopa.edu/class/bio201/cn/cranial.htm

- A good resource on the cranial nerves
- **University of Arkansas Medical School Nerve tables**
 - http://anatomy.uams.edu/htmlpages/anatomyhtml/nerves.html
 - Numerous tables of all nerves throughout the body

A Cyberanatomy Tutorial of the Brachial Plexus and its Associated Injuries

http://anatome.ncl.ac.uk/tutorials/brachial1/test/

A hands on guide to the Brachial Plexus.

Web Sites

Dermatomes

www.meddean.luc.edu/lumen/MedEd/GrossAnatomy/learnem/der mat/main_der.htm

- An interactive review of the body's dermatomes.

Loyola University Medical Education Network Master Muscle List

<u>www.meddean.luc.edu/lumen/MedEd/GrossAnatomy/dissector/m</u> <u>ml/</u>

 An interactive and graphical review of the muscles indexed alphabetically and by region.

Spinal Cord and Nervous System

www.driesen.com/spine_and_cord.htm

A review of the spinal cord and nervous system

Proprioception Exercises Can Improve Balance

http://sportsmedicine.about.com/library/weekly/aa062200.htm

- Proprioception

Manual of Structural Kinesiology

Web Sites

Meds 1 Neurophysiology 2003

www.med.uwo.ca/physiology /courses/medsweb/

- A site with Flash animations regarding neurophysiology.

Muscles

http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/M/Muscles.ht ml

A review of the science behind muscle contractions.

An introduction to the mechanism of muscle contraction

www.ebsa.org/npbsn41/intro_muscle.html

- A graphical review of muscle contraction physiology