NESTA Group Exercise Instructor Program

N.E.S.T.A.
National Exercise & Sports Trainers Association

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Section 1.1
Introduction to Group Exercise

Section Objectives:

Know the benefits of exercise for both the body and mind.

Know the code of ethics for group exercise instructors.

Welcome!

Group Exercise began as "Aerobics" classes in the 1970's when Kenneth Cooper coined the phrase "Aerobics." In the beginning, classes consisted mainly of a warm-up, stretching, cardiovascular exercise with high impact moves, sculpting and a cool-down followed by a stretch.

Eventually there were injuries; mainly of the feet, knees and back. The high impact classes transitioned into low impact classes with much less stress on the body. Hybrid classes combining hi-low moves became popular, and these classes still exist today. It seemed the perfect solution. Students could get a great workout and avoid injury.

Many years later, Gin Miller brought a "step" to Reebok and everyone was "stepping." These classes included the use of blocks or risers that would increase or decrease the height of the step to help accommodate various heights and fitness levels. These classes remained popular for a couple of decades, and you can still find a few on class schedules today. Some people, over time, began to experi-

ence ankle and knee problems from traditional step classes. Steps are found in most fitness facilities, however, but are used in classes other than step aerobics. They're great props for Boot Camp, Circuit Classes and HIIT training.

As Group Fitness classes evolved, along came: cycling, treadmill, kickboxing, circuit, aqua, BOSU, COREBOARD, functional fitness, Pilates, Yoga, Gliding, Core, Pole, Tabata, Kettlebell, and many more. Group Fitness evolved, and continues to evolve, every year. New inventions are made, old ones are brought back, and the desires of the people are being heard.

One thing that never changes is the importance of the personality, skills and teaching techniques of the instructor. If you ask someone why they rush from work to get to the club at a certain time for a class, they usually respond, "I love the instructor. She/he motivates me, encourages me to work hard and I really have a great time."

You could memorize this book from cover to cover, but it wouldn't be enough to stand out above the rest. Only your unique style, care, commitment, passion and presentation can do that! So, let's get started...

Who is NESTA?

NESTA is a professional fitness association offering a wide range of primary, advanced and specialized educational courses and certification programs. NESTA was established in 1992 in Southern California. Today, NESTA is an international fitness association with over 55,000 members from around the world. Approximately 10% of our members are from outside the U.S. NESTA members and graduates have thriving careers in over 50 countries. Our certifications are accepted and used globally. We welcome students from around the world.

Who is this Program for?

For anyone who wants to teach! Sure, it helps if you love fitness, people, helping and performing. But, if you have a love of teaching, this course is for you!

Mission Statement:

This course will ready a future instructor to construct, and safely teach, one-hour group exercise classes that include: a warm-up, main workout based on title/theme, cool-down and stretch. Instructors will be able to "perform" in each class to engage, encourage and excite participants to come back again and again.

Goals of this Home Study:

Our goal is to have you not only competent in group exercise instruction, but be a wildly successful member in the industry. The home study course is designed to be self-paced, easy to understand, concise and thorough. You'll learn all about what is expected as an instructor, and you'll have all the information needed to feel confident in interviews. You will need to read the manual, watch the videos and practice as you go. The anatomy portions will require some memorization. Each section will begin with "section objectives." Think of these objectives as mini pre-tests along the way. If you are proficient in each objectives section, you stand a better chance of passing your final exam.

Home Study Course Objectives:

Students will develop a basic knowledge of anatomy, kinesiology and exercise physiology.

Students will feel comfortable and confident in front of a class.

Students will be able to develop and organize a fitness class.

Students will be able to teach safe and effective classes using a variety of equipment.

Students will be able to properly align bodies for each exercise.

Students will develop leadership and teaching skills.

Students will know basic functions of the muscles.

Students will be able to understand the "Heart Rate Formula."

Students will be able to understand the "Perceived Exertion Chart."

Students will be able to identify the major muscle groups of the body and their functions as it applies to Group Fitness.

Students will be able to identify major professional responsibilities of a group fitness instructor.

Students will understand and identify the NESTA Code of Ethics.

Students will become confident in cueing and teaching techniques.

Students will be able to identify the musical beat and phrase used in teaching classes.

Students will be able to teach at least 2 different exercises for each large muscle group.

Students will be able to teach at least 1 stretch for each large muscle group.

Students will make plans to take CPR training.

Students will be able to identify special populations and seek professional advice as needed.

Code of Ethics for NESTA Certified Group Exercise Instructors:

This code describes the appropriate conduct for all certified group exercise instructors working in the health, wellness and fitness industry.

To provide exemplary instruction in a safe manner.

To act with integrity, showing respect to all clients and fellow health, fitness and wellness professionals.

To always maintain professional boundaries, preserving the confidentiality of all students.

To maintain a current certification through continuing education, and knowledge of the latest research and developments in the fitness industry.

To conduct fitness, health and wellness business practices in accordance with all local, state and federal laws.

To be current with all health, safety and first aid procedures.

To be cognizant of professional limitations and seek the advice of other health professionals when appropriate.

Benefits of a Group Fitness Class:

Physiological

- Increases strength and endurance
- Aid in weight loss and management
- Improve focus and cognitive function
- Minimize chronic disease
- Improves cardiac efficiency
    - increased stroke volume
    - lowers resting heart rate
    - can increase HDL's

Psychological

- Increases vigor
- Decreases depression

Section 1.2
The Fitness Industry

If we are evolving, we are growing. Exercise trends come and go, and they certainly have in the fitness industry, but even trends spark something in people. Sometimes, a passing trend of mini trampolines or bouncing boots, might just inspire a couch potato to get up and try something new. If the trend dies, at least they've been exposed to a gym setting, group classes and a friendly culture. It's all about getting people from the couch to the gym. Once they're there, we hope to win them over and make them lifers of the gym or whatever program comes out next.

Good vs Great:

The deciding factor in your success in this industry rests on one question: Are you good, or are you great? Full classes, your name filling the schedule, happy members and a joyful experience rely on your greatness. The difference between the two often comes down to: **passion**, **personality**, **practice** and **perseverance**.

> If you don't have passion, nothing else will matter, so be sure that teaching and leading light you up!

PASSION

If you don't have passion, nothing else will matter, so be sure that teaching and leading light you up! There's no recipe for passion; you either have it or you don't. You can overcome all the other "P's" on this list, but without passion, nothing else really matters.

PERSONALITY

We all come to the table—or in this case, the stage—with our own unique personalities. It's important to know yours! Are you an extrovert or an introvert? You can be a successful instructor, even as an introvert, so don't let your self-realization scare you away from your passion. Just get to know yourself, and then remember to BE yourself. Copycats aren't authentic; people see right through mimicking. If you're bit shy, hone in on other traits that'll make you shine. Maybe your empathy and warmth are your key strengths. Members will love that! If you're loud and crazy, be aware of that energy too. Some people respond well to that, and others feel overwhelmed. It's important to be yourself while considering things like: maintaining a good volume (too quiet or too loud are both problems), use of language (offensive language or jokes are just as problematic as shy commands that don't convey authority). Are you there for the members and not yourself? People don't care how much you know until they know how much you care! Showing off your knowledge of muscles or how many perfect burpees you can do won't win people over. But if you notice a member who did 5 regular pushups after a week of modified, you've got a fan for life. It's important to note that you won't always be everyone's cup of tea, no matter how much you try. Don't get hung up on that! Variety is the spice of life, so don't try to win everyone over or take it personally. If you are refining the best parts of yourself and focusing on your strengths in front of each class, your personality will get you far.

PRACTICE

Do you know how Jerry Rice got the reputation as the hardest working football player in the NFL? Work ethic! He showed up before everyone, stayed later and ran his plays so that he could do them in his sleep. Much of what we do in the fitness industry is muscle memory, from the movements themselves, to choreography, to rhythmic timing. It can all be learned if you're willing to practice. Do you have the discipline to outwork others? Nothing frustrates classes more than an unprepared teacher, or a teacher who doesn't cue properly. There's really no excuse for either. It simply comes down to practice.

PERSEVERANCE

Not unlike practice, perseverance is available to us all. How willing are you to stick with challenging choreography or memorizing a routine? How much time are you willing to invest in finding the perfect playlist for your class? Will you stick with your new career through bumps like low class attendance or constructive feedback? Great instructors welcome criticism to improve. Some even videotape themselves to hear words they might overuse or to come up with more concise ways to cue. Every class is an opportunity to get better doing what you love, so stick to it, knowing that this is a marathon, not a sprint.

Think about it.....

What do you think is your foremost personality feature which will help in developing your own group exercise program? Explain the pros and cons.

Which, if any, of the subjects in the NESTA Code of Ethics will be problematic for you? Why, and what do you need to do to resolve this?

How do you display your passion? How do you plan to promote this or is it necessary to modify in any way?

Section 2 – The Science of Exercise

In order to be an effective instructor, fitness professionals must have a strong understanding of the human body, how it moves, and how it adapts to exercise. This chapter will review the basics of kinesiology (the study of movement), functional anatomy and exercise physiology (how the body adapts to exercise).

Section 2.1 Kinesiology

Kinesiology is the scientific study of human movement. We start with a review of basic concepts in kinesiology, specifically basic movement terminology. It is vital that a fitness professional understand these terms and be capable of properly applying them. The following terms provide the foundation for properly describing human movement and the efficient application of exercise technique. This chapter also reviews functional anatomy. Traditional anatomy is based on the specific location of different bodily structures. Functional anatomy takes traditional anatomy a step further by considering muscle location as well as the movement produced by that muscle.

Section Objectives:

Be able to differentiate between anatomical position and anatomical neutral.

Know all the planes of motion and be able to name an exercise done in each.

Be able to describe a joint movement by the axis of rotation.

Be able to successfully use anatomical directional terms.

Be able properly define joint motion as based an anatomical movement descriptors.

Anatomical Position and Anatomical Neutral

In order to describe the movement of the human body, a standardized reference point has been used for centuries known as **Anatomical Position**. Anatomical Position is a position of standing erect with the palms facing forward or externally rotated. There is another anatomical reference position with the palms facing the body known as **Anatomical Neutral** (a.k.a. Fundamental Starting Position).

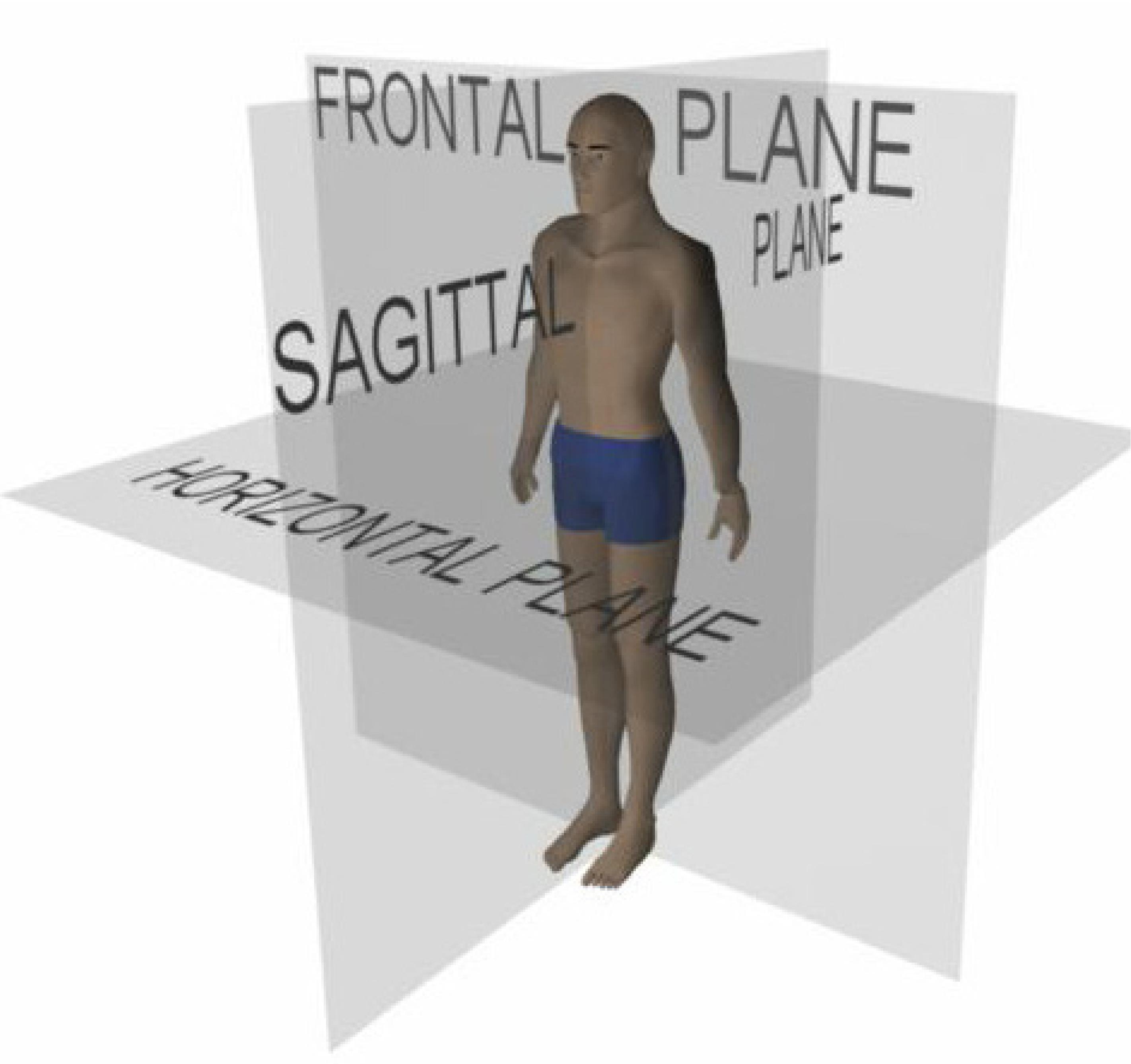
Kinesiology examines the way muscles interact. Therefore, it is essential for fitness professionals to study kinesiology to ensure that the exercises they prescribe to their students will help them achieve their goals and avoid injury.

Anatomical Position

Anatomical Neutral

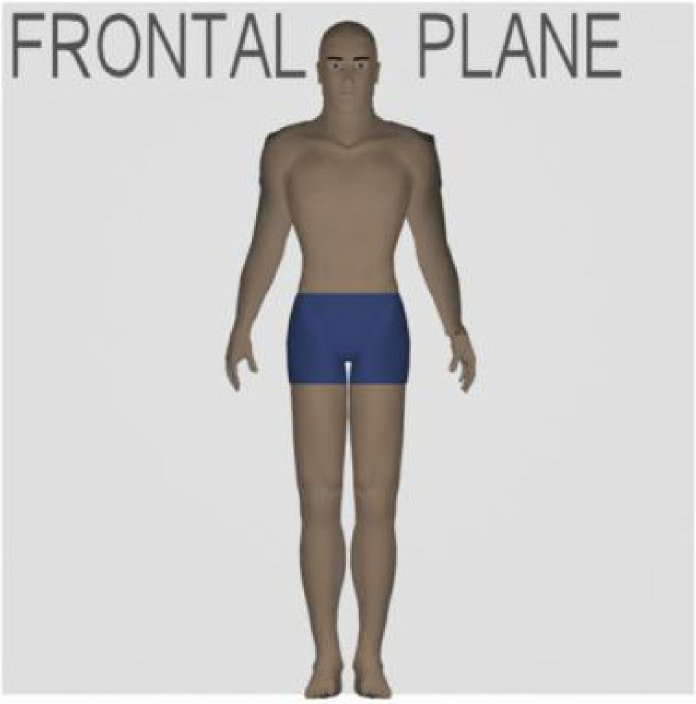
Planes of Motion

We live in a three dimensional (3D) space. In order to describe human movement within three-dimensional space, three planes of motion are used. They are as follows:

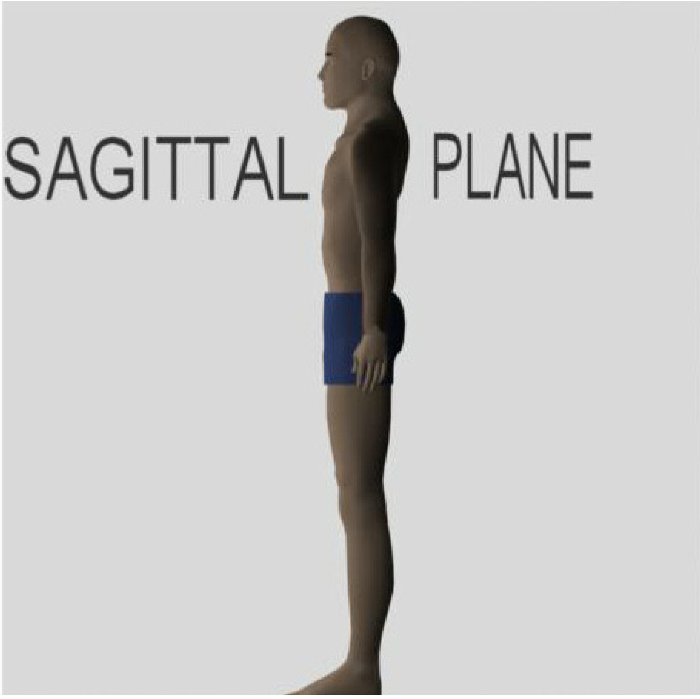


With knowledge of the three planes of movement, it is important to recognize that most human movement (outside of traditional weight lifting machines) is multi-planar and involves movement through more than one single plane. It would be insufficient to refer to the body in general terms (i.e., front, back, side, etc.) due to a need for clarity in reference points. A more efficient, scientific listing of basic anatomical movement descriptors is listed below.

The frontal plane divides the body into front and back halves (A.K.A. coronal plane)



The sagittal plane divides the body into right and left halves



The horizontal plane divides the body into top and bottom halves (A.K.A. transverse plane)

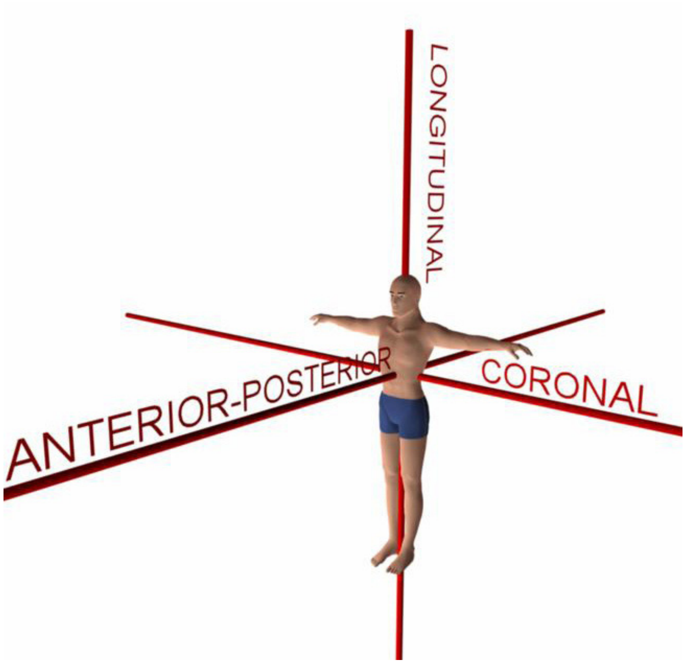
Anatomical Axis of Motion

Each anatomical movement is achieved according to its joint makeup and is bound by the laws of motion around an axis. The Anatomical Axis of Motion describes a movement that occurs in a plane along an axis running perpendicular to the plane.

The longitudinal axis contains movements that occur in the horizonal plane along the longitudinal axis. For example, the movement of turning one's neck to look left and right is about the longitudinal axis.

The anterior-posterior axis includes movements in the frontal plane occur along the anterior-posterior axis. For example, the movement of raising one's arm to the side as if completing a lateral raise (shoulder abduction) is about the anterior-posterior axis.

The coronal axis describes movements that occur in the sagittal plane occur along the coronal axis. For example, the movement kicking a leg forward (hip flexion) is about the coronal axis.



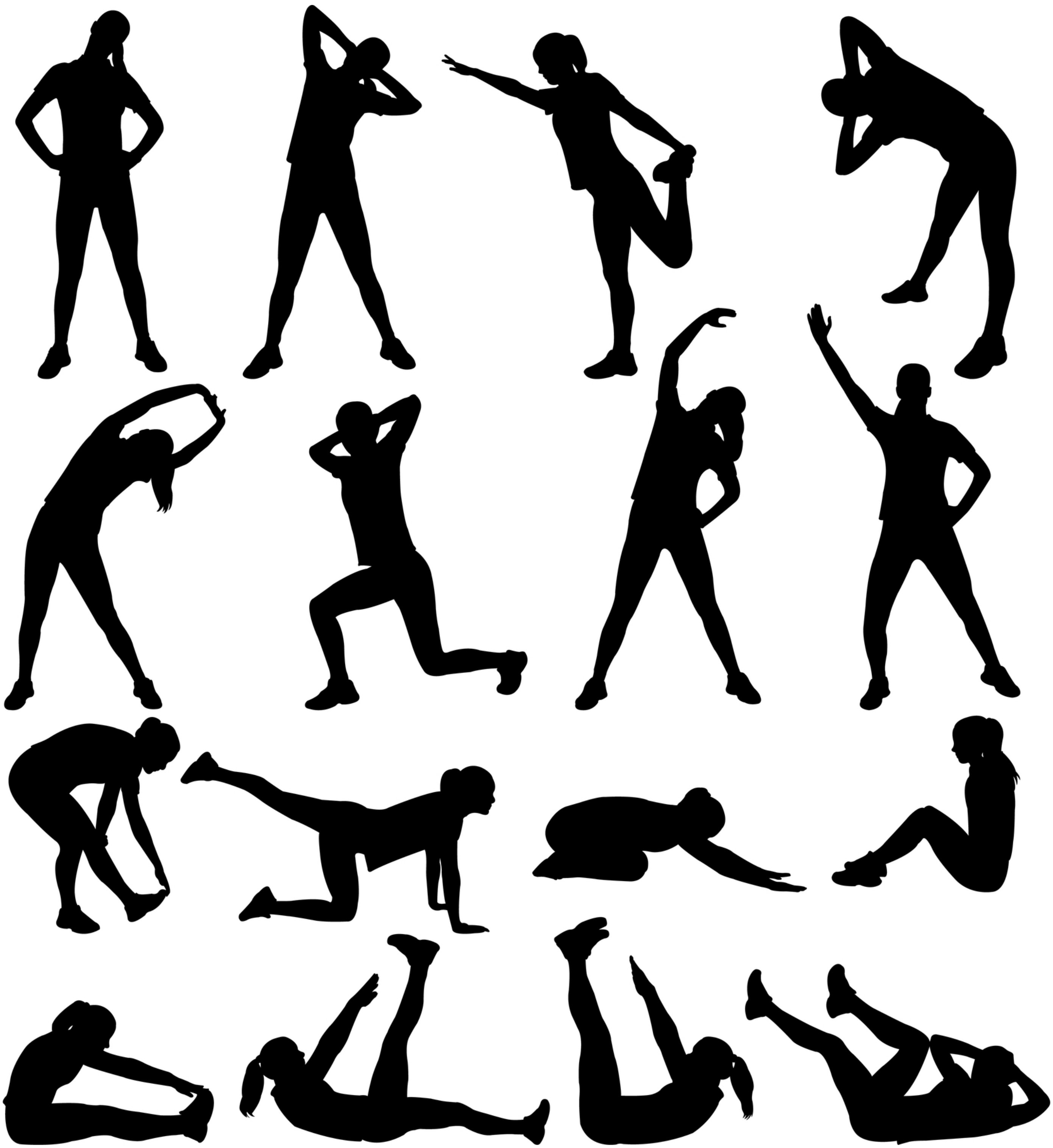
Anatomical Directional Terms

anterior (a.k.a. ventral)	The front of the body relative to another reference point
posterior (a.k.a. dorsal)	The back of the body relative to another reference point
superior	Above a reference point
inferior	Below a reference point
medial	A position relatively closer to the midline of the body
lateral	A position relatively farther away from the midline
proximal	A position closer to a reference point
distal	A position farther from the reference point
unilateral	Refers to only one side
superficial	Near the surface
deep	Further beneath the surface
cephalic	Toward the head
caudal	Toward the bottom
supine	Lying on one's backside
prone	Lying face down

Anatomical movement descriptors, anatomical position and axes of motion are all important facts to know when becoming a fitness professional. These standards have been formulated to allow communication between professionals. Knowing this terminology will help you communicate with personal trainers, physicians, athletic trainers, physical therapists, chiropractors and other fitness professionals to ultimately make you a better and more knowledgeable group exercise instructor.

Think about it.....

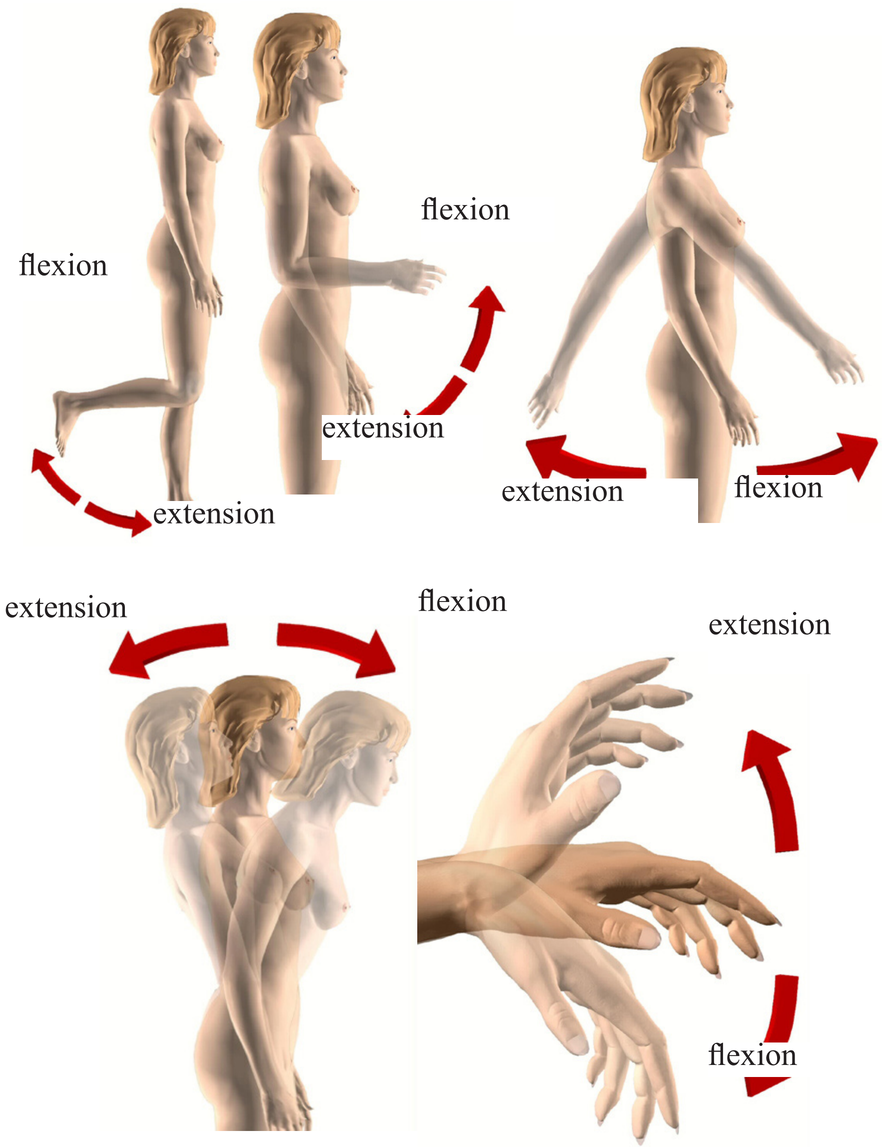
Can you name the dominant plane of motion in each of the images below?

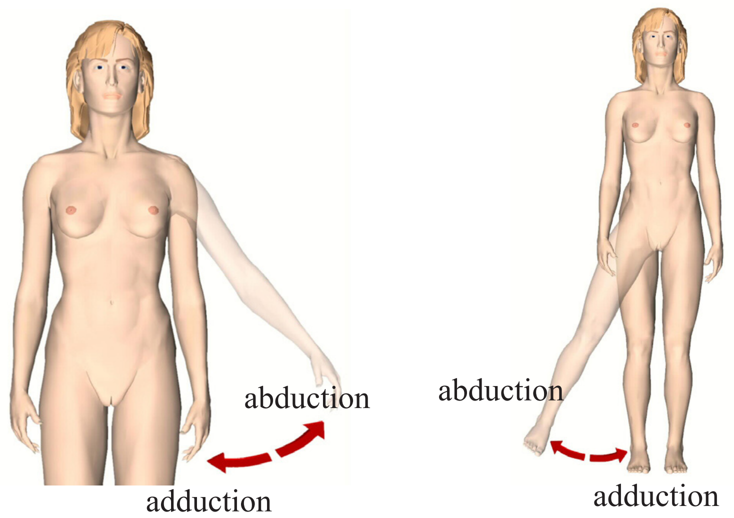


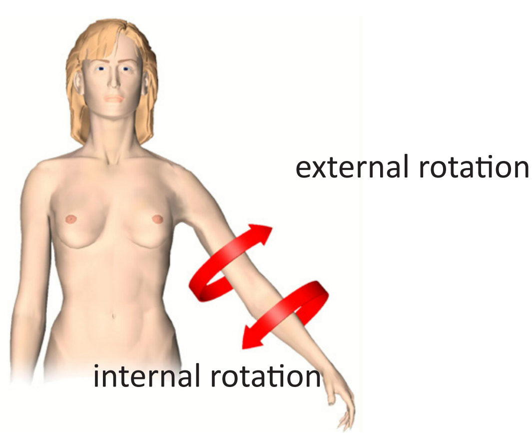
From the top right.....
Frontal; Frontal; Sagittal; Frontal; Frontal; Sagittal; Frontal; Frotal and Sagittal; Sagittal; Sagittal; Sagittal; Sagittal; Sagittal; Sagittal; Sagittal; Sagittal and Horizontal

sagittal plane movements (coronal axis)

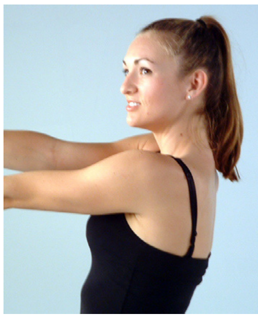
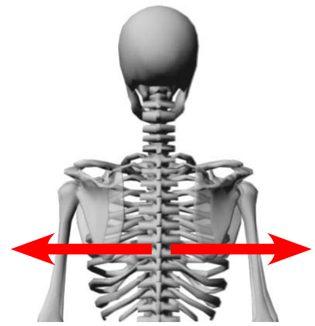
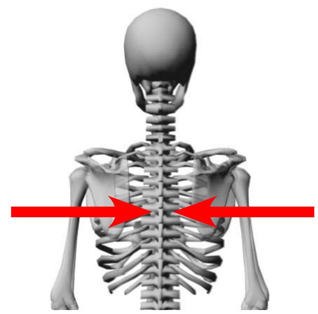
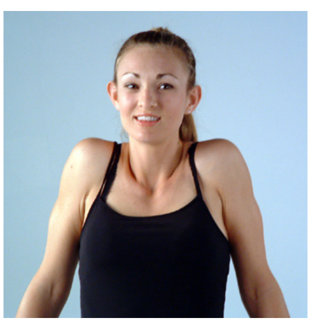
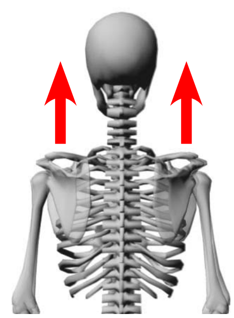
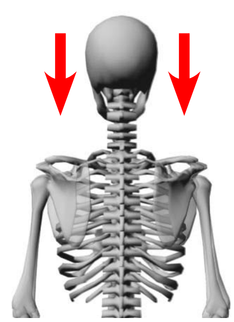
flexion	A bending movement where the relative angle between two adjacent segments decreases
extension	A bending movement where the relative angle between two adjacent segments increases Hyperextension is a movement which continues past anatomical position. (a.k.a. Extension beyond neutral.)



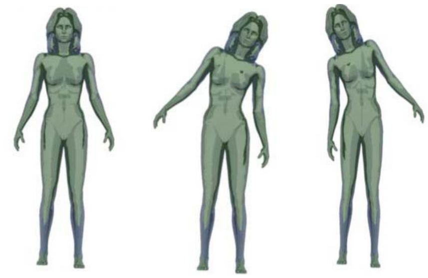
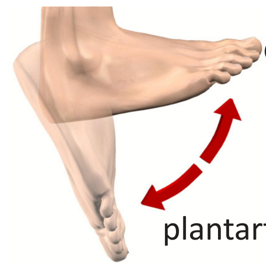
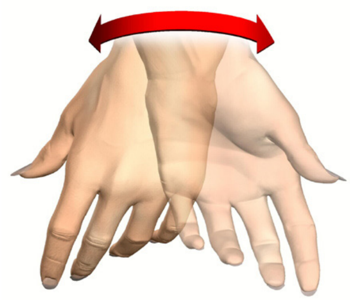
frontal plane movements (anterior-posterior axis)		
abduction	Movement away from the midline of the body	
adduction	Movement towards the midline of the body	

transverse plane movements (longitudinal axis)		
internal/ medial rotation	The rotation of a body part towards the midline (in-side) of the body	
external/ lateral rotation	The rotation of a body part away from the midline of the body	

Specialized Movement Descriptors

positions affecting joint ROM and stability		Movements of the Scapula
protraction	 Abduction of the scapula	
retraction	 Adduction of the scapula	
elevation	 Raising of the scapula (shrug)	
depression	 Lowering of the scapula	

Other specialized movements:

lateral flexion (also known as lateral blending)	spinal movement in the frontal plane	
circumduction	A cone-shaped movement by the body. Circumduction does not require internal and external rotation.	
dorsiflexion and plantar flexion	Only occurs in the foot	
supination	**At wrist:** Movement of the forearm where the palm rotates to face forward from neutral to anatomical position at the radioulnar joint **At foot-ankle:** Supination is a triplane motion which combines the movements of inversion, adduction, plantarflexion	
pronation	**At wrist:** Movement of the forearm where the palm rotates to face backward **At foot-ankle:** Pronation is a triplane motion consisting of simultaneous movements of eversion, abduction, dorsiflexion	*When trying to remember the motion of supination in the hand, there are a few tricks to help you remember the position. Since the palm is up in a cupped position, you can think of supination as holding a cup of "soup." Also, the word "up" is in supination, so your palm is up.*

Think about it.....

Can you name the movement descriptors for each joint in the image below?

From the ground up....

Slight plantar flexion in both ankles. Left knee is flexed. Left hip is flexed, abducted and externally rotated. Right hip is abducted and externally rotated. Both shouders are abducted. Cervical rotation to the left

Section 2.2
The Kinetic Chain

Section Objectives:

Be able to define the kinetic chain and its importance to human movement.

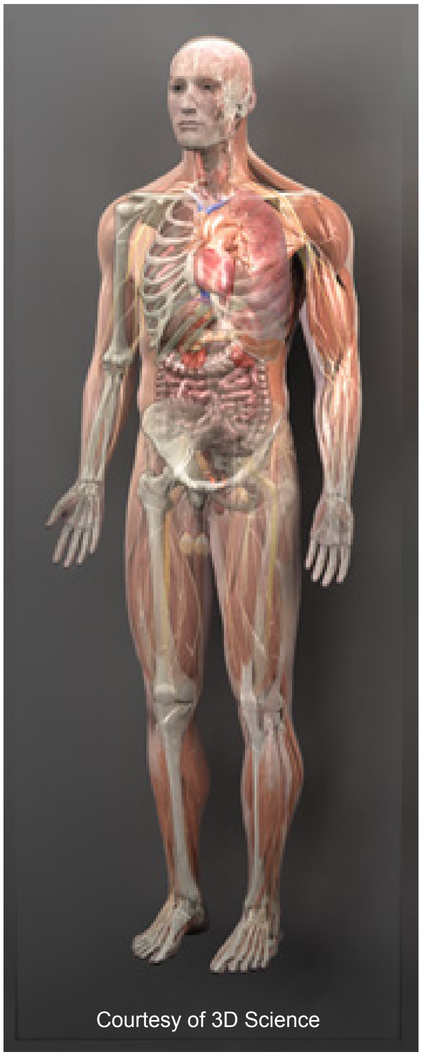
Be albe to list the three bodily systems that make up the kinetic chain.

Be able to describe the integrative nature of the kinetic chain.

What is the Kinetic Chain?

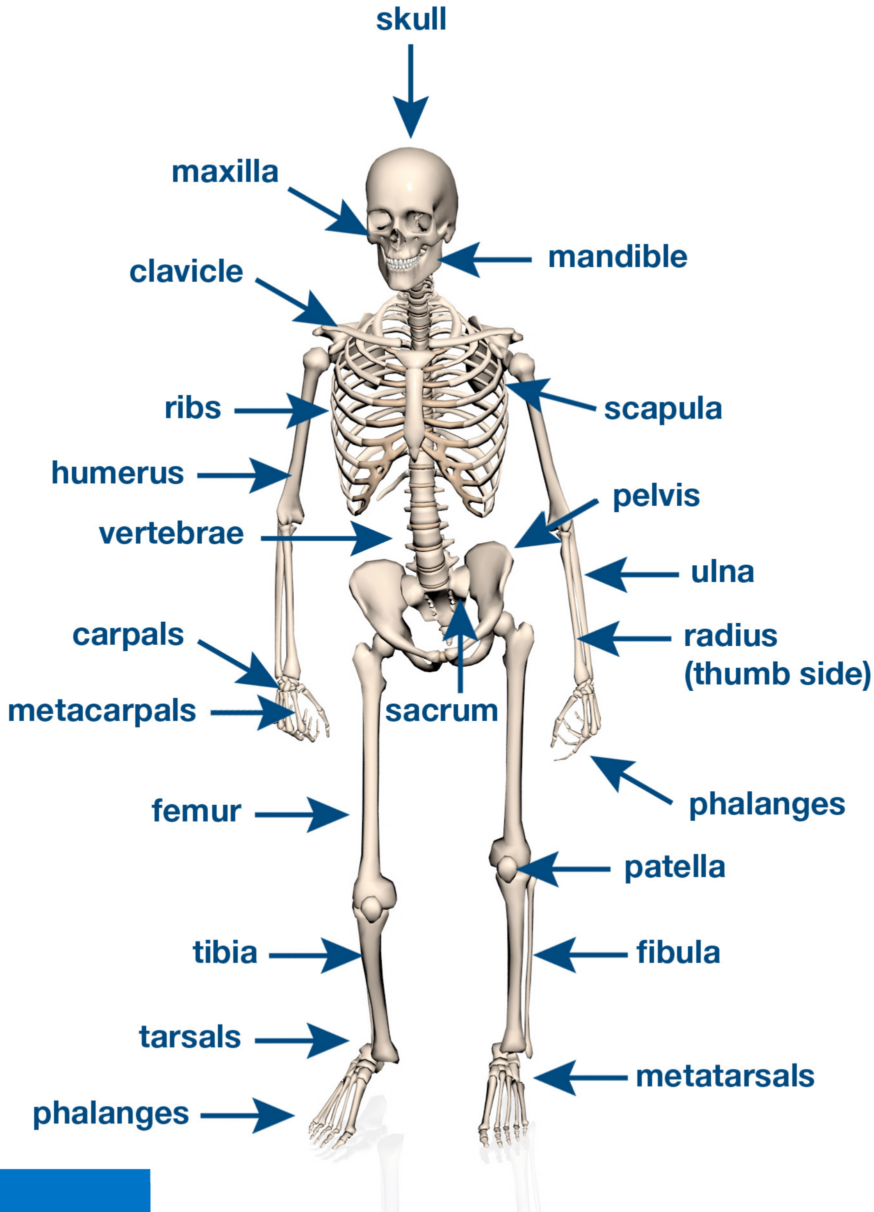
The study of exercise physiology must begin with an understanding of how the body moves. To fully understand human movement, one must first understand the structure and function of bodily muscle and its interdependence upon the nervous and skeletal systems. Much like the checks and balances that exist in human organization to ensure efficient operation, there is a delicate balance within the system known as the Kinetic Chain. The kinetic chain is composed of the **nervous system, muscular system** and **skeletal system**. The systems of the Kinetic Chain must function efficiently for proper functioning of the entire body. Kinetic is usually defined as relating to, or produced by motion. Therefore, the kinetic chain is the "chain" of systems that "link" together to create human movement.

While we define the kinetic chain as three separate systems which work together to create movement, the entire body must work as an integrated unit. For example, the respiratory and digestive systems must import the fuel sources, which power physiological movement. The cardiovascular system must transport fuel to the muscles before movement can occur.



Fitness professionals realize that training involves more than just muscles. All systems of the body must work together as an integrated unit to perform even the most basic tasks.

Section 2.3
The Skeletal System



Section Objectives:

Be able to describe the various roles of the skeletal system.

Be able to explain the materials that make up bone and the structural organization that allows bone to withstand loads.

Be able to explain how bone adapts to load.

Be able to categorize joints based on structure and movement capabilities.

Be able to describe joint positions that affect range of motion and stability.

Be able to describe the components that affect joint stabilization during exercise.

Introduction and Goal

The human skeleton consists of 206 bones. We are actually born with more bones (about 300), but many fuse together as we grow during childhood. These bones support our body and allow us to move. Bones store calcium, a mineral that helps bones stay strong. Calicum is needed for proper funtioning for both nerves and muscles as well. Bones manufacture blood cells and store important minerals for the body.

The longest bone in our body is the femur (thigh bone). The smallest bone is the stirrup bone located inside the ear. Each hand has 26 bones in it. The nose and ears are not made of bone; they are made of cartilage, which is a flexible substance that is not as hard as bone.

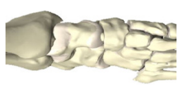
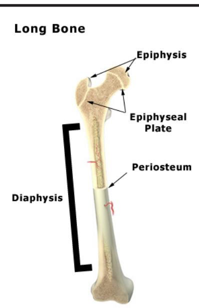
Males and females have slightly different skeletons, as well as having a different elbow angles. Males have slightly thicker and longer legs and arms to accomodate their "hunter-gathering" role; females have a wider pelvis and a larger space within the pelvis to make the whole birthing process possible!

The Goal of this section is to give Group Exercise Instructors an understanding how the skeletal system is designed for both support and movement. In addition, you will be able to educate your athletes on basic joint structure and function, which is essential for safety and efficiency in group exercise classes.

roles of the skeletal system

levers	For motion and restriction of motion
support	The skeletal system is passive and can only move by muscular action. Active systems (such as the muscular system) can only move with the support of the skeletal system.
protection	The simplest example is the ribcage which provides protection for internal organs such as the lungs and heart.
storage	The spongy section of bone is composed of calcium, phosphate and magnesium
blood cell formation	In the bone marrow

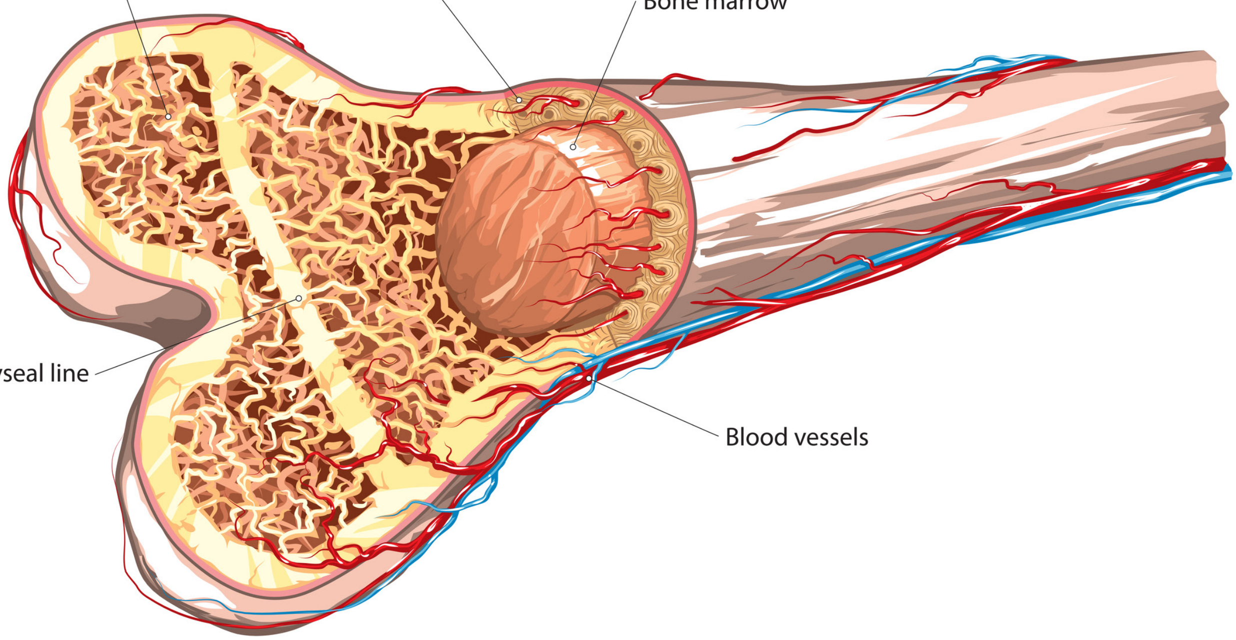
structure and function of bone

short	 The bone is wider than it is long; ex: tarsals and carpals
flat	 ex: pelvis
irregular	 ex: vertebrae
long	 The bone is longer than it is wide (bones of the appendages); ex: femur, humerus
sesamoid	 ex: patella

diaphysis	Cylindrical shaft composed mostly of compact bone surrounding a cavity of bone marrow
epiphysis	Dilated ends, composed of spongy bone surrounded by thin layer of compact bone
epiphyseal plate	Disk of cartilaginous cells separating diaphysis and epiphysis - site of longitudinal growth
periosteum	Fibrous sheath, surrounds long bone, site of attachment to muscle tissue

bone tissue

- One of the body's hardest structures
- 60-70% of bone are made of the minerals calcium and phosphate, and the connective tissue collagen
- Collagen gives bone it's ability to withstand tensile (pulling) loads as well as bone's ductile properties
- Minerals give bone brittleness and the ability to withstand compressive loads
- Composed of 25-35% water



architecture of bone

compact/ cortical bone	Dense, compact tissue on the exterior of bone that provides strength and stiffness to the skeletal system.
spongy/ cancellous bone	Lattice-like and having high porosity, it is capable of high energy storage. Found on interior of bones and in the ends of long bones. Made up of small flat pieces of bone (trabeculae) that adapt to the direction of the imposed stress/force on bone.

Wolff's Law

Wolff's Law states that bone will adapt and grow in line with resistance forces. Bones respond best to compressive forces. Lateral forces may cause the greatest stress and potential damage. However, the bone will still have adaptive abilities. Such forces may have the greatest risk in young athletes/individuals with epiphyseal plate (growth plate) slippage during the years of greatest pre-pubescent growth between the ages of 11 and 14. Epiphyseal plate slippage may inhibit the growth of bone at the affected joint but will not necessarily affect growth of the entire body.

Resorption and Deposit of Bone

Bone is highly adaptive, self-repairing and can alter its properties and configuration in response to mechanical demand. Wolff's Law states: "Every change in the form and function of a bone or of their function alone is followed by certain definitive changes in their internal architecture, and equally definite secondary alteration in their external conformation, in accordance with mathematical laws." In other words, bone adapts to the mechanical stress placed upon it. Large volumes of bone are removed through bone resorption and replaced through deposit. In young adults, the bone deposits equal the bone resorption, and total bone mass is fairly constant. Weight training will increase the amount of bone deposits. Osteoporosis occurs when bone resorption exceeds bone deposits.

Bones require mechanical stress that is created by physical activity in order to grow and become strong. This stress must be performed on a daily basis. Bone loss following a decrease in activity may be significant without sufficient stress.

Structure and Function of Joints

A Joint is an articulation between two bones, which is used to connect one component of a structure with one or more other components. The design of a joint is determined by its function and the nature of its components. Once a joint is constructed, the structure of the joint will determine its function. Joints that serve a single function are less complex than joints that serve multiple functions. Joint typing is based on the type of materials and the methods used to unite bony components.

While muscular injuries are fairly common, joint injuries are often the most devastating, causing long-term problems. Unlike most muscular injuries, joint injuries are more likely to last a lifetime. Hence, it is imperative that fitness professionals understand joint structure and function to prevent the occurence of such devastating injuries.

joint types

synarthrodial

immovable joints (pelvis)

amphiarthroses

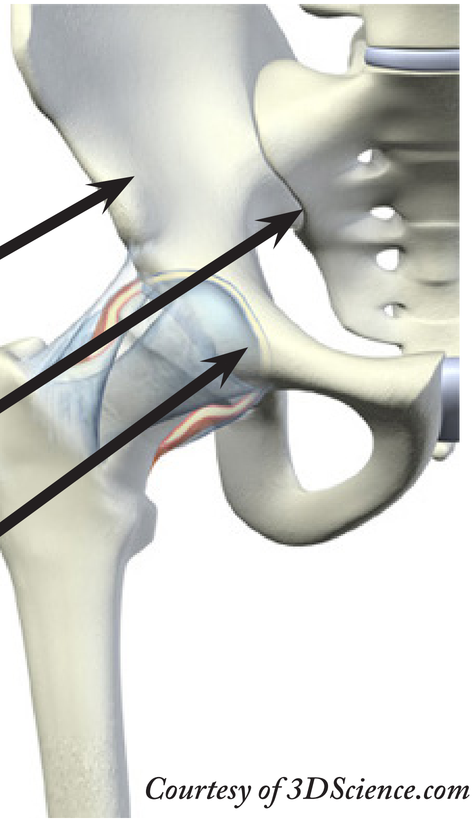
semi-movable joints

(sacroiliac (SI) & pubis)

diarthrodial

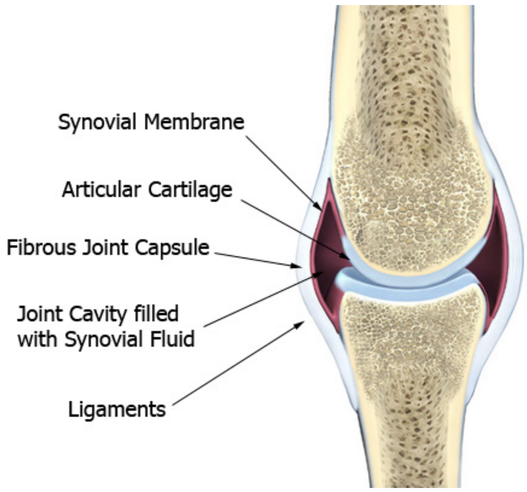
freely movable joints

(hip and knee)

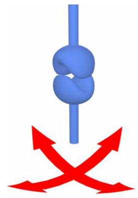
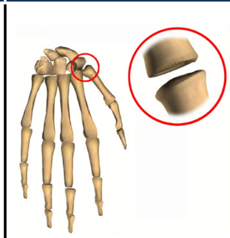
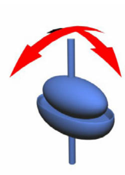
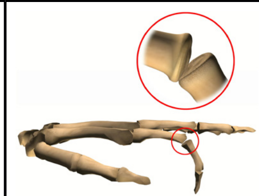
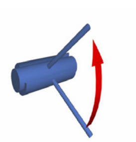
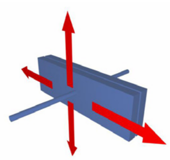
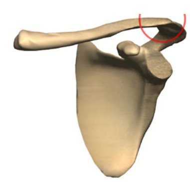
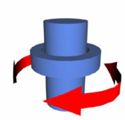
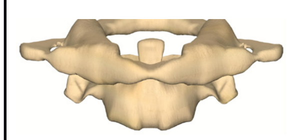
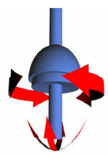
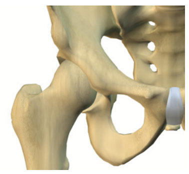


Courtesy of 3DScience.com

5 characteristics of synovial (diarthrodial) joints



1. Articulating bones are separate (not fused)
2. Held together by a capsule of fibrous connective tissue
3. Joint capsule is lined by a synovial membrane
4. Articulating surfaces are covered by cartilage (usually hyaline), but can be fibrocartilage such as the sternoclavicular joint or temporomandibular joint (atypical of synovial joints)
5. A small amount of synovial fluid can be found between articulating bones. Synovial fluid is a liquid that reduces friction in the joint. The synovial fluid changes viscosity (fluid friction) in response to joint movement (this is one of the many reasons for an efficient warm-up prior to exercise).

diarthrodial joint type	movement (Degrees of Freedom are the number of independent movements allowed at a joint)	example
saddle	 Two saddle shaped surfaces allowing two degrees of freedom	 carpometacarpal joint of the thumb
condyloid	 Biaxial, one plane of movement that dominates two planes of motion	 tibiofemoral joint, Interphalangeal joint
hinge	 One degree of freedom	 humeroulnar
plane “gliding”	 Flat surface that allows translation between two bones	 acromioclavicular joint
pivot	 One degree of freedom	 atlantoaxial joint
multiaxial	 “Ball and Socket;” three degrees of freedom, freely movable, allowing motion in all three planes of human movement	 hip joint

positions affecting joint ROM and stability

close-packed	A joint position in which there is maximal contact between two joint surfaces. The majority of ligaments are taut, forcing two bones to act as a single unit. For example, a "locked" (fully extended) knee or elbow is very stable, but is vulnerable to injury due to decreased mobility at either end range of muscular length (excessively short or long).
loose-packed	A joint position with less than maximal contact between joint surfaces and in which contact areas are frequently changing. For the most part, any other joint position that is not close-packed (not locked). Less stable than closed-packed, but not as susceptible to injury due to increased mobility and muscular ability.

characteristics of ligaments

- Connect bone to bone
- Comprised of collagen which is arranged to handle tensile and shear loads
- Maintains contact surfaces at the joint by either limiting or completely preventing "unwanted" (potentially harmful) motion
- Passive stabilizers of the joint which are not meant to be stretched!!!

forms of joint stabilization during exercise

passive	***Internal passive stabilization*** • Performed by noncontractile components (ex: Ligaments) • Needed when there is no anatomical muscular support (ex: lateral knee), • Physiologically muscular support (i.e. no motor pattern), or during active insufficiency
	External passive stabilization • Performed by an outside force (ex: Bench)
active (generated from muscular systems)	***Static*** • Achieved by an isometric contraction of various muscular groups to prevent movement at a joint • While not very functional, it is often required for proper force distribution
	Dynamic • This is stabilization that takes place throughout a range of motion. The prevention of undesirable motions is controlled by dynamic stabilizers in order to maintain relative positions of the appropriate segments.

Section 2.4
The Muscular System

Section Objectives:

Be able to describe the three diffenent types of muscle tissue.

Be able to describe how muscles are stimulated by the nervous system.

Be able to explain the relationships of muscle fiber type to muscle function.

Introduction and Goal

There are three different types of muscle tissue:

muscle tissue		
smooth	Involuntary actions (autonomic nervous system). No striations.	Digestive tract, bladder, uterus, blood vessel walls
skeletal	Voluntary movement (somatic nervous system). Has striations.	All muscles controlling movement
cardiac	An involuntary muscle but has some striations.	Heart only

The skeletal muscular system is the anatomical system most affected by exercise. The framework for the body is provided by the bones and joints. However, movement is enabled by the contraction and relaxation of specific muscles. The goal of this section is to give the student a fundamental understanding of how muscles are able to contract and how they adapt to the stimulus of exercise.

Structure and Function of Muscular System

A muscle is a structure composed of tissues which produce the movements of the body through muscular contractions. Muscles that are capable of voluntary contraction are referred to as striated or skeletal muscle, while involuntary muscles, except the heart, are termed smooth muscle.

Skeletal Muscle

Skeletal muscle or striated muscle cells are some of the largest cells in the body and it is their job to create movement. They do so by contracting (shortening), which pulls the opposite ends of the muscle together. There are over 600 muscles in the human body, and more than 400 are skeletal muscles. Fascia is a sheet or band of fibrous connective tissue which separates and contains muscles within compartments. A tendon is a fibrous cord (consisting primarily of collagen) which attaches muscle to bone, although fascia can also act as a site for muscle attachment.

In addition to the fascia, there are three layers of connective tissue which surround, protect, and enable separate innervation of muscle fibers (muscle cells) within a muscle. The outermost layer is the epimysium, which completely surrounds muscle. The next layer groups

Why do we care?

By understanding how muscle, bone and connective tissue are interdependent to one another, we will not only understand the rationale in creating safer programs but also the underlying causes of injuries such as tendonitis (inflammation of the tendon) and plantar fasciitis (inflammation of the fascia at the arch of the foot).

Skeletal muscle is composed of bundles of long, parallel fibers (cells). Embedded in the muscle fibers are filaments called myofibrils which further divided into sarcomeres. Sarcomeres are the smallest contractile unit of skeletal muscle. Muscle fibers are called striated because they have striations of light and dark bands created by the repeating actin and myosin filaments in the sarcomeres. Muscles are divided by layers of connective tissue to enable it to be innervated from smaller to larger numbers of fibers and sizes. A motor neuron and all the muscle fibers it activates is known as a motor unit. According to the size principle of recruitment, smaller numbers of fibers will be selected before larger numbers of fibers to preserve muscular energy by firing smaller motor neurons, followed by larger motor neurons. Furthermore, once a muscle fiber is innervated, it is either on or off, there can be no partial contraction; this is the all-or-none theory of muscle fiber activation.

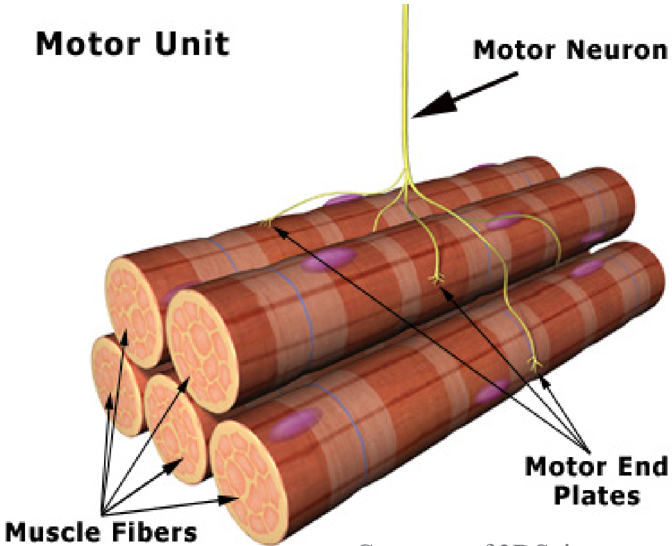
Action Potentials

Muscle fibers contract in response to an electrical signal sent by the motor neuron. This signal is known as an action potential. The signal is sent down the motor neuron to its terminal ending on a muscle fiber known as the motor end plate. Where the motor end plate meets the muscle fiber is the neuromuscular junction.

If the signal is strong enough, an action potential of the muscle fiber is generated. This causes the fiber to contract.

Sarcomere and the Sliding Filament Theory

The sarcomere is composed of thin filaments (chains of globular actin) and thick filaments (organized bundles of myosin). During muscular contractions, these filaments slide over each other with the resulting action being that the sarcomeres shorten together, thereby causing the muscle to contract as a whole.



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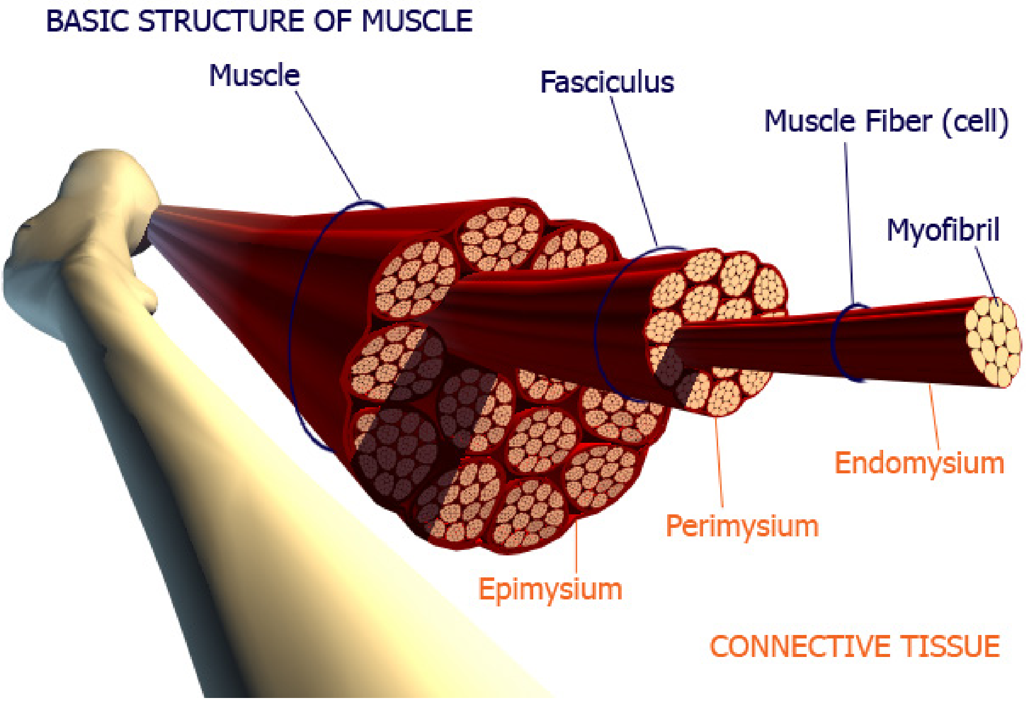
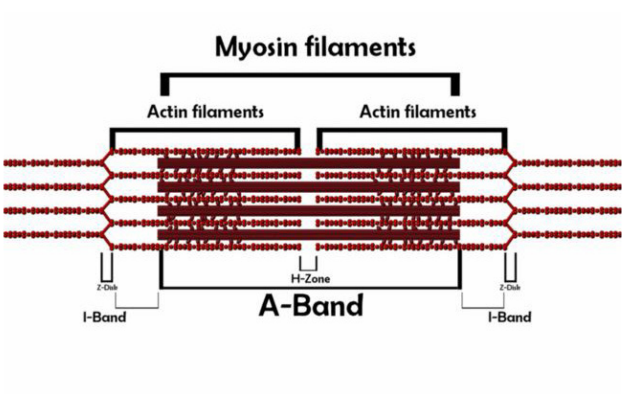
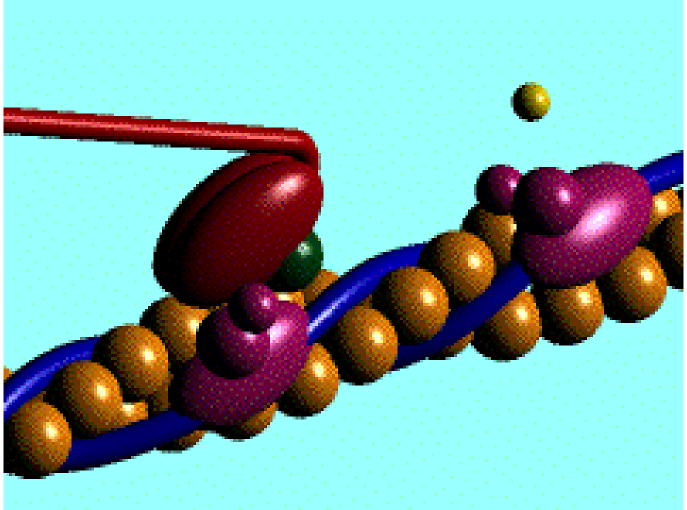


structure of the sarcomere

Z-lines	Defines boundary of single sarcomere
M-line	Runs down center of sarcomere
I-band	Contains thin filaments only
H-zone	Contains thick filaments only
A-band	Contains thick filaments in their entirety without any overlapping portions of thin filaments

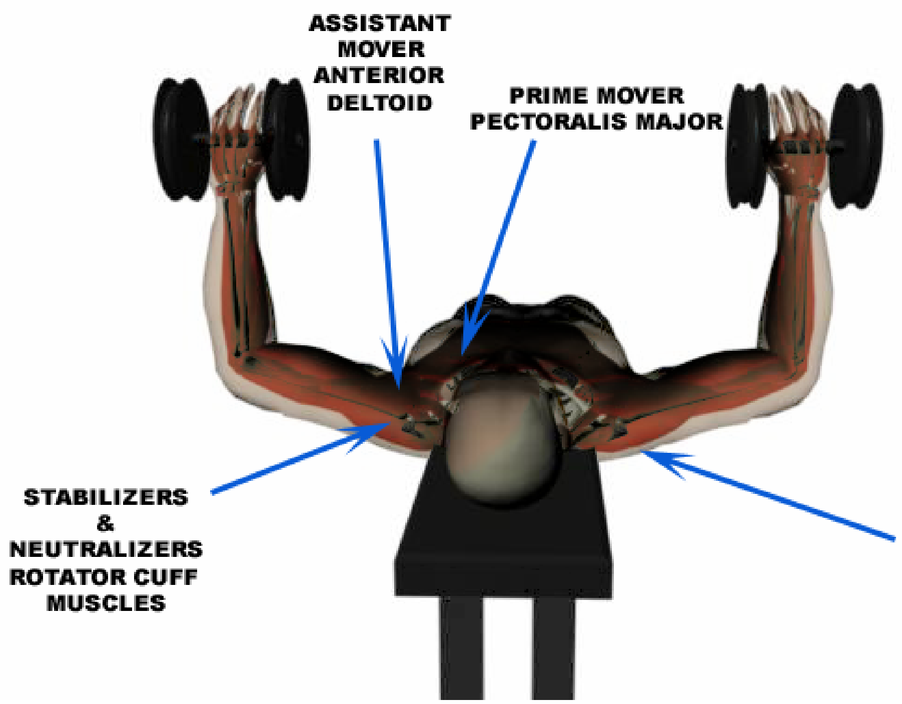




roles of skeletal muscle

prime mover or agonist	A muscle that acts directly to bring about a desired movement through concentric muscle action
assistant mover or synergist	A muscle that assists indirectly to bring about a desired movement
antagonist	A muscle responsible for opposing the concentric muscle action of the agonist (more susceptible to injury).
stabilizer	A muscle responsible for stabilizing an adjacent segment

ROLES OF MUSCLES ON THE SHOULDER JOINT (GLENOHUMERAL JOINT) DURING A DUMBELL BENCH PRESS



muscle fiber types

type I fibers	**RED, slow twitch, aerobic fibers** **These fibers are fatigue-resistant. They are rich in capillaries and myoglobin (enhancing oxygen delivery). They also have increased number of mitochondria which enhances their ability to oxidize fats. Muscles containing a predominant amount of slow twitch muscle fibers tend toward stabilizing functions rather than prime movers of muscle tissue. Individuals with a greater number of Type I fibers tend to excel in endurance related activities that last longer than 3 minutes.**
type IIA fibers	**PINK, moderately fast twitch** **These fibers have traits of both Type I and Type IIB. Individuals with a greater number or more conditioned Type IIA fibers tend to excel in activities lasting between 30 seconds and 2 minutes with a moderate level of strength and aerobic capacity capabilities.**
type IIB fibers a.k.a. "type IIx"	**WHITE, fast twitch, anaerobic fibers** **These fibers are larger in diameter and well suited for brief, powerful contractions. They have little mitochondria and small capillary beds. These fibers tend to be prime movers of joints. Individuals with a greater number of Type IIB fibers tend to excel in highly explosive activities such as maximal lifts and sprinting or jumping. These are also the fibers that have the greatest potential for hypertrophy.** *NOTE: Historically these fibers are known as "type IIB" in humans. However, based on newer techniques to classify muscle fibers based on the type of myosin they have, the newer designation of "type IIx" is now used.*

Fried Chicken

If you want to get a clear idea of the difference between muscle fiber types, look no farther than your nearest bucket of fried chicken. Chickens tend to either sit or walk all day, so their legs and thighs need endurance (the dark meat are Type I fibers). On the other hand, to avoid predators, chickens can explosively use their breast and wing muscles (the white meat - Type IIB fibers) to get away (that is the extent of their flying capabilities).

Training Adaptations to the Muscular System

The increase in the size of muscle is known as **hypertrophy**. Hypertrophy is an increase in the size of myofibrils inside muscle fibers. **Hyperplasia** is an increase in the number of muscle cells in the body with a corresponding increase in muscular size. The phenomenon of hyperplasia is extremely rare, and has only been seen in a few highly advanced bodybuilders and professional athletes. Muscle **atrophy** on the other hand, refers to the wasting or loss of muscle tissue resulting from disease or lack of use.

Muscular Strength and Endurance

There are many types of strength that an individual may need in order to improve performance and/or function. In order to understand the benefits of exercise, we must first define and describe the different types of strength.

Neural Factors Influencing Strength Gains

Exercise elicits a training stimulus: One effect is structural (hypertrophy of muscles and connective tissues); the other is the functional aspect either within a muscle (intramuscular coordination) or within a group of muscles (intermuscular coordination). During any movement, certain muscles will be activated as a primary, secondary, and/or stabilizers to coincide with facilitation (actual recruitment) or inhibition (shut off). This sequence of events takes place during all movements, especially during the initial stages of training (motor learning/motor ability stage).

net muscle actions	
concentric	Definition: Shortening of a muscle fiber against a load • "Raises" the load • "Accelerates" the load • Ex: Upward phase of a dumbbell bicep curl
eccentric	Definition: Lengthening of a muscle fiber against a load • "Lowers" the load • "Decelerates" the load • Ex: Downward phase of a dumbbell bicep curl
isometric	Definition: Where a muscle neither lengthens nor shortens against a load (no net joint movement). A co-contraction of agonist and antagonist muscles. • "Stabilizes" the load • Ex: Holding the elbow still at 90˚ in a dumbbell bicep curl

Is it easier to accelerate, stabilize or decelerate a load? While running, is it easier to speed up or slow down? It is easiest to speed up and the most difficulty is found in attempting to slow down. It is also much harder to stabilize a load in space than it is to create movement with a load in most situations. Therefore, eccentric is referred to as the "strongest" muscular action and concentric the "weakest" of the three. Keep in mind that most injuries occur eccentrically as the muscles attempt to control the downward phase or to decelerate load. When running, jumping or lifting, injury often occurs because of an inability to decelerate due to the build-up of forces from the previous acceleration and the acceleration of gravitational or other resistance forces.

Section 2.5
Functional Muscular Anatomy

Section Objectives:

Know the major muscles and their actions in the following regions:

Muscles of the Lower Leg

Muscles of the Thigh (Quadriceps)

Muscles of the Thigh (Hamstrings)

Muscles of the Hip (Gluteal Muscles)

Muscles of the Hip (Hip Flexors)

Muscles of the Hip (Adductor Group)

Muscles of the Hip (Hip Abductors)

Muscles of the Vertebral Column (Deep to Superficial)

Muscles of the Vertebral Column (Posterior Muscles)

Upper Extremity Musculature

Muscles of the Shoulder Girdle

Muscles of the Shoulder Girdle (Rotator Cuff)

Muscles of the Upper Arm

All About Muscles

There are three general types of muscular tissue. These types can be designated by location, appearance, and control. There are three main parts to a muscle:

Origin (or head)

The less moveable attachment

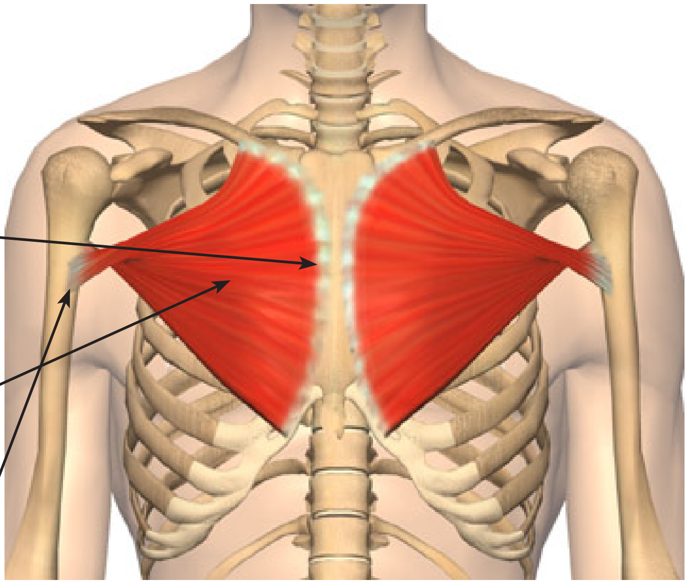
NOTE: there can be more than one origin

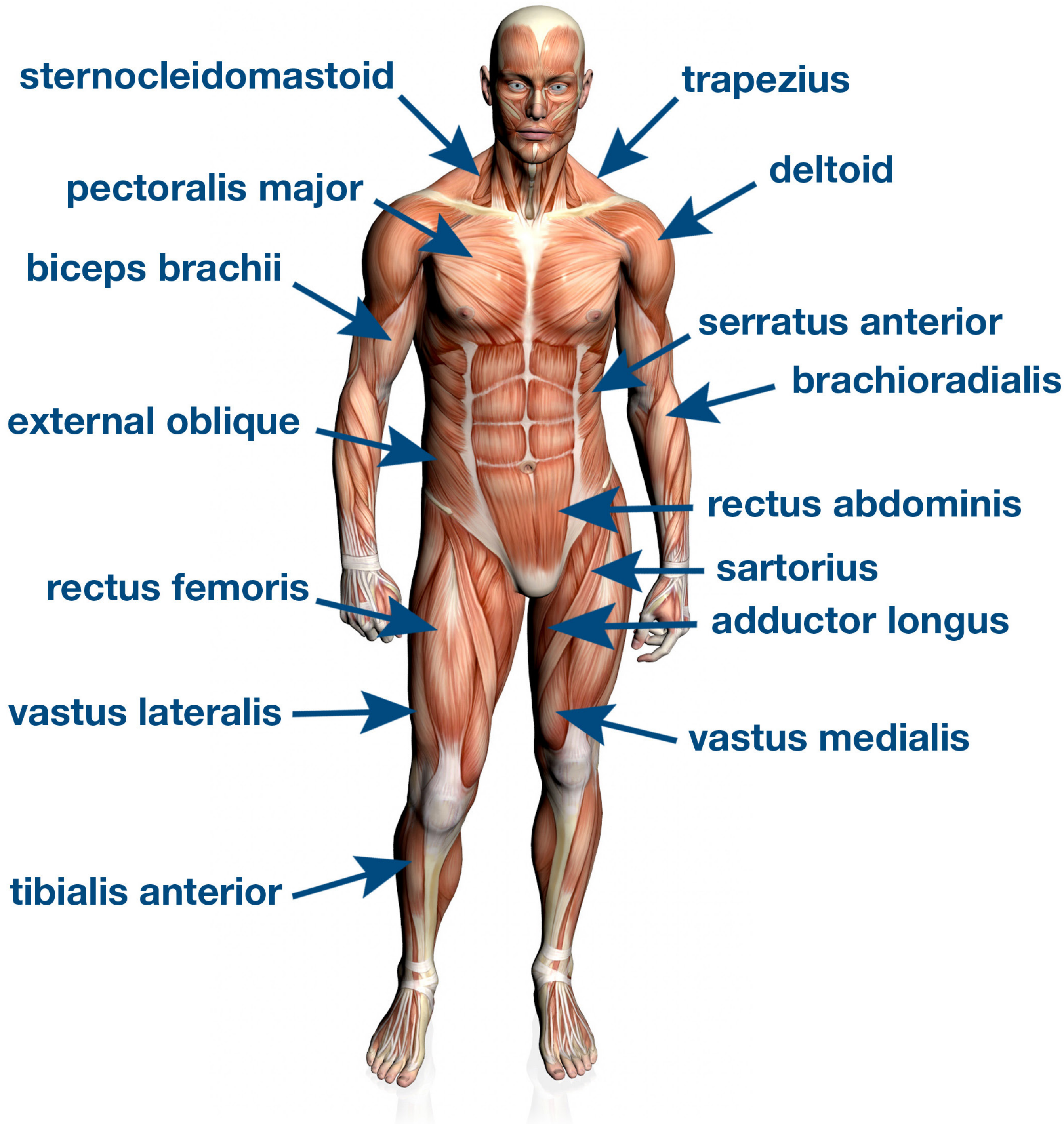
Belly

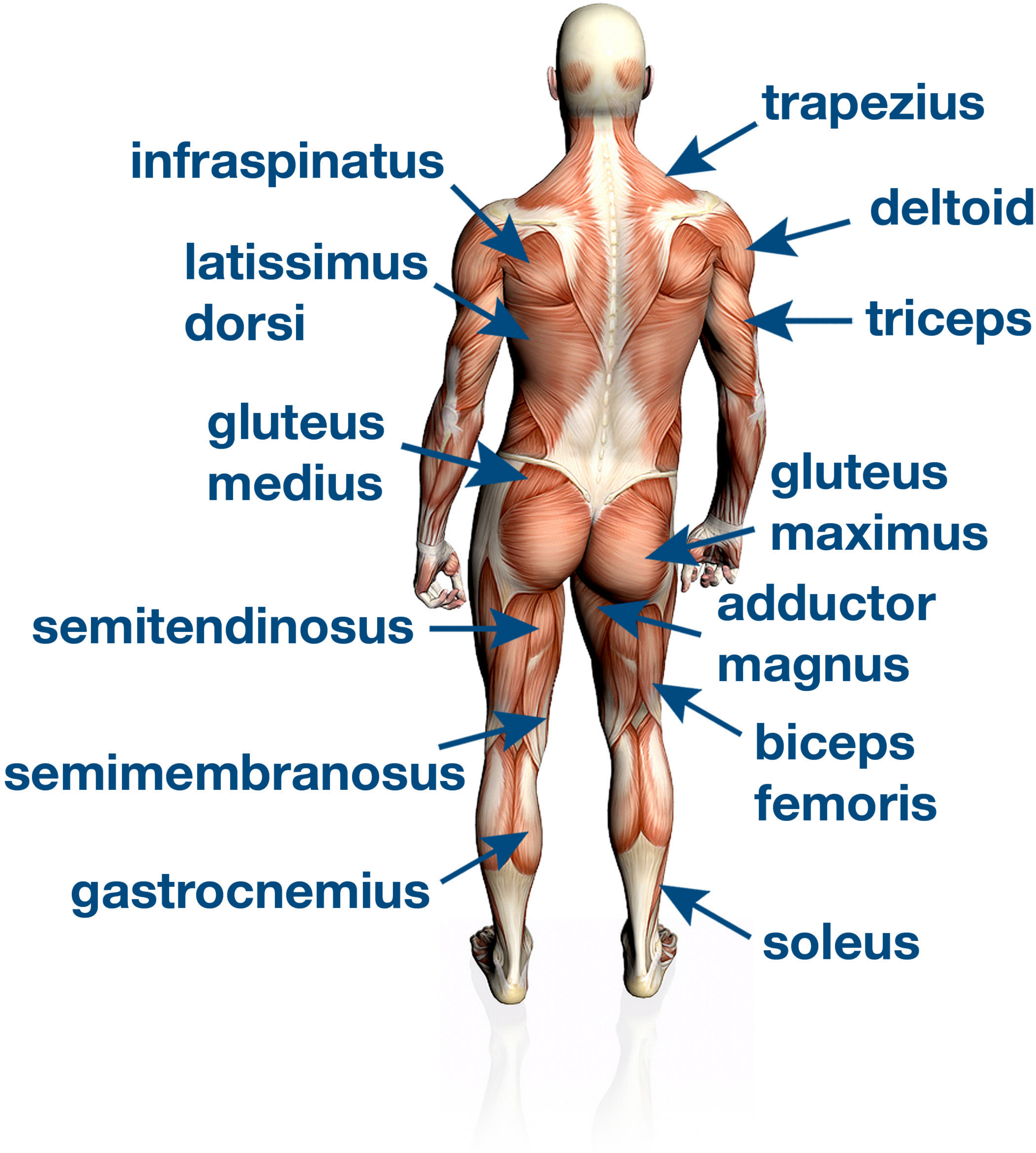
The bulging part of a muscle

Insertion

The moveable attachment

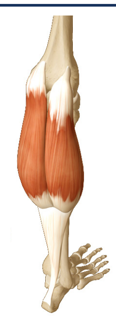



sternocleidomastoid
trapezius
deltoid
pectoralis major
biceps brachii
serratus anterior
brachioradialis
external oblique
rectus abdominis
sartorius
rectus femoris
adductor longus
vastus lateralis
vastus medialis
tibialis anterior


trapezius
infraspinatus
deltoid
latissimus dorsi
triceps
gluteus medius
gluteus maximus
semitendinosus
adductor magnus
biceps femoris
semimembranosus
gastrocnemius
soleus

Below is a list of the major muscles of the human body which are the primary concern of a group exercise instructor. REMEMBER, this is not an all-inclusive list and every fitness professional should have a high-quality anatomy book in their library.

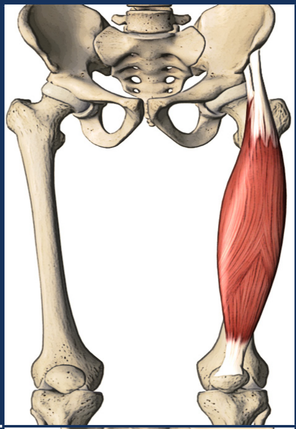
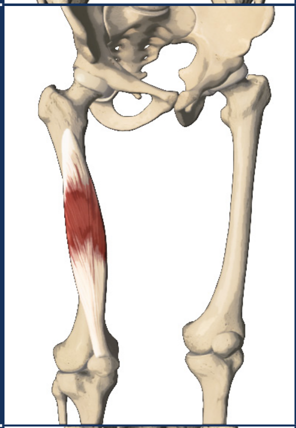
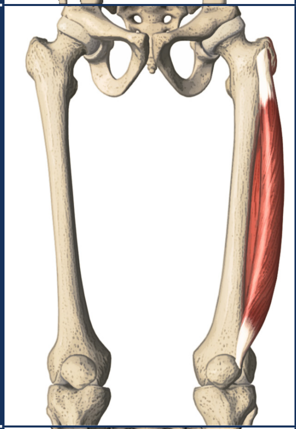
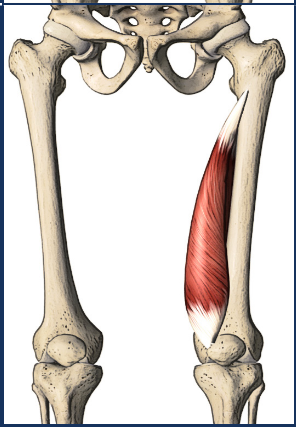
In addition, the primary functions listed are the actions of the muscles when they contract concentrically (shorten under load). REMEMBER, muscles do not just work concentrically to "lift a load!!" Muscles can also act eccentrically to decelerate the opposite motion as well as statically (isometrically) in order to stabilize the joints that they cross over. In other words, when you read the primary functions of each muscle — remember that the muscle will also fire to "lower the load" (the opposite motion) and stabilize motion (or lack of motion).**

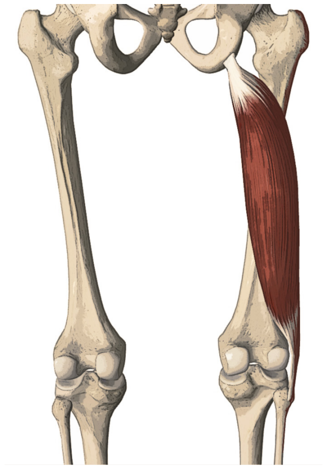
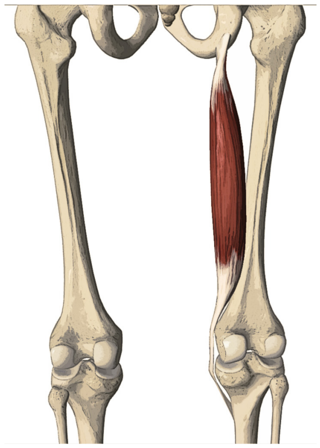
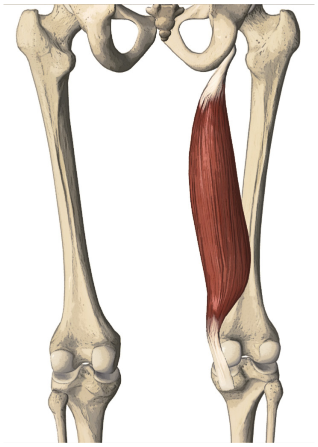
major movers of the lower leg and their primary funcitons		
soleus		plantarflexion
gastrocnemius		plantarflexion and knee flexion
peroneus (fibularis) longus		plantarflexion and eversion
anterior tibialis		dorsiflexion and inversion

Think about it.....

From the previous list, which muscles would be contracting during a calf raise?

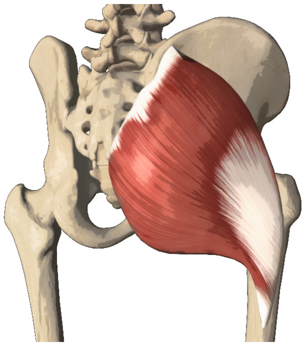
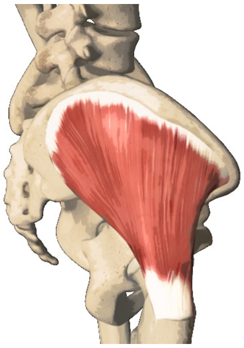
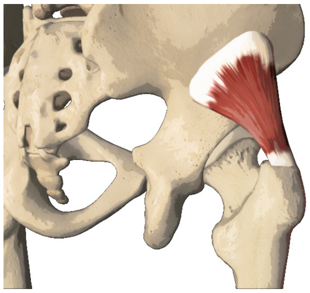
The movement is primarily performed by the gastrocnemius and soleus, with some assistance from the peroneus longus as an assistant mover.

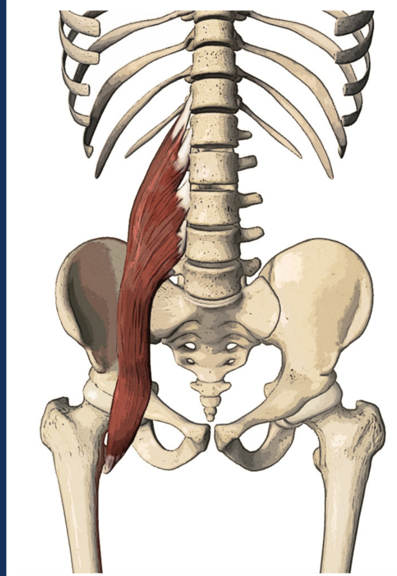
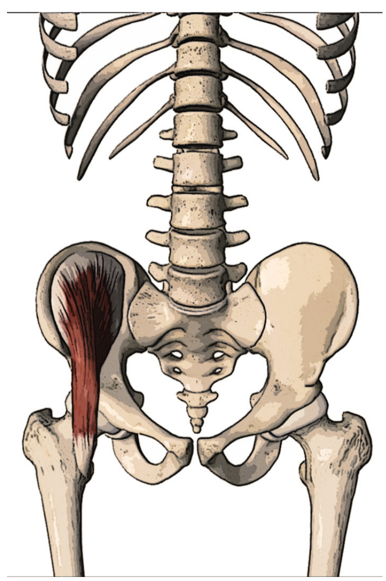
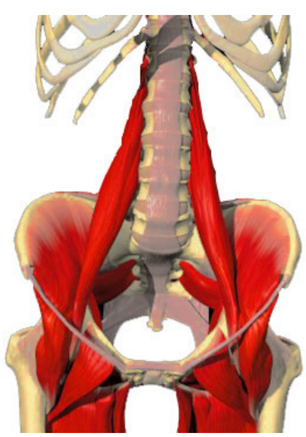
thigh muscles (quadriceps)		
rectus femoris		knee extension, hip flexion
vastus intermedius (deep to rectus femoris)		knee extension
vastus lateralis		knee extension
vastus medialis		knee extension and medial glide of patella

thigh muscles (hamstrings)		
biceps femoris		knee flexion, hip extension and external rotation
semitendinosis		knee flexion, hip extension and internal rotation
semimembranosus		knee flexion, hip extension and internal rotation

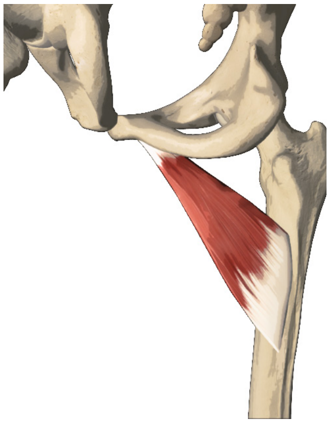
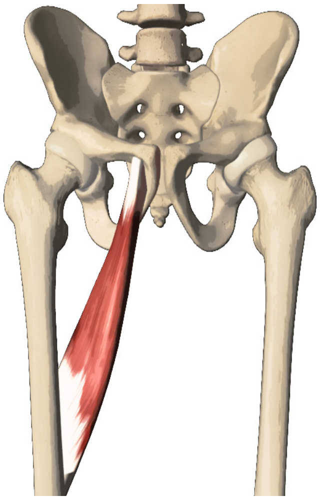
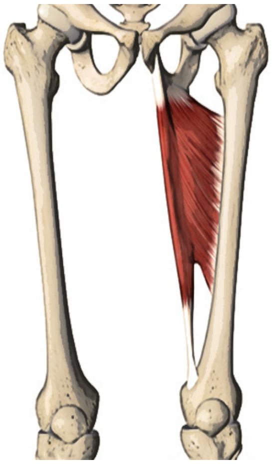
Although muscle groups such as the quadriceps and hamstrings work together to complete the same movement, they also have different actions, independent of each other. While the vastus medialis primarily works to extend the knee, it also has an important role in stabilizing the patella on the medial side, where it attaches. This is why understanding both the origins and insertions of muscles are important, in addition to their actions.

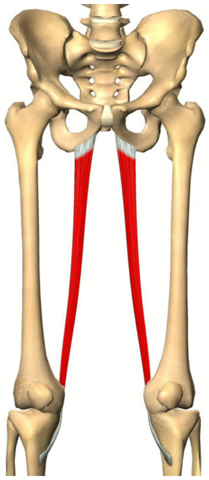
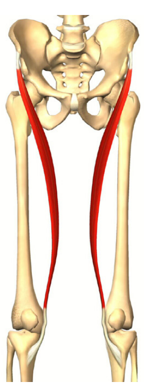
hip muscles (gluteal)

gluteus maximus		external rotation, hip extension upper-half – hip abduction lower-half – hip adduction
gluteus medius		abduction, assists in hip flexion anterior fibers – internal rotation posterior fibers – external rotation
gluteus minimus		abduction, internal rotation and assists in hip flexion

hip muscles (hip flexors)		
psoas major		hip flexion, lumbar flexion, external rotation and slight hip abduction
Iliacus		hip flexion, lumbar flexion and external rotation
		When combined, the Iliacus and Psoas Major are also known as the Iliopsoas.

hip muscles (adductors)

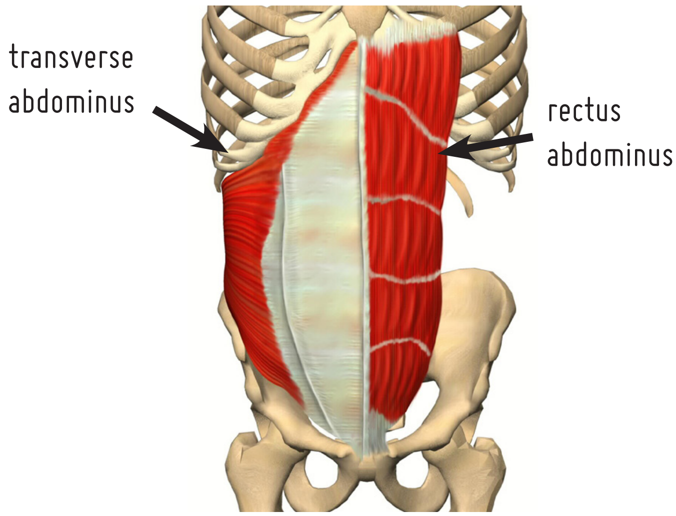
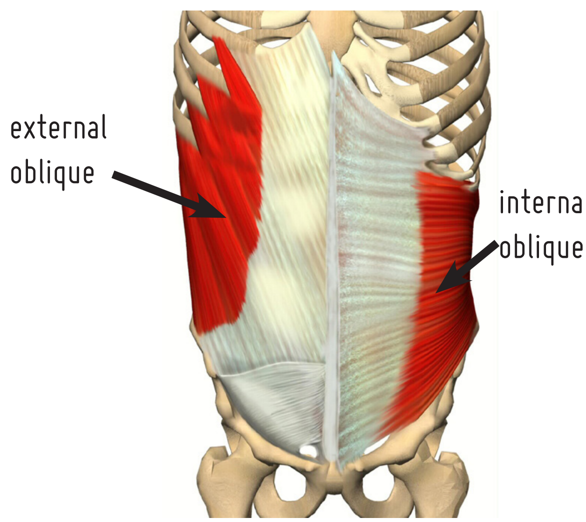
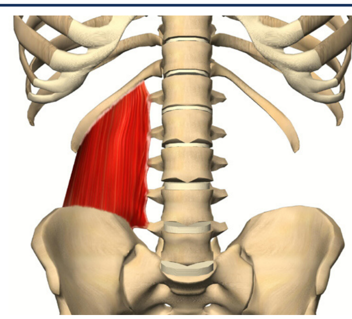
adductor brevis		adduction and hip flexion
adductor longus		adduction and hip flexion
adductor magnus		adduction (some fibers contribute to both internal and external rotation as well as hip flexion and extension)

other hip muscles		
gracilis		hip adduction, internal rotation and knee flexion
tensor fascia latae		hip flexion, abduction, internal rotation
sartorius		hip flexion, abduction, external rotation. knee flexion and internal rotation

Fun Fact: The sartorius is the longest muscle in the human body. It is also known as the "tailor's muscle," for the crossed leg position that a tailor often sits in.

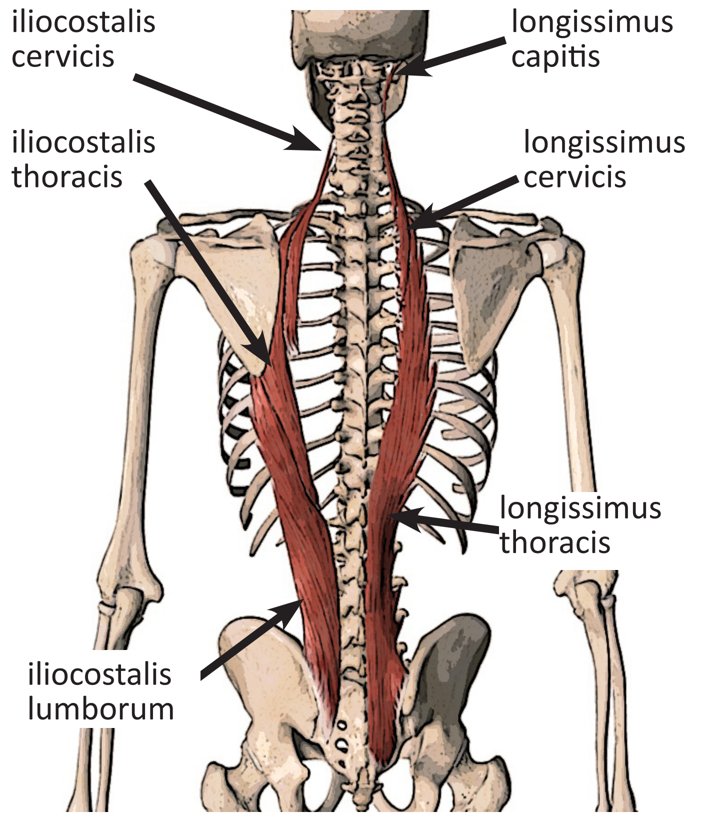
trunk musculature

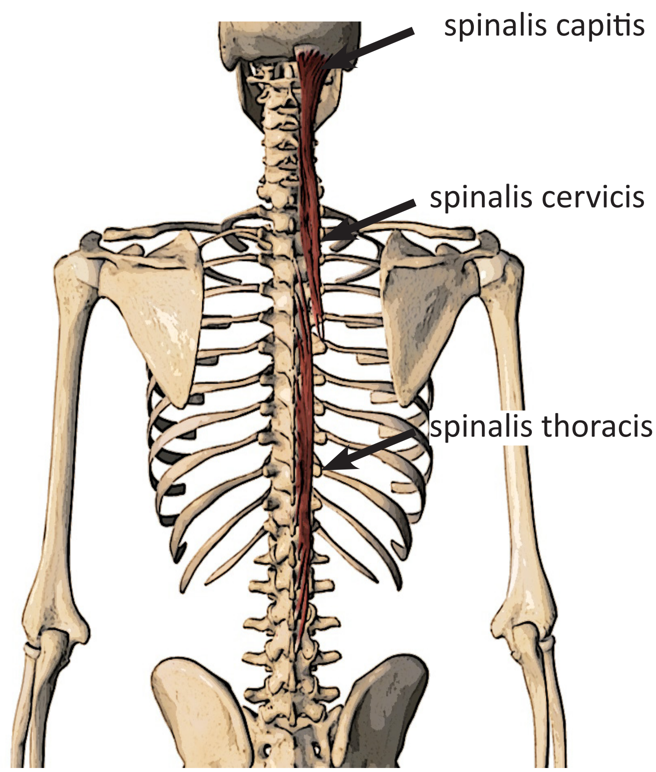
anterior vertebral column muscles

transverse abdominus	forced expiration and increased intra-abdominal pressure (stiffens the trunk to prevent the spine from buckling under compressive loads)	
rectus abdominis	Flexion, posteriorly tilts pelvis and increases intra-abdominal pressure. Although the rectus abdominus is responsible for flexing the "spine," it does not actually attach to the vertebrae. The rectus abdominus attaches to the pubis and sternum.	
internal oblique	flexion, ipsilateral (same side) spinal rotation and increased intra-abdominal pressure Fiber direction - run down and out	
external oblique	flexion, contralateral (opposite side) spinal rotation, tilts pelvis posteriorly and increased intra-abdominal pressure. Fiber direction - think of hands in pockets (i.e. down and in)	
quadratus lumborum	lateral flexion of the vertebral column and laterally tilts pelvis	

posterior vertebral column muscles – erector spinae muscles

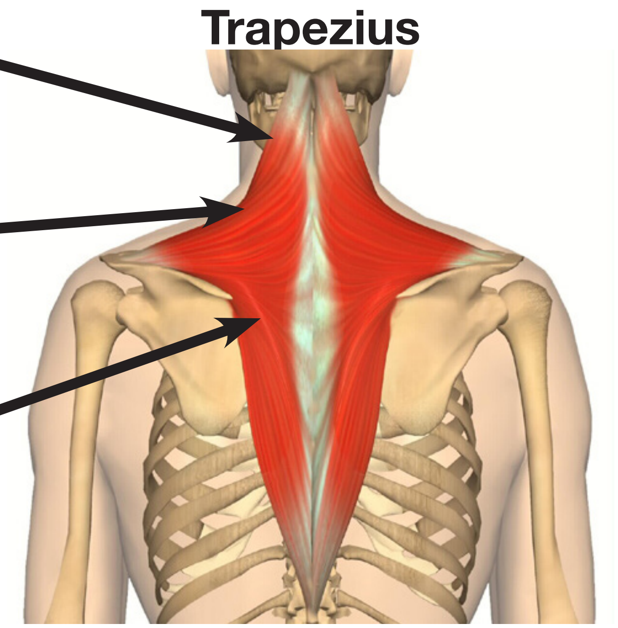
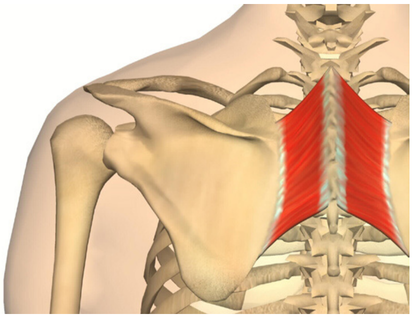
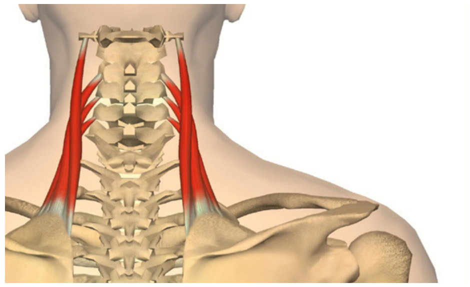
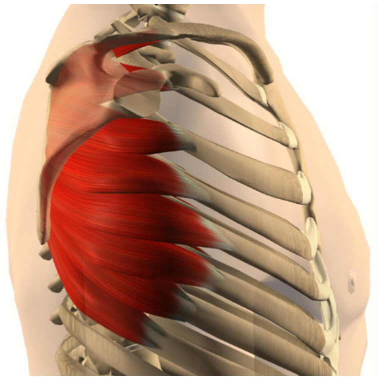
most lateral iliocostalis group (cervicis, thoracis, lumborum)	extend the vertebral column and bend it laterally.
longissimus group (capitis, cervicis, thoracis)	extend the vertebral column and head, rotate head.
most medial spinalis group (capitis,cervicis, thoracis)	extend the vertebral column.



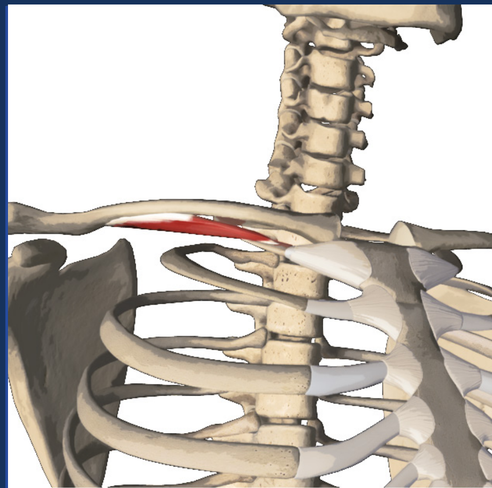
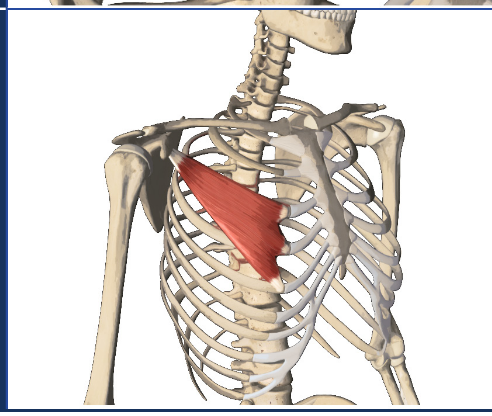


upper extremity musculature

shoulder girdle muscles (i.e. muscles that move the scapula – shoulder blade)

upper fibers	scapular elevation	
middle fibers	scapular retraction	
lower fibers	scapular depression (upward rotation occurs in conjunction with serratus anterior)	
rhomboid major and minor	scapular retraction (adduction) and some elevation	
levator scapulae	downward or medial rotation of the scapula and scapular elevation	
serratus anterior	protraction and upward rotation of the scapula	

shoulder girdle muscles (continued)

subclavius		stabilizes and depresses the shoulder girdle
pectoralis minor		depresses the scapula and pulls it anteriorly

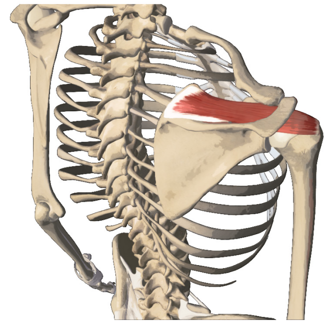
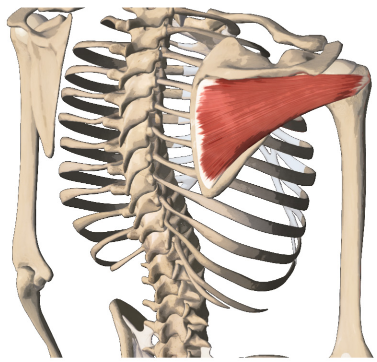
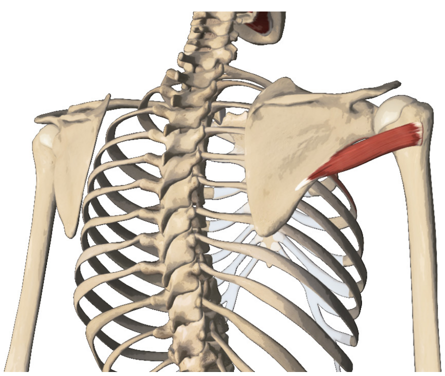
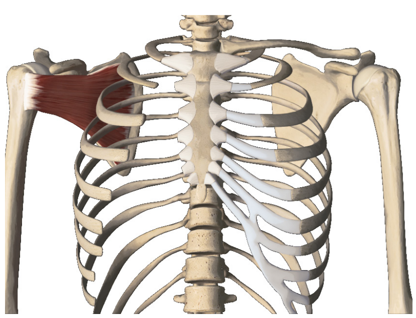
Think about it.....

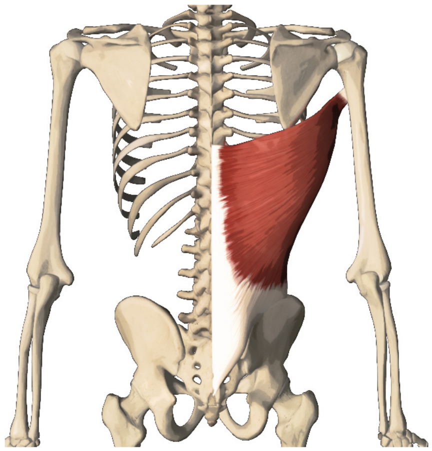
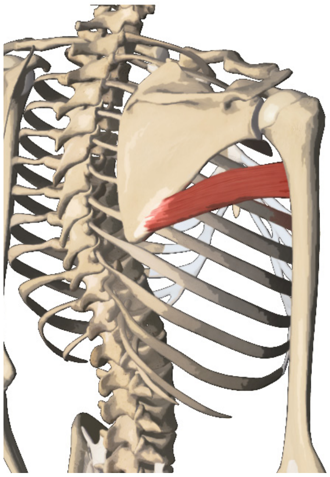
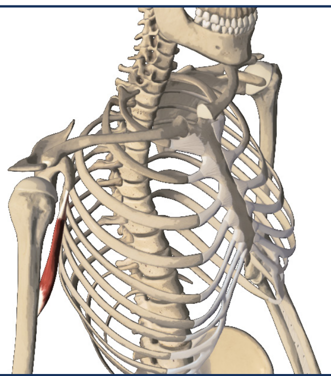
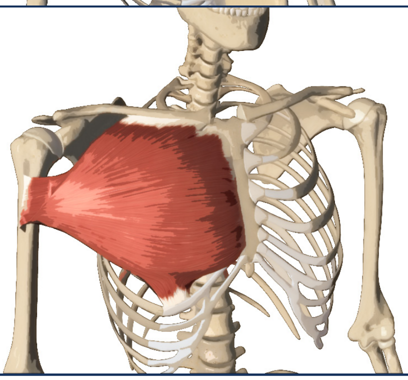
Of the muscles mentioned, which would be be the prime movers during a shrug?

The prime mover of the shrug is the upper fibers of the trapezius.

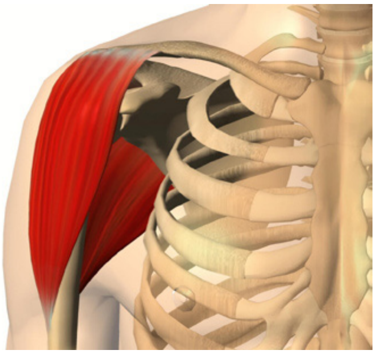
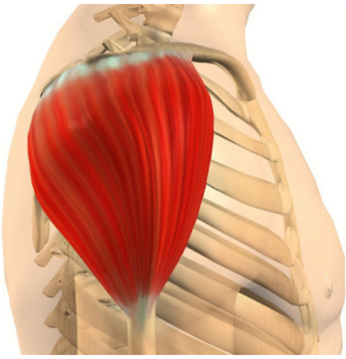
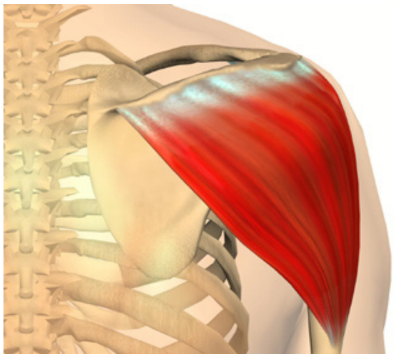
deep muscles of the shoulder joint – the rotator cuff

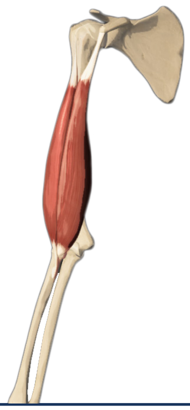
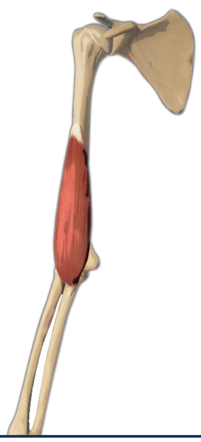
these muscles work together to maintain integrity and alignment of the glenohumeral joint

supraspinatus		Stability of the shoulder joint during swimming and throwing movements. Some abduction/external rotation.
infraspinatus		External rotation of the humerus. In extension, helps move the humerus posteriorly.
teres minor		External rotation of the humerus. In extension, it helps move the humerus posteriorly.
subscapularis		Internal rotation of the humerus. In extension it helps move the humerus posteriorly. In adduction, it helps move the arm toward the body.

shoulder musculature		
latissimus dorsi		extends, adducts, and internally rotates the humerus
teres major		extends, adducts, and internally rotates the humerus
coracobrachialis		flexes and adducts the arm
pectoralis major		Flexion, adduction, internal rotation, horizontal adduction of the shoulder.

muscles of the shoulder joint continued – the deltoid

anterior fibers		Flexion and internal rotation of the humerus. Horizontal adduction.
lateral fibers		abduction
posterior fibers		Extension and external rotation of the humerus. Horizontal abduction.

upper arm muscles		
biceps brachii		Elbow flexion and supination of the forearm.
brachialis		Elbow flexion
triceps brachii		Extension of the elbow. Long head extends the shoulder.

Section 2.6
Introduction to Exercise Physiology

Exercise physiology is the study of the cellular reactions within the body during and after exercise. Observe the pictures below. Why do these individuals' bodies look so different? Other than genetics, each of their bodies has adapted differently to the stimuli (exercise) placed upon them. The bodybuilder has greater lean body mass than the swimmer or the yoga instructor. The swimmer may have a larger VO_2MAX than the bodybuilder and the yoga instructor is probably the most flexible. Each individual has undergone adaptive changes to their body based on the activity they perform. This is exercise physiology in action. In other words, we can look at exercise physiology as the sum total of all human physiological responses and adaptations to physical activity.

Section Objectives:

Be able to describe the GAS Theory and how it relates to exercise adaptations.

Be able to articulate the importance of proper exercise recovery in relation to exercise stress.

Be able to describe in simple terms what is necessary for "optimal training" at the physiological level.

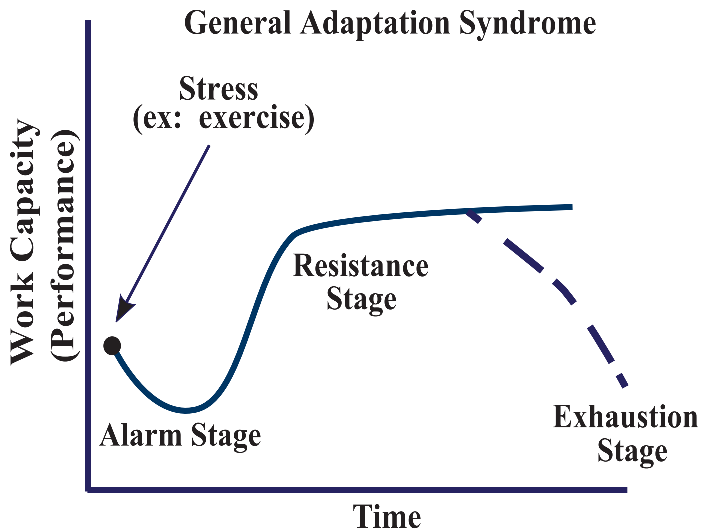
How Does the Body Adapt to Exercise?

The human body is an amazing machine that is able to adapt to the stress that is placed upon it. The process of adaptation due to stress is known as General Adaptation Syndrome (GAS). The body first reacts to stress by entering the Alarm Stage – the "flight or fight" stage where the body prepares for physical activity. Next is the Resistance Stage, where the body attempts to adapt in order to cope with the stress. Lastly, if the stress persists, the body's resources are depleted, and the body enters the Exhaustion Phase.

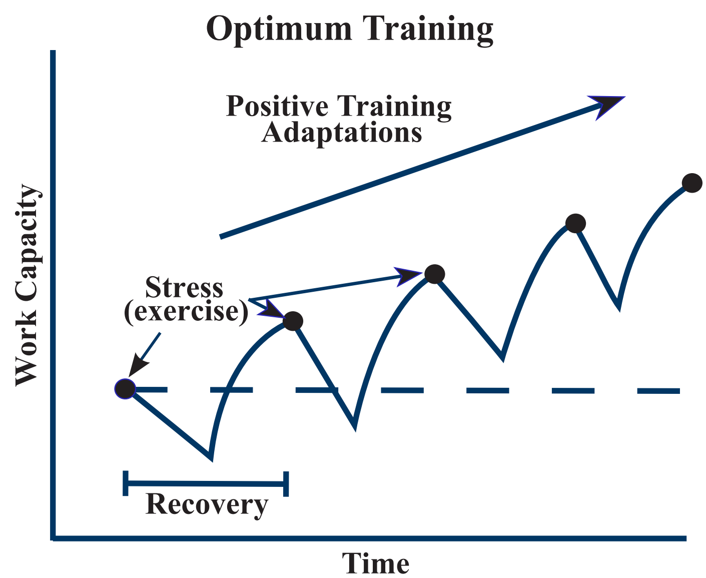
These physiological adaptations are the premise of exercise.

Too much of any type of stress can be detrimental to one's health (even too much exercise!). Prioritizing events in one's busy life can be challenging, which can be stressful itself. Identifying those good stressors (eustress) such as implementing a properly planned exercise program may decrease bad stressors (distress) and improve our quality of health.

When a stress (exercise) causes the body to increase effort more than it is normally accustomed, the body has been put into a situation of "Overload". Overload will temporarily decrease the body's ability to do work (Work Capacity). After the body has had enough time to recover from the original bout of exercise, its work capacity increases to a level greater than the original. Please look at the figure below labeled "Optimum Training" and you can see that not only is the proper form of overload (stress/exercise) important, but also the proper amount of time between training – Recovery.



The GAS Theory – how the body adapts to stress



The GAS Theory applied to the stress of exercise (when appropriately applied)

Think about it.....

Now that you've learned the GAS Theory and how the body adapts to stress, what factors would determine optimal training versus overtraining?

Optimizing both the quality and quantity of exercise stress (e.g. frequency, intensity, time under tension, type of exercise, technique, etc.) AND the quality and quantity of recovery (e.g. rest between workouts, nutrition, sleep, stress, etc.).

Section 2.7 Metabolism & Energy Systems

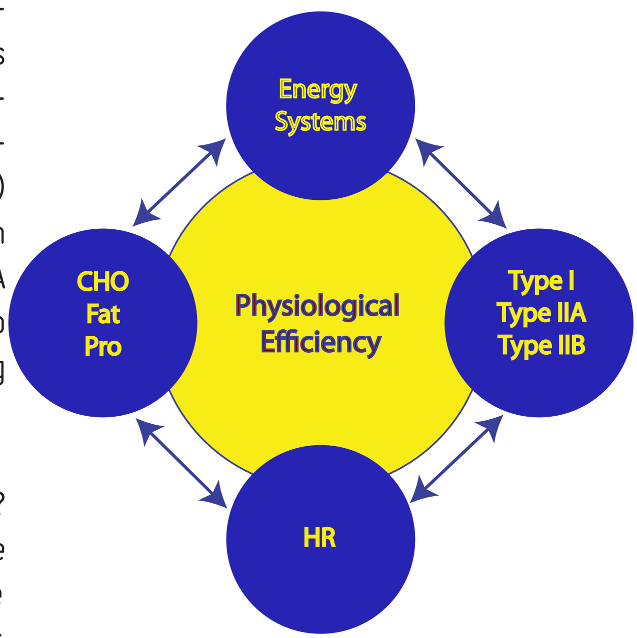
Section Objectives:

Be able to describe the importance of ATP and the three energy systems which supply ATP to all cells.

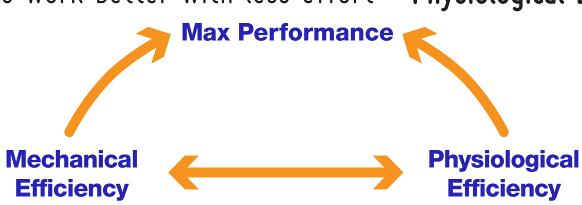
Be able to differentiate between aerobic and anaerobic energy systems.

Be able to describe how intensity and duration of exercise determine the dominate energy system.

The following pages explain how the body obtains and utilizes energy. Why is this important to a group exercise instructor? All movement and performance comes down to energy. By understanding how the body utilizes energy, we can better understand the fuel sources (carbohydrates, fats, or proteins) utilized during training, which muscle fiber types (Type I, IIA or IIB) are involved, and how to monitor energy systems using heart rate measurement.



What are Energy Systems? While not considered one of the eleven bodily systems, these are the processes that the cells of the body use to convert the chemical energy we get from food to a form chemical energy they body can use (**ATP**). By understanding how we utilize energy (ATP), we will better understand the how to make the body's systems work better with less effort – **Physiological Efficiency.**



Energy

Energy is required by all cells to perform work. Cells have the capacity to convert food (carbohydrates, proteins, and fats) into usable energy. All cells must have a constant supply of energy or work will cease. If a muscle cell doesn't have adequate energy supply (the mechanical energy necessary to perform movement), there won't be any muscular contractions. Work is one form of energy, known as mechanical energy.

In order to achieve a constant energy supply, muscle cells are constantly breaking down molecules into usable forms of energy and utilizing the energy released from these chemical reactions to build and repair tissue. **Catabolism** is the breakdown of molecules and **anabolism** is the synthesis of molecules. Anabolic reactions utilize the energy created from the breakdown of molecules in catabolic reactions for the building process. Both reactions are normal and necessary, but if catabolic reactions are so substantial that repair and synthesis from anabolic reactions cannot occur, injury and illness/disease occur. This is what happens when training is too intense or the right nutrients or rest/recovery is not achieved (overtraining).

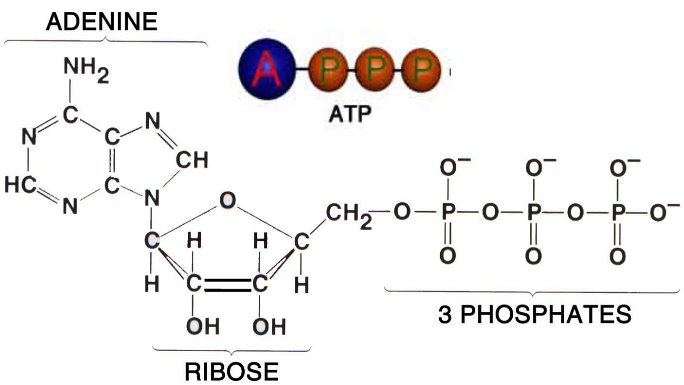
Energy transfer (since energy cannot be created, merely transferred or transformed) occurs when energy is released from the chemical bonds of molecules (food molecules in this case). The process of removing an electron from a molecule is called **oxidation** (which will often include the addition of oxygen to a substance). The speed of cellular chemical reactions such as oxidation is regulated by catalysts called enzymes (cell proteins which are crucial to the metabolic process).

What is a calorie?

There are a variety of ways to express energy. However, the most common measurement in the system, used in the United States, is the calorie. Everyone knows that food contains calories, but few know how to define a calorie. A calorie is a measure of heat. It is the amount of heat needed to raise the temperature of one gram of water one degree Celsius. A calorie is such a small unit of energy, it is often referred to as a kilocalorie (which is equal to 1,000 small calories because kilo = 1000) and is commonly abbreviated "kcal". The "calories" on food labels are actually kilocalories.

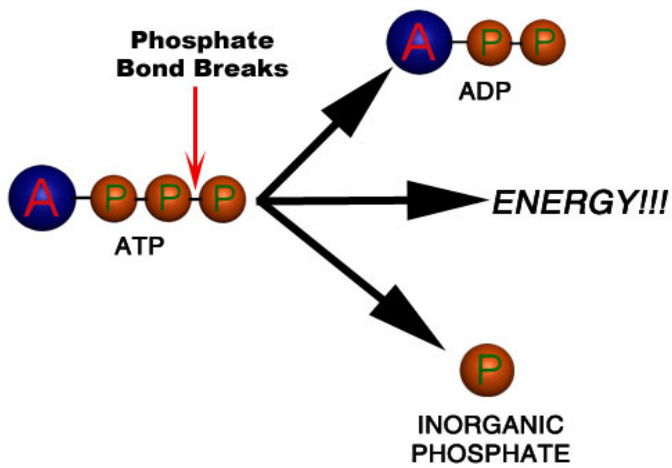
Adenosine Triphosphate

The source of energy for our cells, including the energy needed for muscular contraction, is adenosine triphosphate (ATP). Without sufficient amounts of ATP most cells die quickly. ATP is formed when adenosine diphosphate (ADP) and an inorganic phosphate are combined. This process of combining these phosphates requires a large amount of energy. For this reason, approximately 60% of the energy from food is converted to thermal energy during the process of ATP formation and only about 40% of the actual energy from food is converted to ATP.



ATP is the muscle's primary energy source, just as gasoline is the energy source for an automobile. How quickly and efficiently a muscle cell produces ATP will be a determining factor of how much work the cell can perform before it fatigues.

While there is some ATP stored within a muscle cell, the supply is limited (enough for 2-4 seconds of muscle action). Therefore, muscle cells must be able to produce more ATP in order to continue working. Energy is released when an ATP molecule is broken into an ADP molecule and an inorganic phosphate.



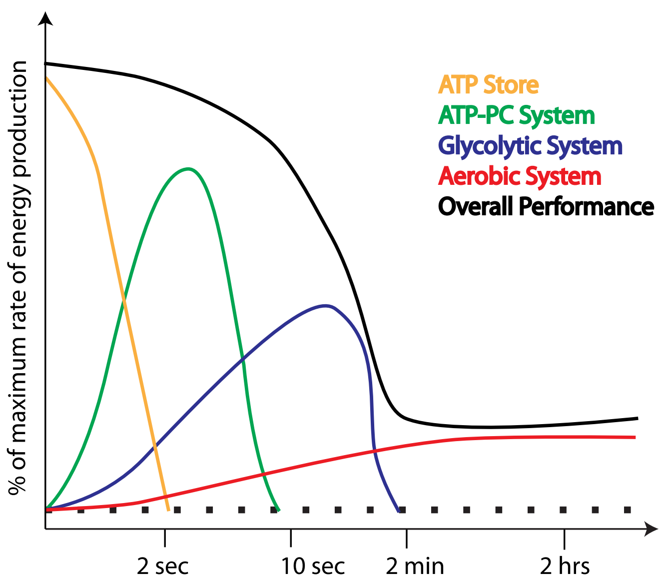
Hydrolyzation of ATP

Since muscle cells can only store a limited supply of ATP, and they require a constant supply of ATP to function, various metabolic pathways must exist to produce ATP quickly or cell death, not just poor functioning, will occur. ATP must be regenerated by reactions that add the phosphate back to ADP (the reverse reaction of the image above). Muscle cells replenish the ATP supply using three distinct biochemical pathways. ATP in muscle cells can be formed through a combination of phosphocreatine (PCr) breakdown, glycolysis (glucose or glycogen breakdown), and oxidative phosphorylation (which is inherently aerobic as the oxidation process requires oxygen).

Anaerobic processes do not require oxygen for reactions while aerobic processes utilize oxygen in the processes of breakdown and synthesis. All anaerobic processes occur in the sarcoplasm (the cytoplasm/cell fluid of the muscle cell). All aerobic processes (utilizing the oxidative/aerobic energy system/metabolic pathway) occur in the mitochondria of muscle cells. The **intensity** and **duration** of activity will determine which energy system/metabolic pathway is dominant at any particular time.

Aerobic and Anaerobic Energy Systems

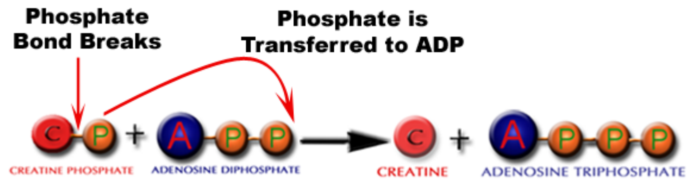
When muscles need energy, ATP is **hydrolyzed** (broken down with H_2O) rather quickly to provide the needed energy, and ADP and inorganic phosphate (P_i) are produced. In order to continue to supply muscles with energy, ATP must be reformed by combining ADP and P_i. The following sections explain the various systems whereby the body regenerates ATP. ALL of these systems are working in the body at ALL times. It is important for the group exercise instructor to understand which system is dominant at a particular time.



The aerobic energy system for producing ATP is dominant when adequate oxygen is delivered to the cell to meet energy production needs, such as when the muscle is at rest. However, as work by the body increases (such as during exercise), oxygen cannot be delivered quickly enough to the working muscles. The muscles must then rely on other processes which do not require oxygen (anaerobic) to gain their ATP (energy).

Anaerobic Pathway I: ATP/PCr System (a.k.a. "Phosphagen System")

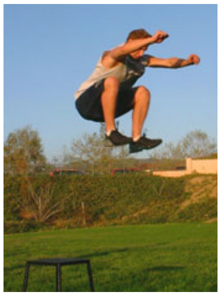
The first anaerobic ("without oxygen") source of ATP is known as *Phosphocreatine* (PCr, also known as Creatine Phosphate). Phosphocreatine functions as a site of storage of high energy phosphates in muscle (the amount of PCr is proportional to the muscle mass). PCr itself cannot be used as an immediate source of energy, but can rapidly replenish ATP.



ATP stored in the muscle is the primary provider of energy for muscular contraction at the onset of exercise (for less than 5 seconds) and during short-term, high intensity exercise (for less than 5 seconds at maximal intensities of effort). Like ATP, only a small supply of PCr is stored within muscle cells (approximately 80-100 grams of ATP can be stored at one time with concentrations of PCr being about 4-6 times greater). PCr stores can supply energy at near maximal intensities of effort for up to about 8 seconds. After about 8 seconds of maximal to near maximal effort, the ATP-PCr energy production system is no longer the dominant energy system.

This process does not involve oxygen so the ATP-PCr energy system provides an anaerobic energy supply. Once PCr stores are depleted (ATP cannot be completely depleted or the cell(s) would die), the reformation of PCr requires ATP and can only occur during rest.

Approximately 70% of ATP is reformed after 45-60 seconds of complete rest from high intensity activity and 100% of ATP is reformed after 2-3 minutes of complete rest. The greater the effort that is required, the more rest is needed between efforts in order to allow time for the reformation of ATP and PCr within muscle cells.

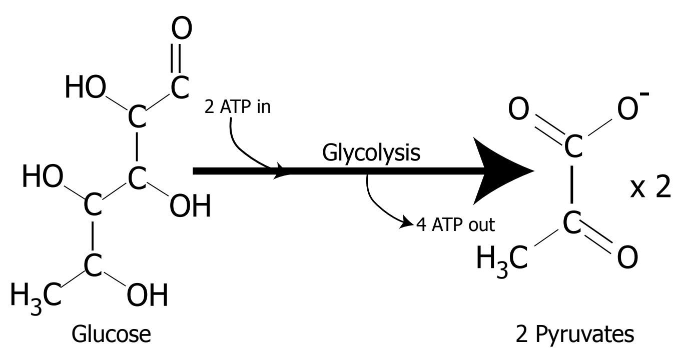


As an example, PCr provides much of the energy for a 100m sprint or nearly all of the energy during a single explosive jump or burst of speed. The ability to perform repeated exercises or movements at near maximal effort is largely dependent on PCr stores. For some clients, enhancing PCr stores through creatine monohydrate supplementation can increase the amount of work that can be performed in repeated efforts at high intensity.

Beyond the first few seconds of near maximal exertion or after the first few seconds of activity, the phosphagen and glycolysis energy systems share in the energy production process (between 6-45 seconds of intense exertion).

Anaerobic Pathway II: Glycolysis

The second metabolic pathway is known as *glycolysis* (glyco = "relating to sugar"; lysis = "breakdown"). Glycolysis is anaerobic and hence is capable of producing ATP quickly without oxygen. Glycolysis involves the breakdown of glucose (a sugar, specifically a monosaccharide) or glycogen (polysaccharide) in a multi-step process into pyruvate. Pyruvate can then either be converted to lactate for more immediate energy usage at higher intensities or be transferred into the mitochondria of the cell during lower intensities of exercise.



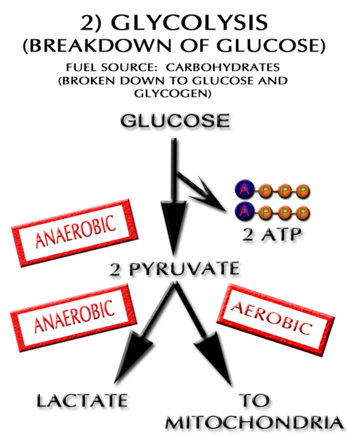
Summary of Glycolysis

The process of glycolysis actually requires ATP (2 molecules) in order to complete the transfer of energy from glucose to rejoin an inorganic phosphate with ADP and results in more ATP (with a net gain of two more ATP if the conversion involves the simple sugar glucose and three ATP if it involves the starch glycogen) being made available for use.

Glycolysis is the primary provider of energy for muscular contraction during moderately high intensities of effort and moderate duration (from about 45 seconds to about 2 minutes) efforts. The glycolytic energy system becomes involved at about 9-10 seconds into an exercise and will actually have some involvement in energy production until about 10 minutes of exercise duration has elapsed. This is the predominant energy system involved during most strength training workouts, as most sets will last between the 45 seconds to 2 minute time frame.

Glycolysis is sometimes referred to as anaerobic (fast glycolysis) and aerobic (slow glycolysis) to differentiate the fast resynthesis of ATP when pyruvate is converted to lactate (anaerobic or fast glycolysis) from the slow conversion when pyruvate is shuttled into the mitochondria of the cell before undergoing the Krebs Cycle (aerobic glycolysis). However, as glycolysis does not involve oxygen, these terms are not practical for describing the process.

Lactate Threshold and the Onset of Blood Lactate Accumulation during Glycolysis



As the level of intensity of exercise increases, the body reaches a point where the level of oxygen within the cell's mitochondria is not sufficient. Since there is not enough available oxygen, the pyruvate produced by glycolysis cannot be oxidized. Furthermore, since energy production must continue, ATP production from glycolysis must increase.

For glycolysis to continue to produce ATP, certain compounds that were "used up" (i.e. reduced) in glycolysis must be regenerated (i.e. oxidized) so that the process can continue. For this to happen the excess pyruvate is reduced to lactate. Lactate production begins to occur at a rapidly increasing rate (due to maintaining a high level of intensity for either seconds or minutes, depending on conditioning). This point is known as the Lactate Threshold (LT). Note: this is also often referred to as the

Anaerobic Threshold (AT). The only essential difference between the lactate and anaerobic threshold is that the lactate threshold is measured through blood concentrations of lactate and the anaerobic threshold is measured by a ventilatory (gas exchange) test.

Lactate accumulation in the blood is a signal that there is not enough oxygen getting to the working muscles (i.e. "going anaerobic"). During energy production, there are several reactions that cause a release of a hydrogen ion (H+). This causes a decrease in blood pH (i.e. making the blood more acidic). Without going into detailed biochemistry, when the body is "aerobic" it uses buffering capabilities so that the pH of the blood does not go down. However, when there is not enough oxygen being supplied to the working muscles, muscle acidosis can begin. The "burning" sensation in muscles is attributed to this muscle acidosis and **correlates** to the accumulation of lactate. The point where so much lactate accumulates that exercise intensity is forcibly decreased (due to muscle acidosis induced fatigue) is known as the Onset of Blood Lactate Accumulation (OBLA).

Why is this important? These values (LT, AT, OBLA) attempt to find the point where an athlete will "redline". The athlete who can delay acidosis the longest typically wins the race. High lactate values increase injury risk due to the disturbance of coordination capacity because the affected muscle(s) is (are) unable to sufficiently contract.

At rest, it takes about 25 minutes to remove 50% of the accumulated lactate and muscle acid, and about 75 minutes to remove 95% of the buildup. Lactate will either be converted back to glucose in the liver at rest (gluconeogenesis), excreted in urine or metabolized for fuel by other organs (brain, heart or other muscles).

If sufficient rest/recovery between intense workouts is not achieved there may be severe damage to muscle cells. This damage may take days or weeks for full repair, which results in lost performance and training time. More benefits of understanding both AT and LT are described later in this chapter.

Aerobic Pathway: Aerobic Glycolysis and Oxidative Phosphorylation

Most cells, including muscle cells, contain structures called mitochondria. The mitochondria are the sites of cellular aerobic energy production (also known as cellular respiration, aerobic oxidation and oxidative phosphorylation). Larger numbers of mitochondria in a cell lead to a greater capability for aerobic energy production. Therefore, cells with larger numbers of mitochondria have a greater aerobic capacity and are more resistant to fatigue.

The third pathway for producing ATP involves oxygen. This oxidative phosphorylation (utilizing oxidation and adding a phosphate) or aerobic metabolic pathway utilizes both the Krebs cycle and the electron transport chain.

The Krebs cycle involves a series of chemical reactions to help convert macronutrients (carbohydrates, proteins, and fats) into usable energy (ATP). Oxygen is not involved

Think about it...

So, whatever happened to lactic acid? Science used to attribute the "burning" in muscles to lactic acid. When working at high intensities, scientists saw that there was an accumulation of lactate and hydrogen ions (causing muscle acidosis). The theory was that pyruvate was reduced to lactic acid (not lactate) and that as soon as is it released in the blood, it separates into lactate and H+ (hydrogen) molecules. We now know that lactate does NOT CAUSE muscle acidosis, but the onset of lactate CORRELATES to acidosis.

So how does this fact affect training? Not much. We can still use the lactate threshold to determine when an individual is going "anaerobic" and starting to "redline".

in the Krebs cycle but it is involved at the end of the electron transport chain (a chain of molecules involved in the aerobic production of ATP). The Krebs cycle removes hydrogen molecules from the ingested macronutrients so that these hydrogen molecules can be used to complete the electron transport chain along with oxygen, an inorganic phosphate, and ADP to form ATP. This process will form a net gain of two more ATP molecules to be used for energy (the process also involves two carrier molecules known as NAD and FAD which transport the hydrogen molecules). During the activation of the electron transport chain in the aerobic production of ATP free radicals are formed.

Free radicals are molecules that now have an unpaired electron as a result of the oxidative phosphorylation or from the aerobic production of ATP. Free radicals are highly volatile and reactive and will bind quickly to other molecules and damage the cells they contact. The number of free radicals produced is directly linked to the rate of aerobic metabolism (which is dependent upon the conditioning level of the individual combined with the current exercise intensity and duration).

The breakdown of fat to yield ATP is known as **lipolysis**. Fat is the most abundant energy source available to the muscle, and the predominant energy source used during the aerobic oxidation phase of energy production. Although there is a virtually unlimited supply of fatty acids in humans, the rate at which the body can metabolize them is the limiting factor in obtaining ATP.

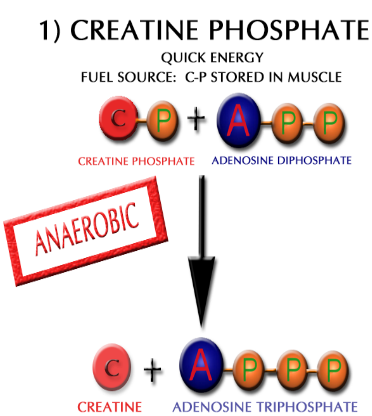
Lipolysis is the primary source for energy production during rest and low level activity. But, its input to the overall muscular energy supply will decrease as the intensity of muscular contraction increases. When lipolysis is unable to meet the increasing energy requirement of exercise (it is too slow to supply enough energy), stored glycogen from both the liver and muscles is used. Once glycogen depletion occurs, exercise intensity will decline.

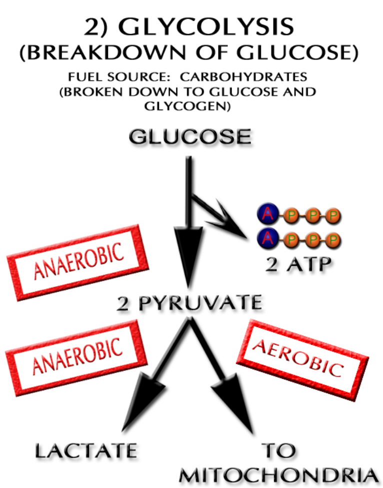
All exercise intensities (including rest or no activity) that can be maintained for 2 minutes or longer utilizes the oxidative system for energy production. Once approximately 10 minutes of continuous exercise has elapsed, glycolysis is no longer significantly involved in energy production and the oxidative energy system supplies almost all cellular energy for the muscles.

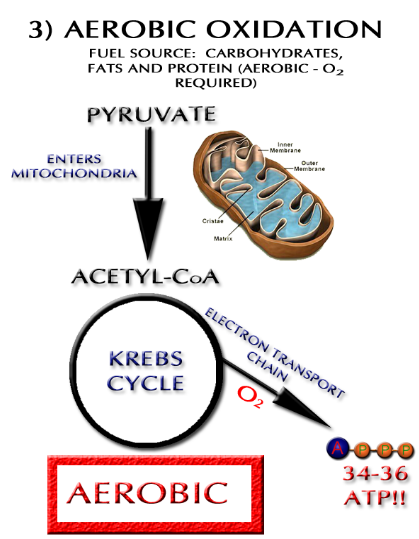
Energy Supply During Varying Intensities and Durations of Muscular Activity

Activity Duration	Aerobic or Anaerobic?	Primary Energy Supply	Secondary Energy Supply	Intensity of Effort (Approximated)
1-5 seconds	Anaerobic	ATP	N/A	Maximal
6-8 seconds	Anaerobic	PCr	ATP	Near Maximal
9-45 seconds	Anaerobic	Glycolysis	ATP, CP	High
45-120 seconds	Anaerobic	Glycolysis	N/A	Moderately High
2-4 minutes	Anaerobic + Aerobic	Aerobic Oxidation	Glycolysis	Moderate
4 minutes and beyond	Aerobic	Aerobic Oxidation	N/A	Moderate to Low

* Note: N/A refers to dominance of the primary energy system (other systems are always involved to a lesser degree at all intensities and durations of muscular activity)







Section 2.8 The Cardiovascular System

Section Objectives:

Be able to describe the roles of the cardiovascular system and how it adapts to exercise.

Know the various components of the cardiovascular system.

Be able to describe how and why to monitor heart rate during exercise.

The cardiovascular (CV) system has many roles in the support of other bodily systems as it transports respiratory gases, nutrients, and wastes to and from cells. It also maintains body temperature, prevents dehydration and infection.

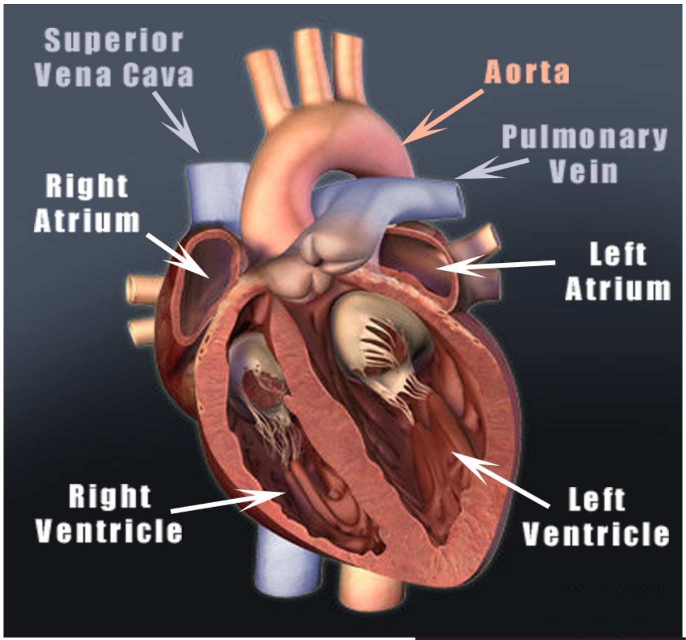
Primary Roles of the CV System	*Example*
Delivery	O_2 and nutrients
Removal	CO_2 and wastes
Transport	Hormones
Maintenance	Body temperature
Prevention	Infection

The components of the cardiovascular system include **blood**, **blood vessels**, and a muscular four-chambered **heart**. These chambers are the right and left **atria (atrium)**, and right and left **ventricles**.

The Heart

The heart is the driving force of the circulatory system (the blood and lymph distribution network) and it functions two separate pumping organs. The right side performs pulmonary circulation (blood flow from the body to the lungs) and the left side performs systemic circulation (blood flow from the lungs to the body). The right side of the heart pumps deoxygenated blood into the lungs through the pulmonary arteries from the right ventricle, and oxygenated blood returns to the left atrium through pulmonary veins to the heart. Oxygenated blood is then pumped into the aorta, which branches out into the arterial system, to the arterioles and then to the microscopic capillaries. The capillaries come into direct contact with cells of the body for exchange of gases, nutrients, and waste. Capillaries then converge into venules, then into the larger veins to reverse the process. Venous return is the process of bringing deoxygenated blood back to the right atrium of the heart (from the lower body through the inferior vena cava and from the head and neck through the superior vena cava). The heart muscle itself is oxygenated by the coronary arteries, and deoxygenated blood returns to the right atrium through the coronary veins and the coronary sinus.

The atria of the human heart are thin-walled, and ventricles are muscular (the left side more than the right side because it powers systemic circulation). The heart also has two distinct valve systems. The atrioventricular valves are located between the atria and the ventricles to prevent backflow. The right side is the tricuspid valve and the left side is the mitral/bicuspid valve. The semilunar valves (the aortic valve and the pulmonary valve) each have three cusps and are located in the aorta and pulmonary artery, again, to preventing backflow into the heart.



Courtesy of 3DScience.com

There are two alternating ventricular phases which make up the heartbeat. The systolic phase is cardiac muscle contraction, whereby the ventricles contract, pushing blood away from the heart (1st part of heartbeat). The diastolic phase is cardiac muscle relaxation. When performing a blood pressure reading, this is a measure of the pressure on the arterial walls during ventricular filling (2nd part of heartbeat).

Blood

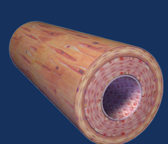
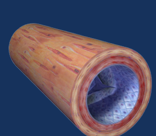
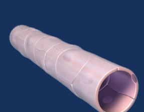
Blood delivers oxygen and nutrients to the tissues of the body and removes carbon dioxide and waste products. On average, the human body has four to six liters of blood. Blood is 55% liquid (plasma, aqueous mixture of nutrients, salts, respiratory gases, wastes, hormones, and blood proteins) and 45% cellular (erythrocytes, leukocytes and platelets) base.

Blood Vessels

Blood vessels are the "tubes" through which blood circulates in the body. There are three types of blood vessels (see table below).

Blood Pressure

Blood pressure (BP) is a measure of the force that blood exerts on the walls of the blood vessels (measured with a sphygmomanometer, and expressed by systolic pressure/diastolic pressure). Normal resting blood pressure is considered to be approximately 120/80 mm/hg. High blood pressure is 140/90 mm/hg or higher. If the systolic pressure is high and the diastolic pressure is normal (or vice versa), BP is still considered to be high. As blood flows through the circulatory system, blood pressure gradually drops. During intense exercise, blood flows outward to the periphery (limbs) of the body. When exercise is stopped abruptly, blood can potentially pool in the extremities; it is slow to return to the heart and brain, leaving the individual feeling light-headed or dizzy. These symptoms are suggestive of what is called *venous pooling* and is a dangerous situation. Blood pressure decreases dramatically and oxygen cannot effectively be delivered to the heart and brain. During exercise, an increase in blood pressure occurs when an individual performs an intense exercise or lift and holds their breath by closing the glottis of the

arteries		Thick-walled, muscular, elastic vessels that conduct oxygenated blood away from the heart (except pulmonary arteries which pump deoxygenated blood).
veins		Thin-walled, inelastic vessels which conduct deoxygenated blood towards the heart (except pulmonary veins which pump oxygenated blood). Much blood flow within the veins depends upon compression of skeletal muscles during movement.
capillaries		Very thin walls composed of a single layer of epithelium across which respiratory gases, nutrients, enzymes, hormones and wastes readily diffuse or exchange gases.

throat in an attempt to briefly increase muscular power. In reality, any increase in muscular power is a result of all muscles of the body voluntarily becoming more tense, making it difficult to breathe properly. This is known as the Valsalva maneuver and is not recommended.

Heart Stimulation

Similar to skeletal muscles in the body, when just one heart muscle cell is activated by the nervous system, the action potential (electrical signal from nervous system for muscle contraction) is spread to all of the other heart muscle cells. This process allows the atrial or ventricular muscle to contract and to then effectively pump blood. Action potentials in cardiac muscle specialize in maximizing the pumping function of the heart. These action potentials last 10 to 30 times as long as those of skeletal muscle and cause a correspondingly increased period of contraction over skeletal muscle.

Heart rate (HR) is determined by the rate of discharge of the autorhythmic pacemaker cells located in the (SA) node. The SA node, located in the right atrium is the pacemaker for the heart. The sinoatrial node spreads electrical impulses through both atria making them contract simultaneously. The impulse arrives at the atrioventricular (AV) node which conducts slowly (allowing both ventricles to fill with blood). Then the impulse is carried by the AV bundle (Bundle of His) which branches left and right, through the Purkinje Fibers, in the walls of both ventricles, to generate a strong contraction. Normal resting heart rate is in the range of 60-80 bpm (beats per minute).

If the system that either regulates or performs heart stimulation is damaged, it may send unreliable messages to the heart chambers. Symptoms of a damaged heart may include irregular heart rate, tiredness, dizziness, and loss of consciousness. A client with these symptoms may use a pacemaker, which is an implantable device for a severely damaged heart that mimics the actions of the nodes and conducting system, and helps to regulate the heart rate. The good news for clients who may have this condition is that evidence has shown that human heart muscle regenerates, to some degree, by muscle cell replication following cardiac injury.

Heart Rate (HR)

Heart rate (HR) is the measure of how many contractions (beats) of the heart are in one minute (calculated as beats per minute, bpm). It is the primary method of measurement that a group exercise instructor will use to program and monitor exercise intensity. The following is a list of important heart rate measurements (or metrics) that a group exercise instructor will utilize (either by direct calculation or estimation).

Measuring Heart Rate

In training environments, the most accurate and effective way of measuring heart rate is accomplished by using a heart rate monitor. The monitor measures the electrical signals that cause the heart to contract. Hence, it measures heart rate directly and more accurately than that of the pulse method. Furthermore, unlike the pulse method the client does not have to stop their exercise to determine their heart rate

To determine whether the client is exercising within their target heart rate range without a heart rate monitor, exercise must stop briefly in order to properly measure pulse. The pulse (HR) can be taken at the neck, the wrist, or the chest. It is recommended to take the pulse at the wrist (radial artery). Taking the pulse at the chest or neck can be inconsistent. The radial pulse is taken on the artery at the wrist in line with the thumb. Place the tips of the index and middle fingers over the artery and press lightly. Do not use the thumb (it has a pulse of its own). Take a full 60 second count for the most accurate measurement, or count 30 seconds and multiply the measurement by two. Start the count when the first pulse is felt, which is counted as "zero."

resting heart rate (RHR)

Normally between 60-80 bpm, but this varies and can be much lower in athletes

heart rate reserve (HRR)

Training Heart Rate (THR) = 50-85% HRR (50-85% VO_2R)

max heart rate (MHR)

resting heart rate (RHR)	As the term implies, it is the heart rate at rest. Ideally, this is measured first thing in the morning upon waking. However, it can be estimated after at least 5 minutes of quiet rest (as long as there have been no extraneous factors that would increase heart rate such as just completing strenuous activity or consuming a stimulant such as caffeine). A RHR with an increase of more than 8 bpm combined with fatigue and lack of interest in training may indicate the onset of illness. Illness will also raise known exercise HR by 10 bpm or more compared to normal.
maximum heart rate (MHR)	Once again, as the term implies it is the maximum number of contractions the heart will beat in one minute. This is reached through maximum physical exertion. While not measured directly by a group exercise instructor (only specialized medical personnel can conduct a MHR test), it can be estimated through a variety of methods.
heart rate reserve (HRR)	Heart rate reserve is the difference between MHR and RHR. This is where training takes place. Trained athletes can achieve 4-5x their RHR while untrained individuals only reach 2-3x RHR.
target heart rate (THR)	Ideal heart rate intensity during exercise. This is determined by the group exercise instructor and based on the client's current abilities and goals. Usually calculated as percentage of VO_2max (see aerobic capacity) or percentage of HRR.
recovery heart rate	The post-effort drop in heart rate. The more fit the individual, the quicker the cardiovascular system recovers after effort.
Rating of Perceived Exertion (RPE)	A subjective scale used to estimate the level of difficulty a given exercise has on an individual. This varies based on the individual and the exercise. Typically a scale from 1-10 is used with 10 being 100% effort. Historically, the Borg RPE scale uses a scale from 6-20 (with 6 being no exertion and 20 maximum exertion).

What is VO_2max?

In order to understand the concept of VO_2max (**aerobic capacity**), the group exercise instructor must understand a few important exercise physiology concepts.

Cardiac Output (Q), also sometimes noted as CO, is quite simply a measure of how efficiently the heart is able to deliver oxygen to all tissues. Cardiac Output is the total amount of blood the ventricles pump from the heart per minute. This is equal to the heart rate (HR, rate at which heart works in beats per minute) x stroke volume (SV, amount of blood ejected).

$$Q = HR \times SV$$

At rest, the heart pumps out about 10ml of blood per beat (stroke volume) and about 10 pints per minute (cardiac output). Generally, a high stroke volume and low heart rate are desired.

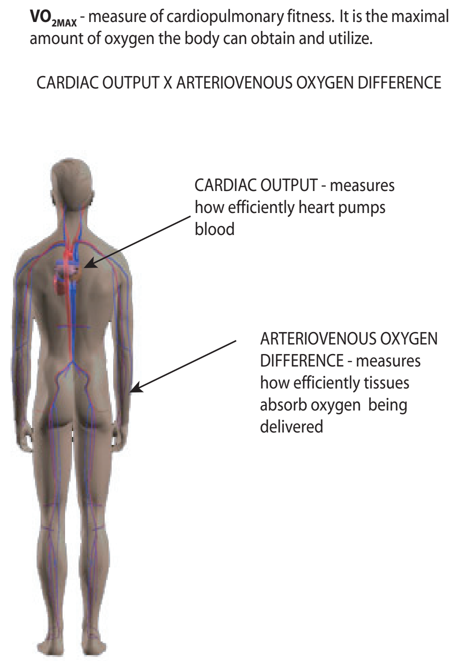
Arteriovenous Oxygen Difference

Arteriovenous Oxygen Difference (a-vO_2), also sometimes noted as AOD, is the measure of how efficiently tissues extract the oxygen being delivered by the cardiovascular system. a-vO_2 is the difference between the oxygen content of arterial blood versus the oxygen content of venous blood.

Aerobic Capacity

Aerobic capacity, also known as VO_2max, is the most common measurement of cardiopulmonary fitness. **VO_2max** is a measure of the maximum oxygen consumption (transport and use of oxygen) during maximal effort lasting longer than 2 minutes and shorter than 5 minutes. VO_2max measures how efficiently the cardiopulmonary system is able to **deliver** oxygen to the tissues (Cardiac Output) and how readily the tissues are able to **utilize** the oxygen (Arteriovenous Oxygen Difference).

$$VO_2max = Q \times a\text{-}vO_2$$



This is expressed in liters of O_2 per minute. In terms of cardiopulmonary fitness, the greater the VO_2max the better.

During exercise, it is important to work at the appropriate intensity level, according to current ability, conditioning, age, training stage and individual goals. Intensity of cardiovascular exercise should be based on oxygen consumption (VO_2) where both the delivery system (cardiac output) and the oxygen consumption of the muscles (a-vO_2) are challenged when overloaded. This value can be measured using a VO_2max test or a submaximal test. That said, unless you are training in a laboratory, you won't be measuring your client's oxygen consumption. Therefore, NESTA recommends programming cardiovascular intensity based on Heart Rate (HR).

During aerobic exercise, heart rate varies with oxygen consumption in a linear manner. In other words, if a certain intensity of cardiovascular training (VO_2) causes a client's HR to go up by 10 beats per minute (bpm), then something that doubles the VO_2 increase will also double the HR increase (to 20 bpm).

All of these factors must be taken into consideration when determining the ideal Target Heart Rate (THR) range for cardiovascular (CV) exercise.

Section 2.9
Proper Fuel: Nutrition Basics

Section Objectives:

Know the three macronutrients.

Know how many calories are in per gram of each macronutrient.

Know what trans fats are.

Know the definitions of calories, empty calories, amino acids, complete proteins.

General nutrition questions are asked all the time. It's imperative that instructors have a basic understanding on the role nutrition plays in exercise, and in life, but that they use caution when making recommendations and answering questions. Nutrition is ever-evolving. In recent decades, many things have changed based on science, and, increasing obesity and disease rates. The federal government revamped their "Food Pyramid" and the "low-fat" craze officially ended (but not before it increased the percentages of diabetes and cancer to all-out epidemics). Since diets come and go, having factual information about food groups, macronutrients, organic products, inflammatory foods and pre-post workout foods is best. Prescribing any diet is out of scope of practice for instructors, unless that instructor holds a nutrition degree or certification. However, information regarding what to eat before a tough class, where to shop for organic produce, or which vegan protein sources are best can help members immensely, while also strengthening the bond between class and instructor.

Calories:

A calorie is a unit of energy. Every cell in our bodies require energy to function optimally; if we do not take in enough, our cells would perish and our organs would cease to function. Take in too many, and health complications arise. The number of calories food contains tells us how much potential energy they contain. Medical News today says, "In nutrition and everyday language, calories refer to energy consumption through eating and drinking, and energy usage through physical activity. For example, an apple may have 80 calories, while a 1 mile walk might use up about 100 calories."[1]

There are two types of calories:

A small calorie (sympbol: cal) – 1cal is the amount of energy required to raise one gram of water by one degree Celsius.

A large calorie (symbol: Cal, kcal) – 1Cal is the amount of energy required to raise one kilogram of water by one degree Celsius.

The caloric values in the foods we eat are as follows:

- 1 gram of carbohydrates = 4 calories
- 1 gram of protein = 4 calories
- 1 gram of fat = 9 calories

You can add up the calories in any food using the grams of macronutrients they contain. For example, a hypothetical meal of chicken and rice cooked in oil containing 30 grams of carbohydrates, 14 grams of fat and 25 grams of protein equals: 346 calories.

- 30 grams carbohydrates x 4 calories = 120
- 14 grams fat x 9 calories = 126
- 25 grams protein x 4 = 100
- 120+126+100=346 calories

1 http://www.medicalnewstoday.com/articles/263028.php

Quick calorie facts from Medical News Today

A calorie is a unit of energy
Calories are essential for human health; the key is taking on the right amount
Everyone requires different amounts of energy per day depending on age, size and activity levels
More than 11% of Americans' daily calories come from fast foods
"Empty calories" describe foods high in energy but low in nutritional value
Solid fats are so called because they are solid at room temperature
Foods such as ice cream and bacon contain the emptiest calories
Americans consume an average of 336 calories per day from sugary beverages alone
More than 50% of Americans have at least one sugary drink per day.

Calories in versus calories out is the premise of many popular diets including Weight Watchers and Jenny Craig. Take in fewer calories than you burn, and, voila, the scale decreases. The concept makes sense, and does work for many people. Ubiquitous food logging apps like 'My Fitness Pal' and 'Lose It' aim to have people logging every bite they take, and calorie they burn, for a live and up to date reading on their calorie deficit. It makes sense that novices should start out learning about calories and tracking their foods. Apps and food logs allow people to get specific about their consumption and learn the macronutrient profile of the foods they eat. One of the most common complaints from dieters is: "I eat super healthy and cannot lose a pound." The compelling question there is: "how do you define healthy?" Everyone has a different definition. For some, it means all whole and raw foods, for others, it means low carb, and others claim it's a perfect balance of macronutrients, while someone else will claim it's a Paleo diet. And further, what's right for some may not be right for all. One person might thrive on a vegan diet, whereas another might feel lethargic and gain weight foregoing animal protein. There's not a one-size-fits-all plan, which is, in large part, why weight loss is so challenging and a billion-dollar industry. **Scientific America** debunks the calories in/out theory by stating, "Almost every packaged food today features calorie counts in its label. Most of these counts are inaccurate because they are based on a system of averages that ignores the complexity of digestion. Recent research reveals that how many calories we extract from food depends on which species we eat, how we prepare our food, which bacteria are in our gut and how much energy we use to digest different foods. Current calorie counts do not consider any of these factors. Digestion is so intricate that even if we try to improve calorie counts, we will likely never make them perfectly accurate."[2]

We know that processed foods are more quickly digested and give us a lot of energy (calories) without much bang for our buck. But veggies, whole grains and nuts offer more vitamins and nutrients, keep us fuller longer, digest more slowly, and create a more hospitable environment for our guts. They make us work for our digestion too, which means a lot more bang for our buck. The logical food choices for those wanting to lose weight, therefore, are whole and raw foods with as few as possible processed items.

It is because of complexities like this, that we, as instructors, do not dole out nutrition advice. The best answers for frustrated clients will always be a referral to a nutritionist. However, it's perfectly acceptable to steer members towards an app that helps them see the profiles of the foods they eat. Most people severely underestimate the calories in the foods they eat and the quantity. Portion sizes are often to blame for weight gain. Suggesting that people focus on portions and measure out their peanut butter, for example, is a simple and useful way to assist people in creating better habits. People also grossly overestimate the number of calories they burn while exercis-

2 https://www.scientificamerican.com/article/science-reveals-why-calorie-counts-are-all-wrong/.

ing. Everyone is different! A 200-pound 6'2 man might burn 2-3 times as many calories in a kickboxing class as a 150-pound 5'3 woman. Certain apps have libraries of exercises with general calorie burns. A kettlebell class might clock in at 450 calories for a 1-hour class and a weight-lifting circuit might register at 220. But those numbers do not consider your body composition, age and fitness level. Heart rate monitors produce more accurate results but nothing is 100%.

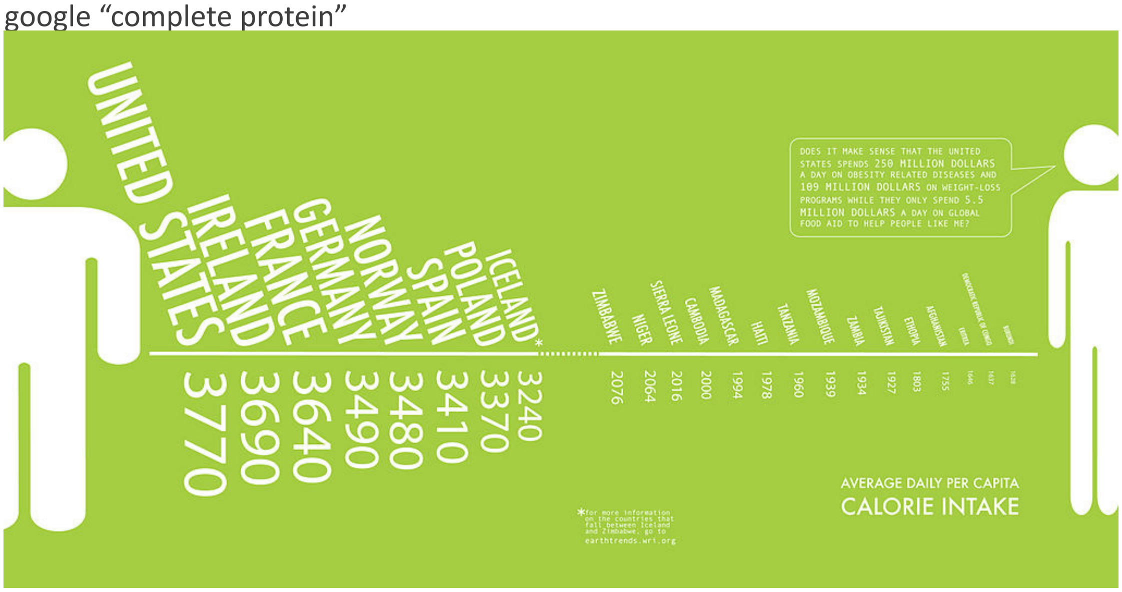
Here's a list of general statements that are acceptable, helpful and useful to clients without crossing the line as an instructor. Add to it with the goal of being informative and thought-provoking, never as a replacement for a nutrition expert.

- Don't forget to get your 8 or more glasses of water in today.
- You don't know what you don't know.... get a food logging app and log every bite for one week to see what you're consuming.
- Go "P-Free" this week. See what happens when you cut processed food for an entire week.
- The magic window after a tough class is 45 minutes. Refuel within that window to help recovery and repair.
- Go home and google "complete protein" and ensure you're getting enough for your size.
- Check out the different heart rate monitors on the market if you want more accurate readings.
- Try getting in those 10,000 steps today.
- Proper planning is essential! Meal prep this week!

No one requires the same number of calories each day. Ideal consumption depends on a variety of factors, including: general health, physical activity, sex, weight, height, and shape. A 6ft tall, 22-year-old student and swimmer needs far more calories per day than a sedentary 65-year-old man of the same build.

Health authorities around the world find it hard to agree on how many calories their citizens should ideally consume. Web MD suggests that men consume no more than 2,400 calories per day and women no more than 2,000. Those numbers do not take into consideration a person's size and activity levels, however, which is why everyone should try a BMR (Basal Metabolic Rate) calculator to acquire slightly more specific readings. Basal Metabolic Rate is the number of calories you burn while at rest, also known as your body's metabolism. Any increase to your metabolic weight (exercise) increases your BMR. Once you discover your BMR, you can start monitoring how many calories a day are needed to maintain or lose weight, or discover why your weight loss efforts have stalled. Online Calculator.[3]

Around the world, the recommendations differ, and consumption varies greatly, too.[4,5]

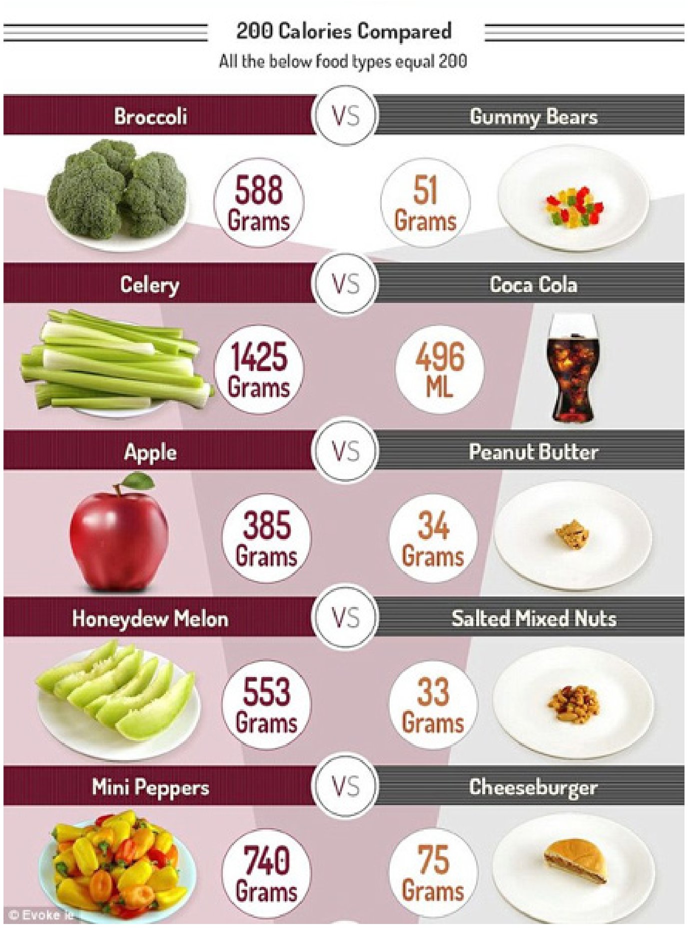


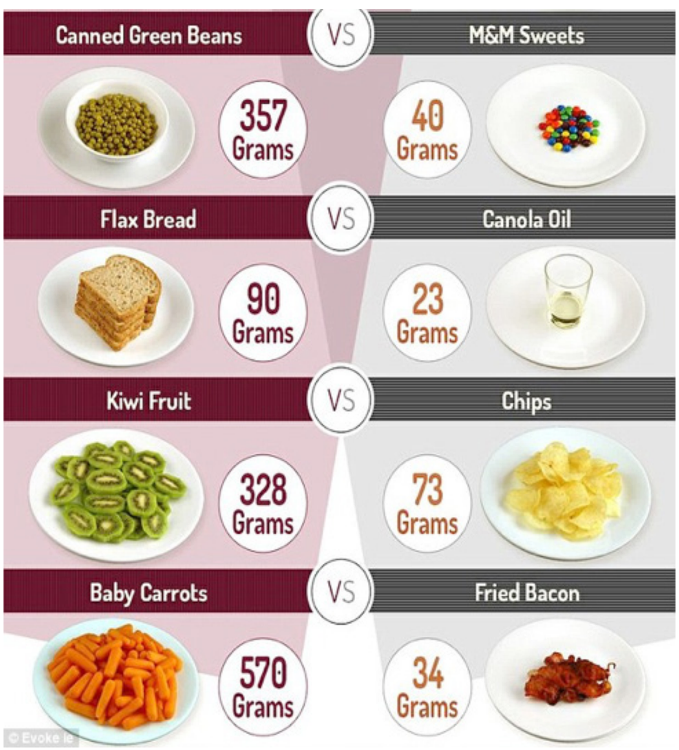
3 http://www.active.com/fitness/calculators/bmr

4 http://www.dailymail.co.uk/femail/article-2722815/Daily-calorie-intake-countries-world-revealed-surprise-U-S-tops-list-3-770.html

5 © Lauren Manning / Wikimedia Commons / CC-BY-SA-3.0 / GFDL

The graphics below show the volume of a variety of foods all equaling 200 calories. It's easy to decipher which ones are more nutrient dense, contain more fiber and provide more satiety.





Empty calories, are a major problem because they're food items (and calories) possessing little nutritional value (little to no fiber, vitamins, amino acids, etc.). Many of these foods cause cravings for similar foods, and that becomes a vicious cycle. It leaves little room for healthy foods as well.

According to ChooseMyPlate.gov, a part of the USDA, empty calories come mainly from solid fats and added sugars.

- Solid fats, such as beef fat, shortening and butter, are solid when at room temperature. Although solid fats exist naturally in many foods, they are commonly added during industrial food processing, as well as when certain foods are being prepared.
- Added sugars - these are calorific sweeteners that are added to foods and beverages during industrial processing. In the USA, the most common types of added sugars are sucrose and high-fructose corn syrup, which are mainly composed of about half fructose and half glucose.

Added sugars and solid fats generally make food more enjoyable. They are added by food and beverage companies to boost sales. However, they also add many calories and are major contributors to the climbing obesity epidemic.

Per ChooseMyPlate.gov, the following foods and drinks have the emptiest calories in the United States:[6]

Solid fats + added sugars

- ice cream
- donuts
- pastries
- cookies
- cakes

Solid fats

- ribs
- bacon
- hot dogs
- sausages
- cheese
- pizza

6 http://www.medicalnewstoday.com/articles/263028.php?page=2

Added sugars

- fruit drinks
- sports drinks
- energy drinks
- sodas.

Macronutrients:

Macronutrients are: proteins, fats carbohydrates. They are the building blocks that comprise the food we eat for fuel, growth, endurance, satiety and recovery. All three fuel the body, but they each have critical functions that extend beyond energy. Every food we eat falls into at least one of the above categories. Some foods are a combination of two, or even three. Edamame, for example, contains protein, fat and carbs. Turkey is just protein. Looking at a nutrition panel can help decipher which categories foods are in.

Protein

Protein is found throughout the body—in muscle, bone, skin, hair, and virtually every other body part or tissue. It makes up the enzymes that power many chemical reactions and the hemoglobin that carries oxygen in your blood. There are a minimum of 10,000 different proteins that make up, and maintain us.

The Institute of Medicine recommends that adults get a minimum of 0.8 grams of protein for every kilogram of body weight per day (or 8 grams of protein for every 20 pounds of body weight). In the United States, the recommended daily allowance of protein is 46 grams per day for women over 19 years of age, and 56 grams per day for men over 19 years of age. [7]

Many athletes, weight lifters and exercisers require, or prefer, a lot more protein than that. Many are closer to 1-2 grams per pound of their body weight. Most people will take a stance on how much protein they believe is right for them after reading an article or just discussing it with people whose bodies they admire. They think, "she looks good, so I'll do what she does." Everyone is built differently, and demands for all the macronutrients depend on an array of variables, including: body weight, sex, activity, goals, liver function, blood sugar and overall health. There's no one size fits all when it comes to macros.

Protein is built from building blocks called amino acids. Our bodies make amino acids in two different ways: Either from scratch, or by modifying others. A few amino acids (known as the essential amino acids) must come from food, meaning we cannot make them

Animal sources of protein tend to deliver all the amino acids we need.

Other protein sources, such as fruits, vegetables, grains, nuts and seeds, lack one or more essential amino acids to be considered a "complete protein," which is why food combining is important in some instances. Vegans and vegetarians (or anyone who doesn't eat meat, fish, dairy or eggs) should eat a variety of protein foods each day to ingest the amino acids needed to make new protein.[8]

Carbohydrates

Not all carbs are created equal. Not by a long shot. Chocolate is a carbohydrate, aka, carb, and so is broccoli. The amount, and types you choose, are critical. People often slash carbs to lose weight. It's true; cutting carbs very well may be a quick way to drop unwanted pounds, but unless it's a lifestyle, people almost always regain the weight they lost by "going low-carb." It's far more important to, "eat carbohydrates from healthy foods than to follow a strict diet limiting or counting the number of grams of carbohydrates consumed," says The Harvard School of Public Health."[9]

Carbohydrates are found in both healthy and unhealthy foods: bread, beans, milk, popcorn, potatoes, cookies, pasta, rice, French fries, soft drinks, corn, and cake are

7 Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. 2007, World Cancer Research Fund, American Institute for Cancer Research.: Washington, DC.

8 https://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/protein/

9 https://www.hsph.harvard.edu/nutritionsource/carbohydrates/

all forms of carbs. They look vastly different from food to food. "The most common and abundant forms are sugars, fibers, and starches." Broccoli would be a fiber, while gummy bears would be sugar.

The Harvard School of Public Health states, "Carbohydrates provide the body with glucose, which is converted to energy used to support bodily functions and physical activity. But carbohydrate quality is important; some types of carbohydrate-rich foods are better than others. The healthiest sources of carbohydrates—unprocessed or minimally processed whole grains, vegetables, fruits and beans—promote good health by delivering vitamins, minerals, fiber, and a host of important phytonutrients."

"Unhealthier sources of carbohydrates include white bread, pastries, sodas, and other highly processed or refined foods. These items contain easily digested carbohydrates that may contribute to weight gain, interfere with weight loss, and promote diabetes and heart disease."

Most fibrous vegetables are relatively low in calories with a high nutritional punch in the form of fiber (to keep you full) and vitamins and antioxidants for disease prevention and fighting free-radicals. It stands to reason that the more veggies on a plate means less room for empty calories, while staying nice and satisfied.

Fats:

For a few decades, we were told that fat made us fat. Food companies swapped fat for sugar, creating Franken-foods that made Americans fatter than ever. Low-fat diets are often high in carbohydrates, often from quickly-digested foods like white flour, white rice, potatoes, sugars and processed snacks. Eating lots of these simple carbs spikes blood sugar and insulin levels, which increases the risk of diabetes and heart disease. "High-carbohydrate, low-fat diets also have a negative effect on the fats and cholesterol in our blood: They raise "bad" blood fats (triglycerides) and they lower the "good" blood cholesterol (HDL), both of which can increase the risk of heart disease. These diets also tend to increase blood pressure," per The Harvard School of Public Health. Furthermore, low-fat diets are unsatisfying. Low-fat fanatics finish a meal and within a few hours, they are hungry again, or have sugar cravings. The quickest way to get glucose into the system to squash the hunger is more carbs. This cycle of eat, craving, eat, craving leads to weight gain, high blood pressure, low HDL, cancer, and more.

Within the last decade, the tides turned and fat is no longer the villain it was once painted to be. Just like carbs, there are healthy and unhealthy fats. It's also important to remember, that even though some fats are healthy and aid in lower cholesterol, there are 9 calories per gram of fat, which makes it more calorie-dense than protein and carbohydrates. So, portions must be adjusted.

The Harvard School of Public Health states, "Unsaturated fat is the healthiest type of fat. Plant oils, such as olive, canola, corn, peanut and other nut oils; nuts, such as almonds, peanuts, walnuts, and pistachios; avocados; and fish, especially oily fish such as salmon and canned tuna, are excellent sources of unsaturated fat. Eating unsaturated fat in place of refined grains and sugar can improve blood cholesterol profiles and lower triglycerides, and in turn, lower the risk of heart disease. It is essential to include a special kind of unsaturated fat, called omega-3 fats, in the diet; good sources include fish, walnuts, flax seeds, and canola oil. Keep in mind that omega-3 fats from marine sources, such as fish and shellfish, have much more powerful health benefits than omega-3 fats from plant sources, like walnuts and flax seeds. But omega-3 fats from plant sources still are a good choice, especially for people who don't eat fish.

Saturated fat is less healthy, since it raises "bad" cholesterol in the blood. We can't eliminate saturated fat from our diets, though, because foods that are rich in healthy fats also contain a little bit of saturated fat. The best strategy is to limit foods that are very high in saturated fat, such as butter, cheese, and red meat, and replace them with foods that are high in healthy fats, such as plant oils, nuts, and fish. An alternative approach is to just use a very small amount of full-fat cheese, butter, cream, or red meat in dishes that emphasize plant foods such as vegetables, whole grains, and legumes."[10]

The Mayo Clinic states, "Trans fat is considered by many doctors to be the worst type of fat you can eat. Unlike other dietary fats, trans fat — also called trans-fatty acids — both raises your LDL ("bad") cholesterol and lowers your HDL ("good") cholesterol.

A diet laden with trans fat increases your risk of heart disease, the leading killer of men and women."

Trans fat in your food

The manufactured form of trans fat, known as partially hydrogenated oil, is found in a variety of food products, including:

Baked goods. Most cakes, cookies, pie crusts and crackers contain shortening, which is usually made from partially hydrogenated vegetable oil. Ready-made frosting is another source of trans fat.

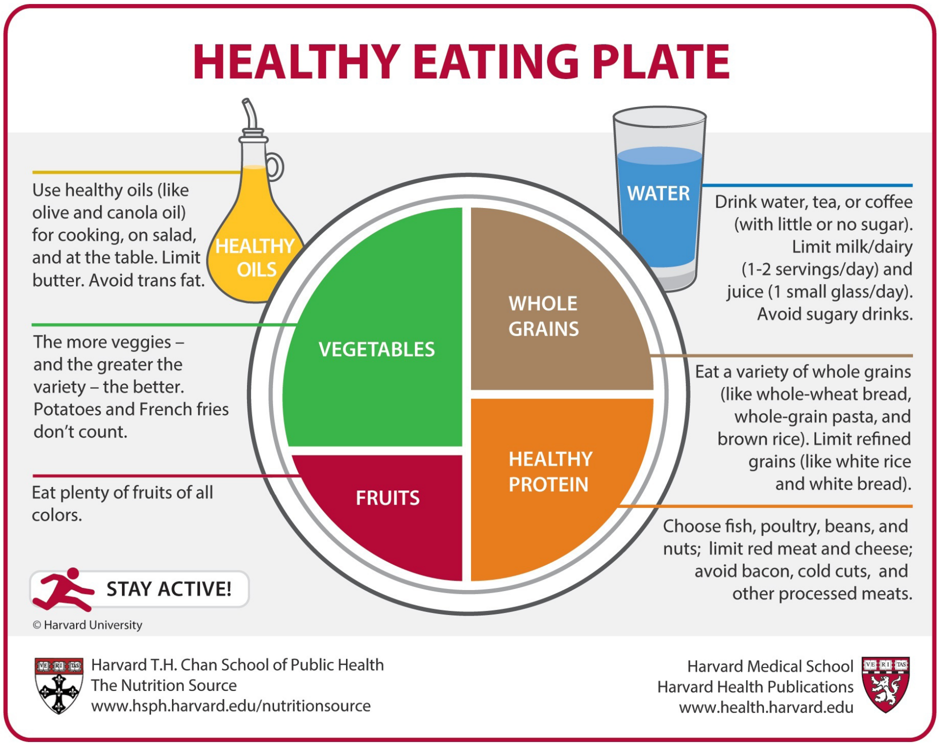
Snacks. Potato, corn and tortilla chips often contain trans fat. And while popcorn can be a healthy snack, many types of packaged or microwave popcorn use trans fat to help cook or flavor the popcorn.

Fried food. Foods that require deep frying — french fries, doughnuts and fried chicken — can contain trans fat from the oil used in the cooking process.

Refrigerator dough. Products such as canned biscuits and cinnamon rolls often contain trans fat, as do frozen pizza crusts.

Creamer and margarine. Nondairy coffee creamer and stick margarines also may contain partially hydrogenated vegetable oils.[11]

The US government's "Healthy Eating Plate" came out in 2011 and replaced The Food Pyramid, which had been the guideline since 1991. Major changes were made, including the number of servings of grains, more vegetables, limiting dairy and emphasizing no sugary drinks. Conceptually, the plate idea and portions are much easier to understand, and hopefully, follow. People still need to be cautious of portions and the quality of food within each category.



10 https://www.hsph.harvard.edu/nutritionsource/2012/06/21/ask-the-expert-healthy-fats/

11 http://www.mayoclinic.org/diseases-conditions/high-blood-cholesterol/in-depth/trans-fat/art-20046114