Level 2 Fitness Instructing
GYM BASED EXERCISE

Welcome to your Level 2 Fitness Instructing – Part 1 Level 3 Personal Training & Gym Based Exercise course.

Please visit the member zone online at www.boffit.online with password boffitmember

Here you will receive some pre-course reading materials, details about workshop dates and venues, how to complete your Learner Achievement Portfolio (LAP) and an array of extra learner support.

In this document you will find information slides and images which cover the Anatomy and Physiology unit of the course. You will be assessed on this unit via a theory exam at the end of the course. We suggest that you look over these slides as often as possible before the course starts.

If you have any questions leading up to the course, please contact us directly at team@boffit.co.uk

Learning Outcomes

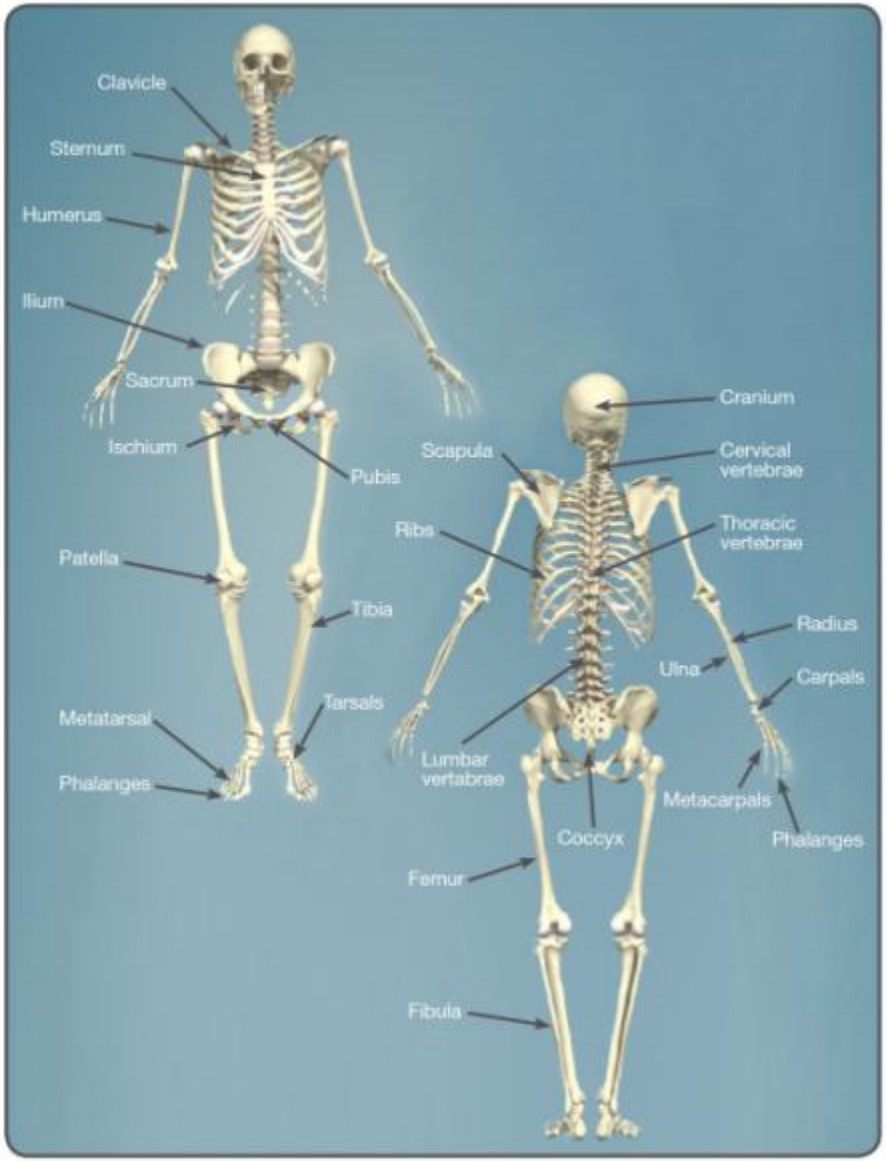
- By the end of this section you will:

- Identify and name the major bones of the human skeleton
- Specify the functions of the skeleton
- Identify the role of the spine and effects of exercise on spine alignment
- Describe the four types of bone and understand their development
- Describe the effects of exercise, age inactivity and hormonal status on bone structure

What does the Skeletal System consist of?

- 206 bones in total
- Bones are attached to other bones by ligaments
- Bones are attached to muscles by tendons
- Cartilage covers the end of bones at a joint and allows friction free movement

The Skeleton



Functions of the Skeleton

MUSCLE ATTACHMENT AND MOVEMENT

- The long bones of the skeleton act as levers. muscles attached to these bones and pull on them to create movement

STORAGE OF MINERALS

- Minerals such as calcium and phosphate ions are stored in the bones to be drawn upon when necessary

PROTECTION OF VITAL ORGANS

- The skeleton protects vital organs and delicate structures within the body

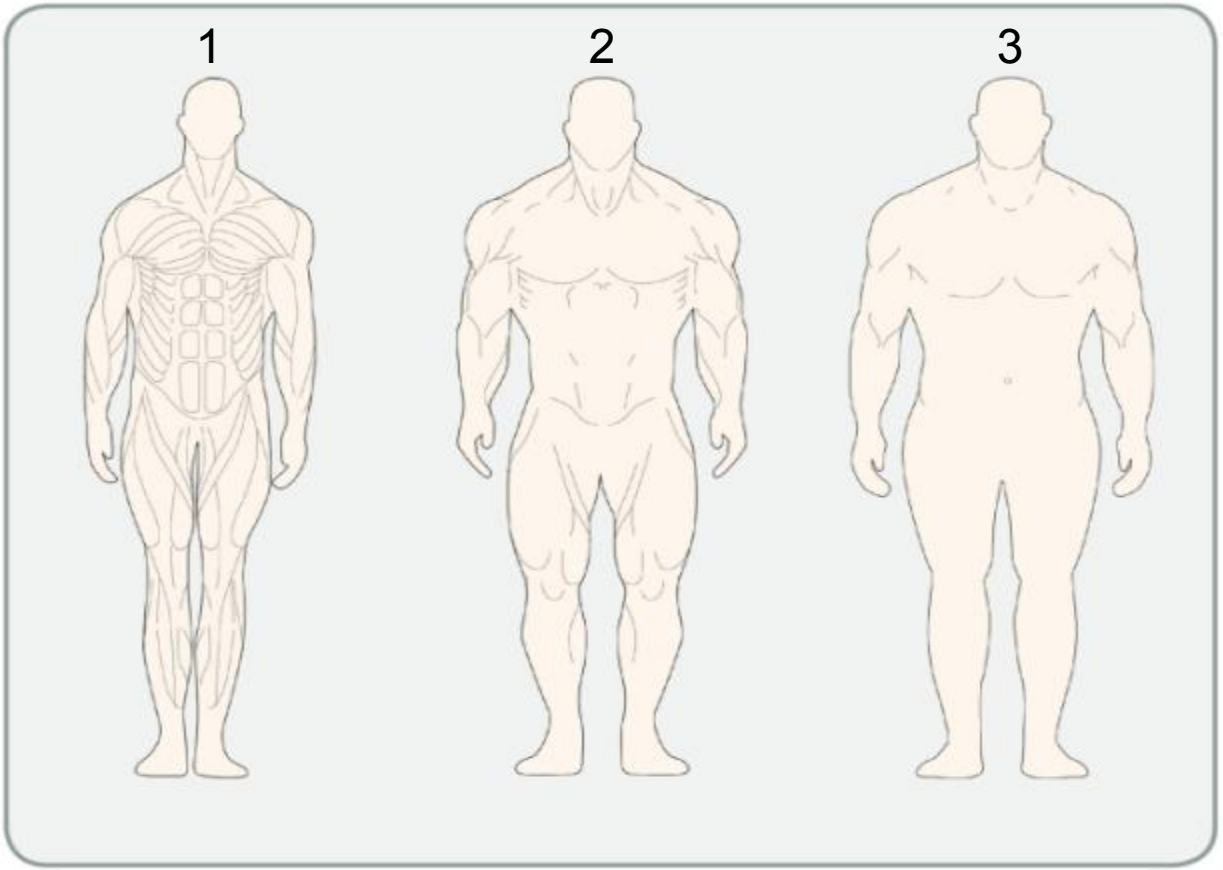
SHAPE

- The skeleton gives the body its characteristic shape and provides a framework for support

PRODUCTION

- The marrow cavity of some bones, such as the sternum, is a site of production for red and white blood cells.

Somatotypes



1. Ectomorph
2. Mesomorph
3. Endomorph

Divisions of the Skeleton

- **Axial Skeleton (80 bones)**
  - Lies on the long axis or midline of the body and includes the skull, vertebrae, sternum and ribs

- **Appendicular Skeleton (126 bones)**
  - Includes bones of the shoulder girdle, arms and hands and the pelvic girdle, legs and feet

Vertebral Column (Spine)

- Cervical curve is forward (convex)
- Thoracic curve backward (concave)
- Lumbar curve forward (convex)
- Sacral curve backward (concave)

Vertebral Column (Spine)

There are 33 individual bones in total:

7 Cervical vertebrae:

- 1st is called the ATLAS which supports the skull and forms a pivot with the AXIS (2nd cervical vertebrae)

12 Thoracic vertebrae:

- Form joints with the ribs to form the ribcage

5 Lumbar vertebrae:

- The largest and strongest vertebrae

5 Sacral:

- Fused to form the sacrum

3 - 5 Coccygeal:

- Fused to form the coccyx

Vertebral Column (Spine)

- All the vertebrae join to one another to form a flexible column that:
    - Supports the trunk & head
    - Encloses and protects the spinal cord

- In between each vertebrae there are intervertebral discs (fibrous cartilage) which act as shock absorbers between each of the vertebrae

Curves of the Spine

- 4 ‘natural’ curves named after the vertebrae that form them:

  Cervical = Forwards

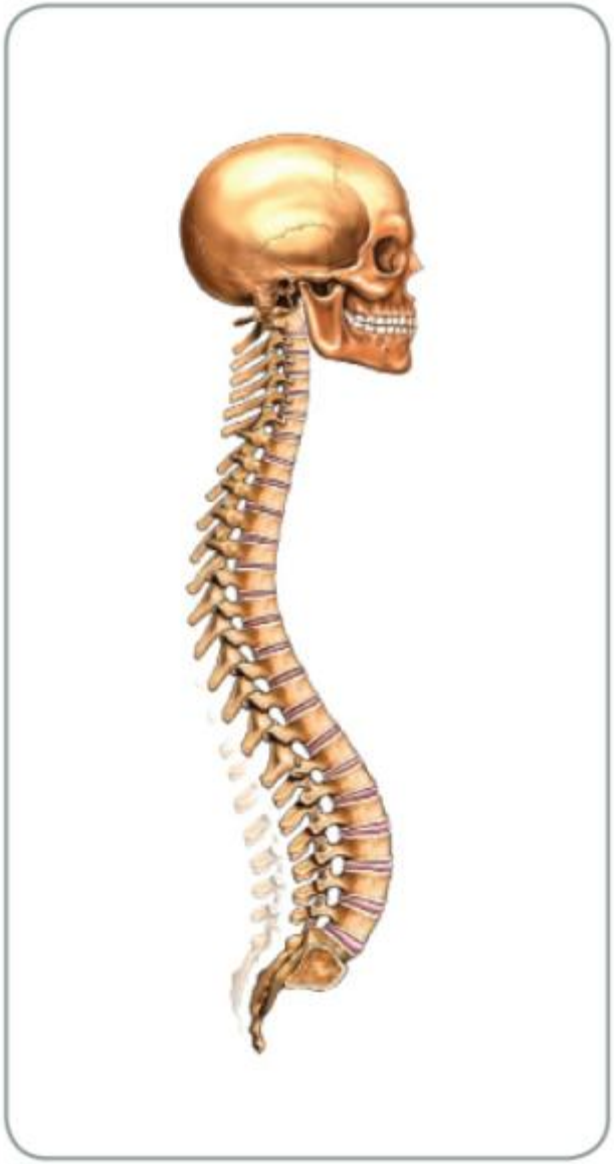
  Thoracic = Backwards

  Lumbar = Forwards

  Sacral = Backwards

- These curves centre the head above the body and make walking and maintaining an upright posture more easy

Lordosis



Kyphosis

Scoliosis

Bones

Bone Classification

- **Long Bones**

  Found in the limbs. Their length is greater than their breadth. They have a tubular shaft and usually an epiphysis at each end covered by hyaline cartilage
  Movement

- **Short Bones**

  Found in the hand and foot primarily. Roughly cuboid in shape
  Movement / strength

- **Irregular Bones**

  Composed of a thin shell of compact bone and an interior of cancellous bone
  Protection

- **Flat Bones**

  Composed of thin and inner and outer layers of compact bone separated by a layer of cancellous bone
  Muscle attachment

Bone Growth

- Bones are living and need a good blood supply in order to bring nutrients and oxygen, and to get rid of waste products
- The bone also needs nerves to send information to the brain about pain or damage caused to a bone
- Bones at birth are mainly cartilage. As the skeleton matures calcium and magnesium are deposited within the cartilage by osteoblasts (bone building cells). This process of bone growth is called OSSIFICATION
- Ossification is complete by the age of about 25 years
- The cartilage gives the bones their resilience and calcium gives them their hardness.

Structure of a Long Bone

- COMPACT BONE forms the main shaft of the bone.
- SPONGY BONE (cancellous bone) is found at the ends of the bone
- RED MARROW, which produces red and white blood cells is found within the cavity of the bone shaft
- With the exception of the ends of the bone, a fibrous sheath covers the bone, this is called PERIOSTEUM
- Periosteum has a rich supply of blood vessels, providing nutrients for bone cells during growth and repair.

Structure of a long bone

Ossification:
Important implications for exercise

- Growing bone is vulnerable to damage
- Exercise training with children therefore requires care
- Research suggests exercise with young children needs to be of moderate intensity to have a positive effect on bone development
- Resistance training with children should consist of high reps and low resistance
- Heavy / Strenuous work with young children could lead to overuse injuries and fractures of the epiphyseal plates, which could effect growth and future bone development

Factors Affecting Bone Growth

- Bones change their size and shape during a lifespan
- Increasing age and inactivity can lead to bone demineralisation and fragile bones (osteoporosis)
- Regular weight bearing exercise will increase bone density, making it stronger as a result of the pulling forces exerted by the muscle on the bone

Osteoporosis

- This is where bones become thinner and more fragile
- Exercise does not need to be vigorous; everyday activities such as walking are beneficial
- Any weight bearing exercise program is effective as it encourages an increase in bone density. Bones become stronger due to the pulling forces of the muscles on the bone. Without this action, bone loses calcium faster than it can be replaced

Learning Outcomes

- By the end of this section you will:
  - Understand the joints of the skeleton
  - Describe the classifications of joints
  - Describe the structure of synovial joints
  - Describe the types of synovial joints and their range of motion
  - Describe joint actions
  - Understand the life-course of the musculoskeletal system and its implications for special populations exercise

Joint Classifications

- A joint is where a bone meets another bone
- There are 3 classifications of joints:

  - Immovable e.g. the skull
    - Also known as fused or fibrous
  - Slightly moveable e.g. the thoracic vertebrae
    - Also known as cartilaginous
  - Freely movable e.g. the shoulder
    - Known as synovial

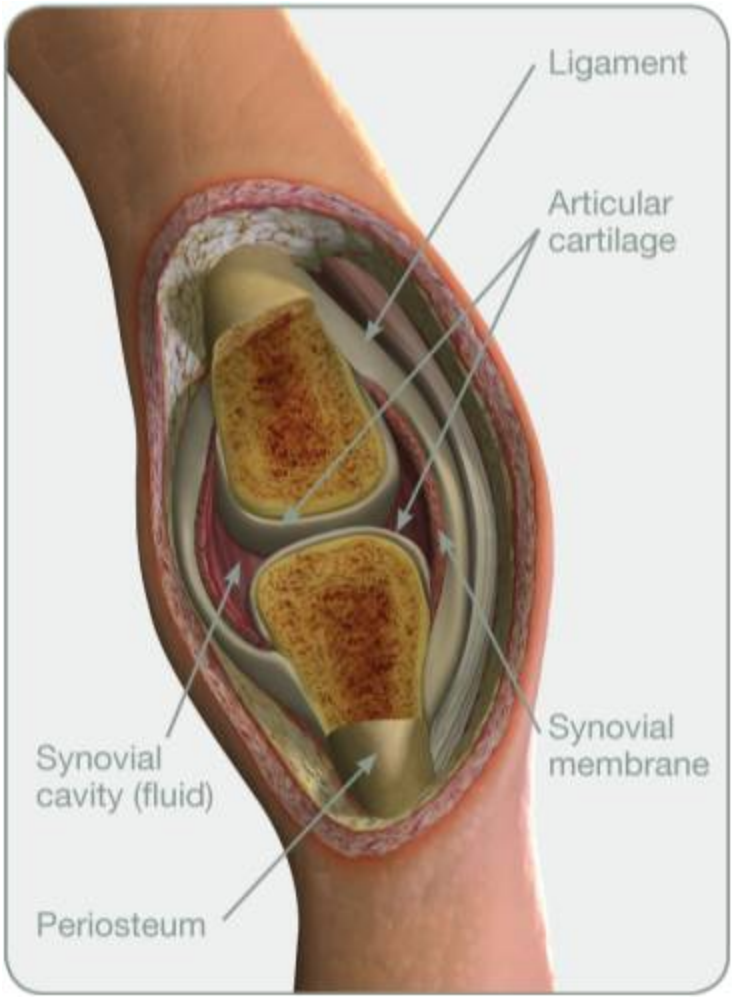
Synovial Joints – Structure

- Articular cartilage
  - Lines the ends of bone for smooth movement
  - Shock absorption
- Joint capsule
  - Sleeve-like capsule that encloses the joint cavity
- Synovial membrane
  - Secretes synovial fluid into the joint
- Synovial fluid
  - Lubricates the joint

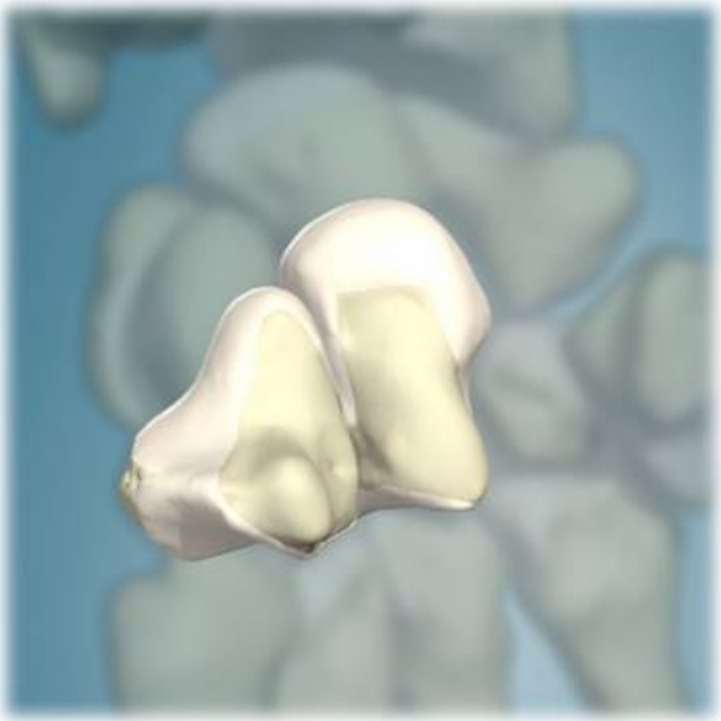
Synovial Joints – structure

- Ligaments
  - Links bone to bone and adds stability
- Tendons
  - Tendons attach muscle to bone

Synovial Joints – structure



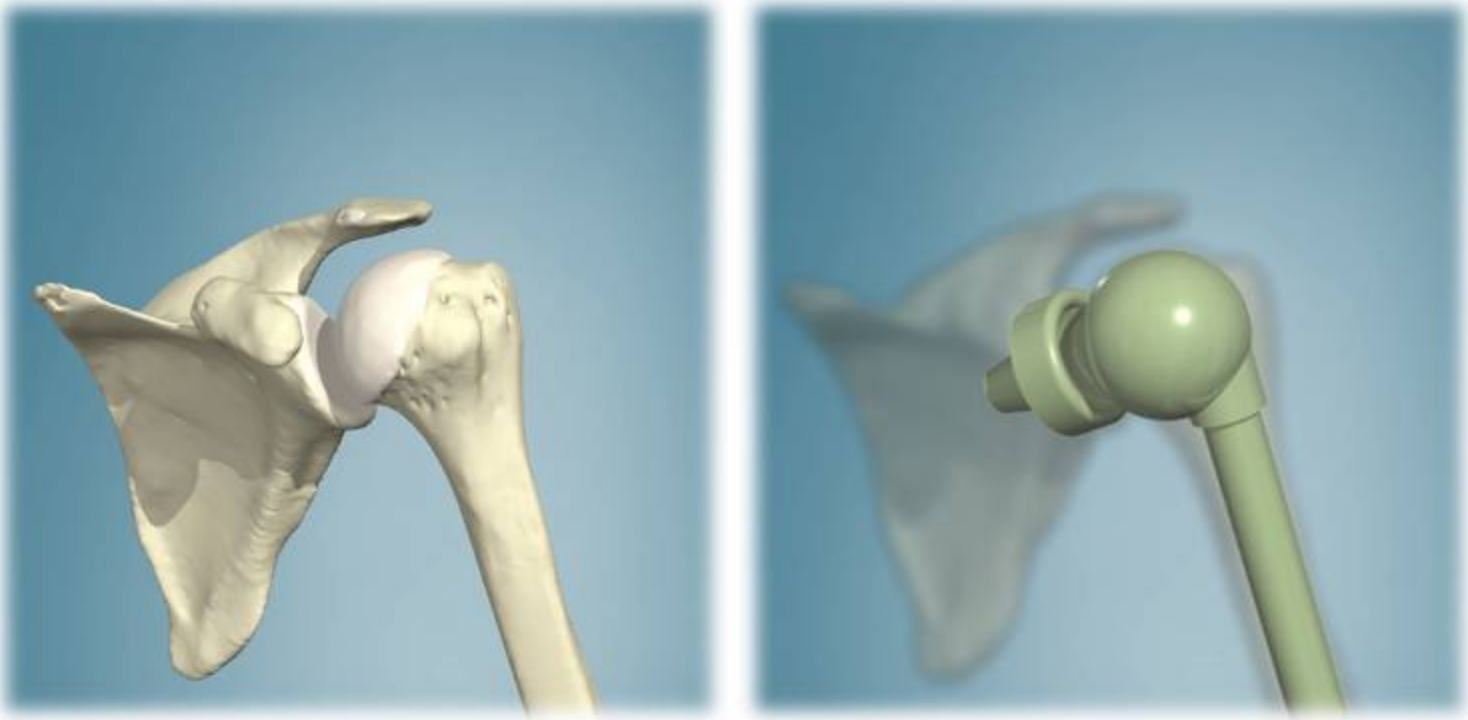
Gliding Joint



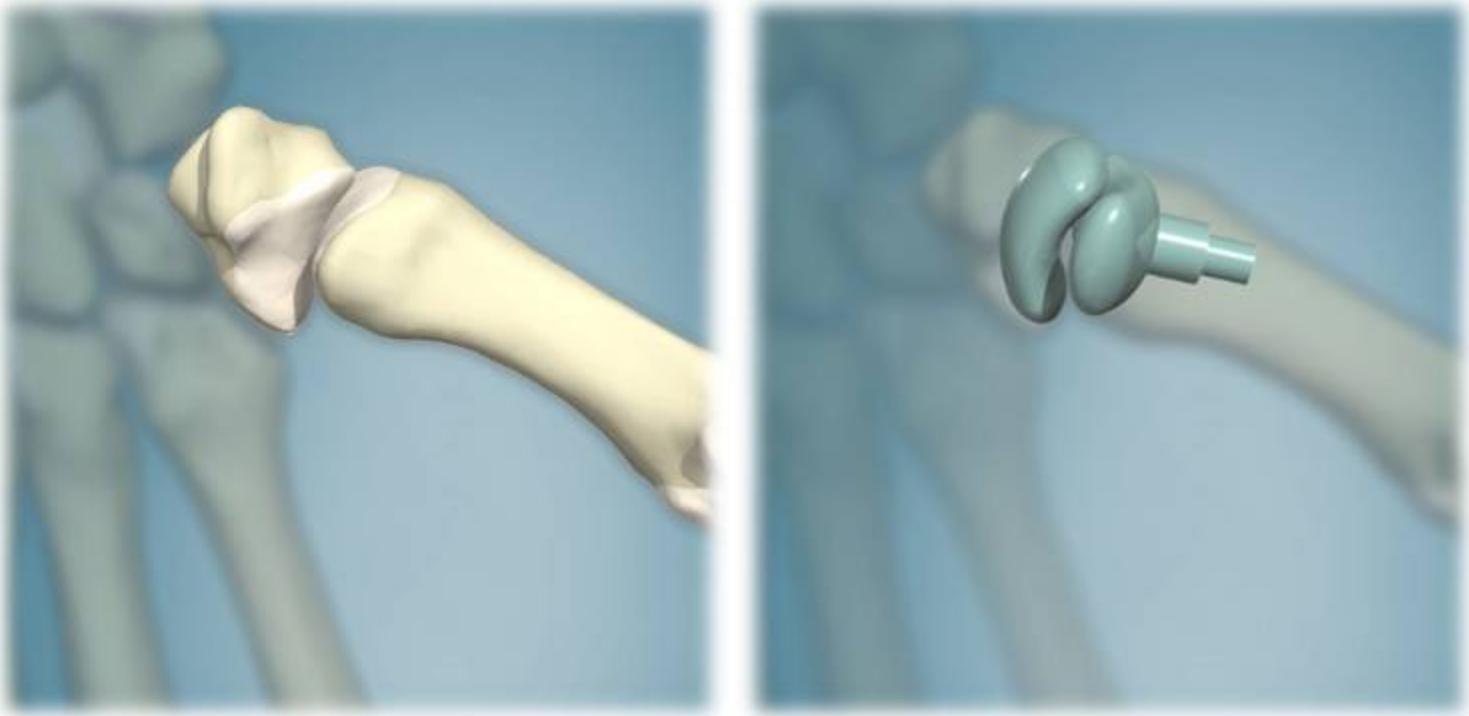
Hinge Joint

Pivot Joint

Ball and Socket Joint



Saddle Joint



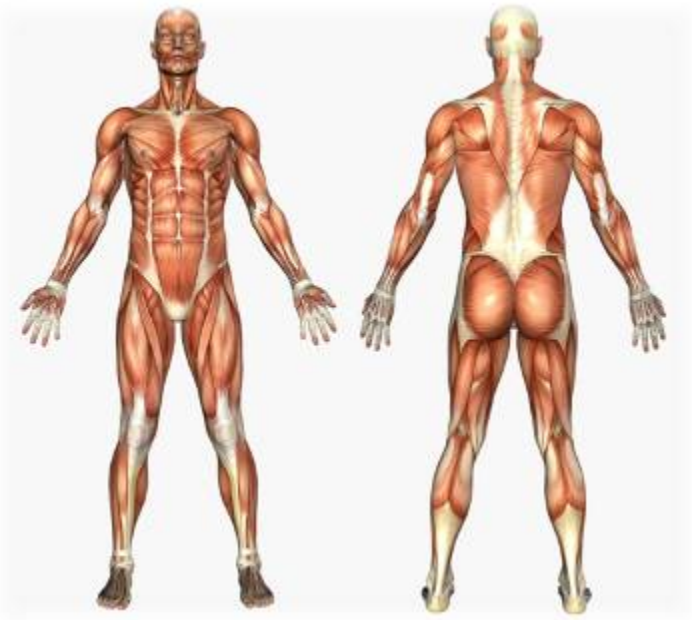
Condyloid Joint

Joint Actions

Level 2 Anatomy and Physiology
for Exercise

Joint Actions

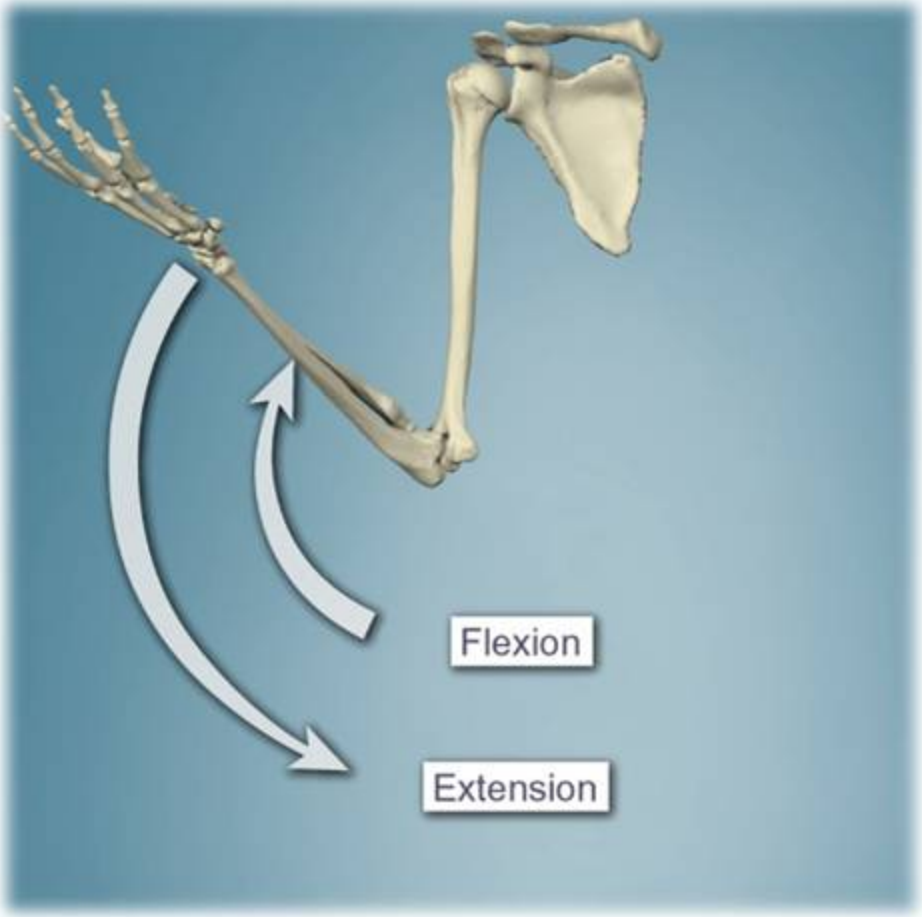
- When analysing joint actions the starting point is the anatomical position



Joint Actions

- Flexion is usually forward of the body
  - E.g. When the elbow flexes
  - Except the knee
- The joint angle decreases
- Extension is the opposite
  - Except the knee

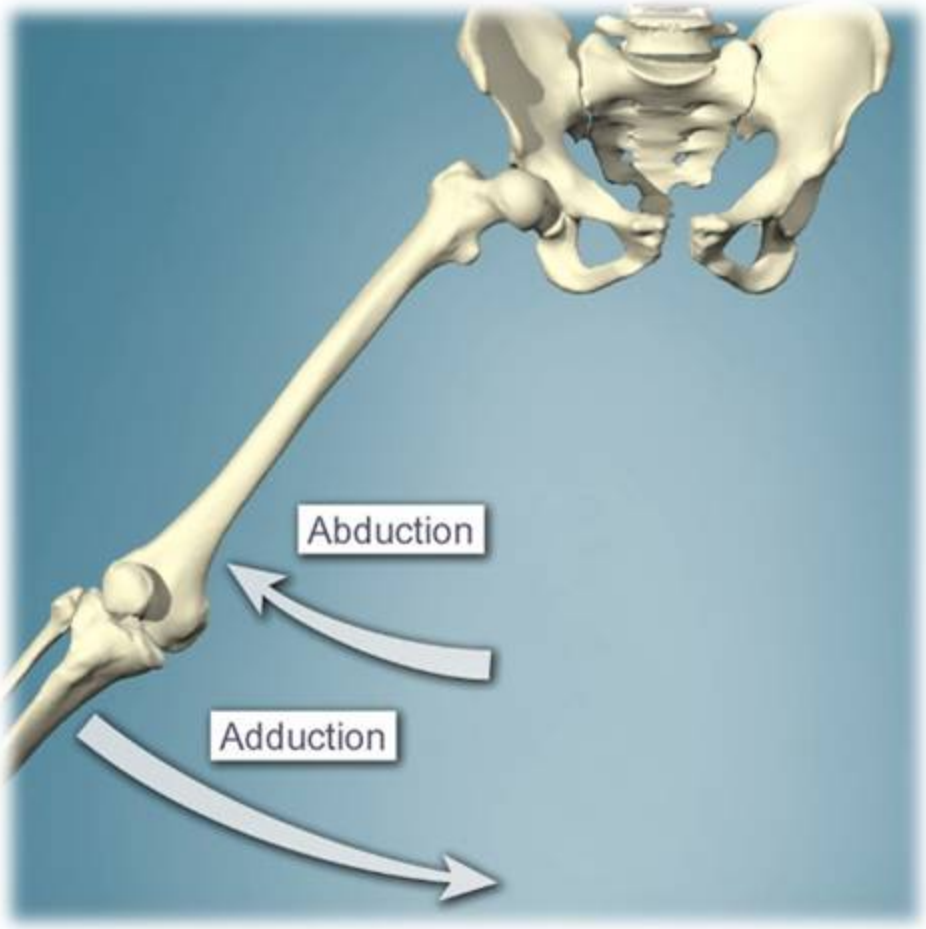
Flexion and extension



Abduction and Adduction

- Abduction – away from the midline of the body
- Adduction – towards and continuing across the midline of the body

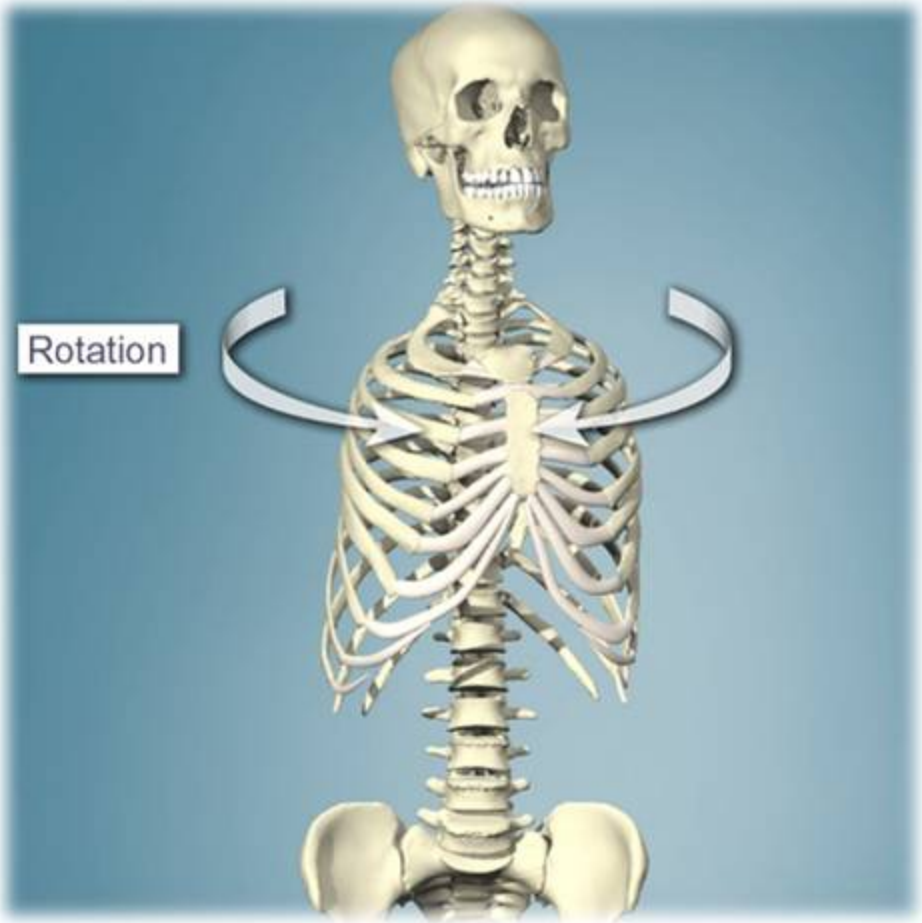
Abduction and Adduction



Rotation

- A rotary movement inward (medial) or outward (lateral)
- E.g. turning the hip in and out, or rotation of the thoracic vertebrae

Rotation

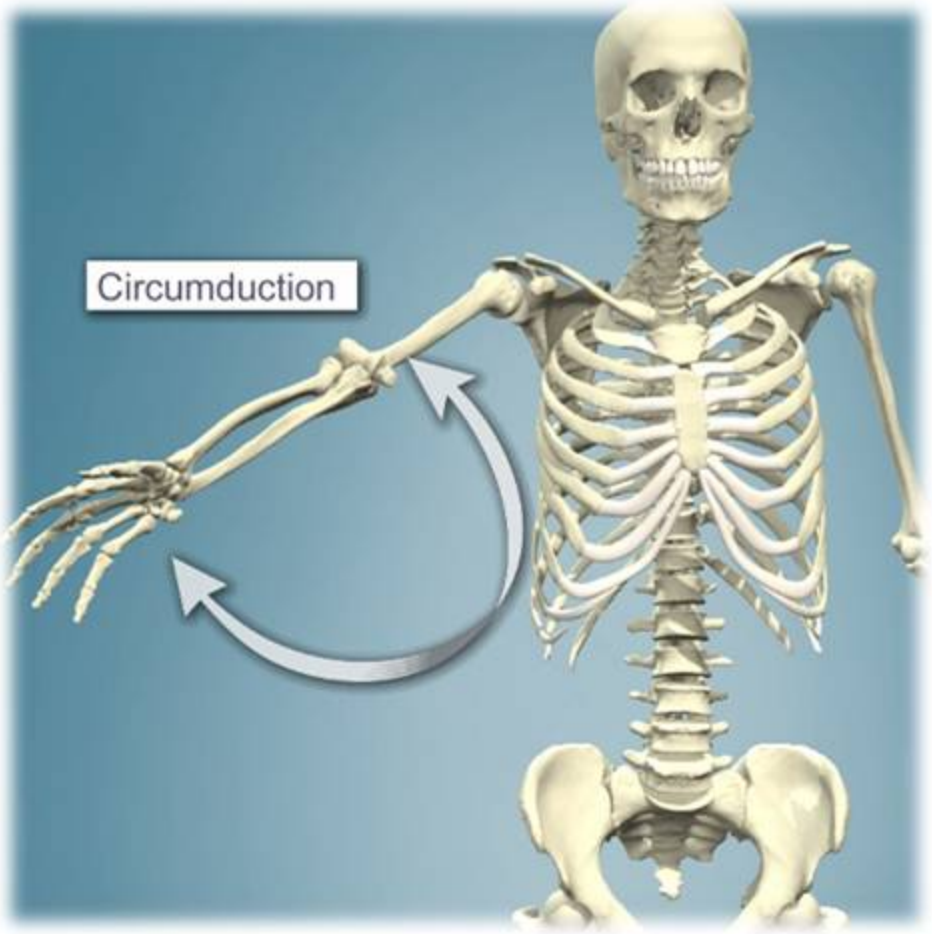


Circumduction

Circumduction

- Circle part of the body
- E.g. the ball and socket joints

Circumduction



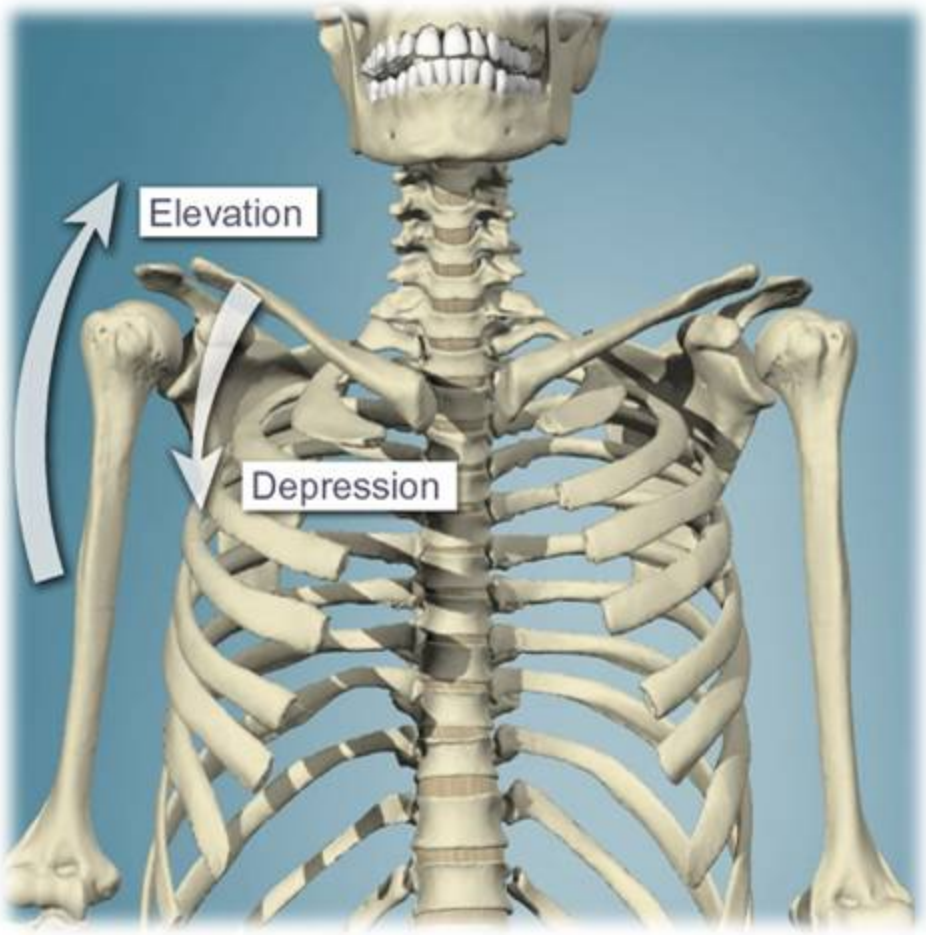
Horizontal Flexion and Extension

- Also known as Horizontal shoulder adduction (flexion) and abduction (extension)
- A forward or backward movement in the horizontal plane e.g. drawing the arm across the body

Elevation and Depression

- To lift and drop a joint
- Mainly referring to the shoulder girdle
- E.g. shrugging the shoulders

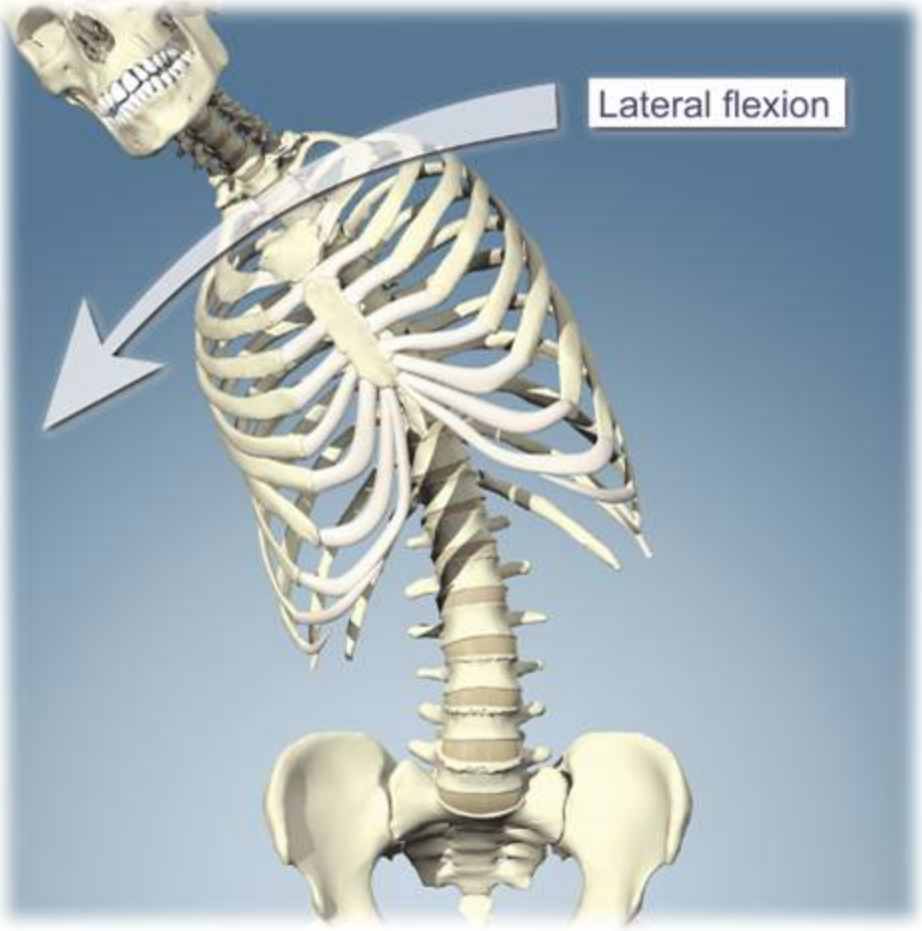
Elevation and Depression



Lateral Flexion

- Lateral flexion
  - To bend sideways with the truck or neck
- Lateral extension
  - To straighten from a sideways bending movement

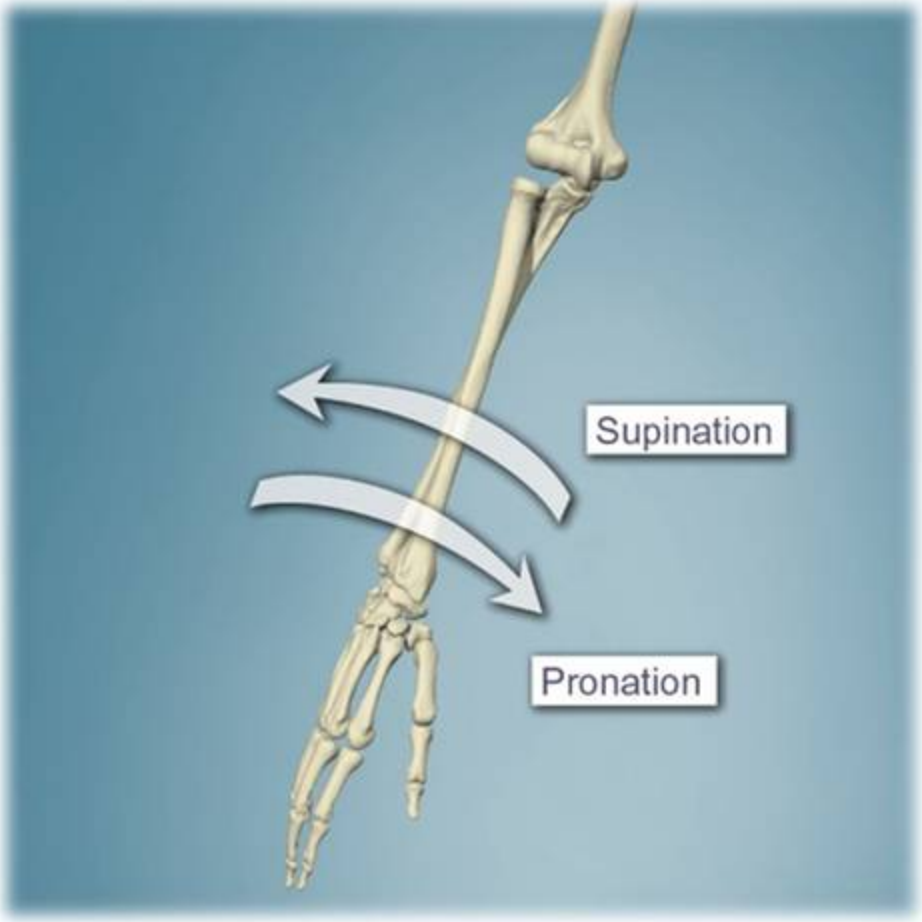
Lateral Flexion



Pronation and Supination

- Pronation
  - To turn the palm down
- Supination
  - To turn the palm up
- The terms ‘prone’ and ‘supine’ relevant to exercise
  - Prone – face down
  - Supine - face up

Pronation and Supination



Plantar and Dorsi Flexion

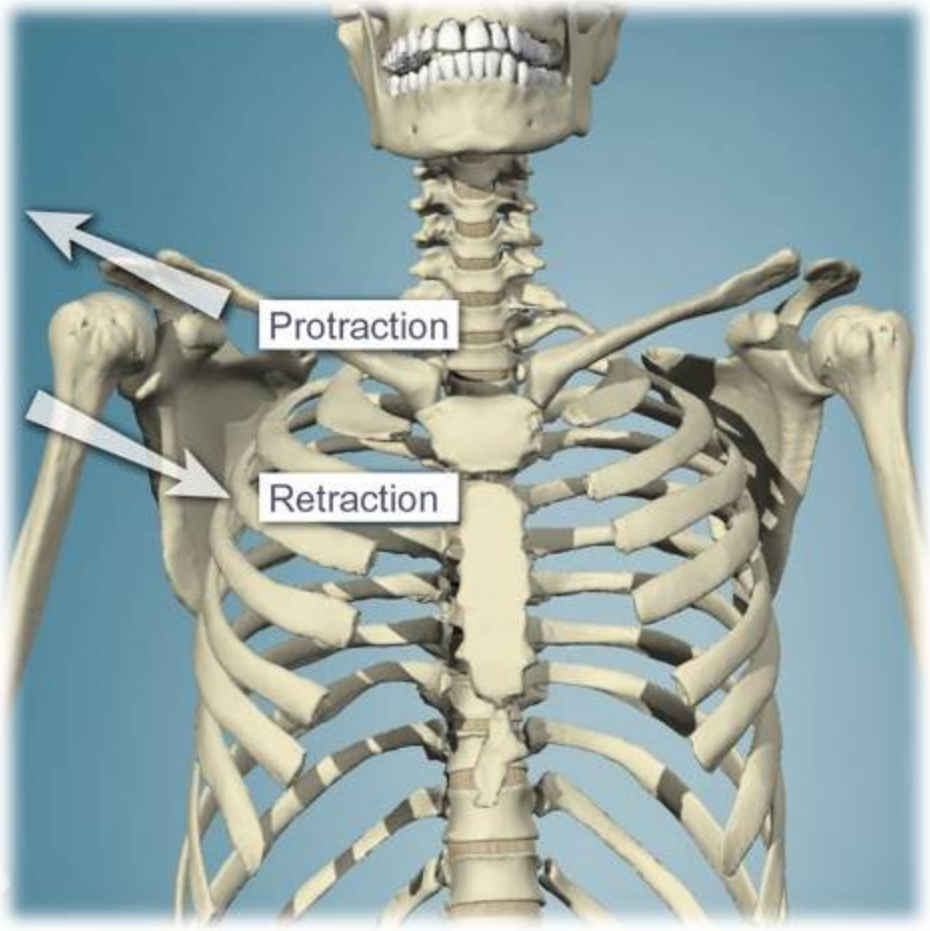
- Plantar Flexion
  - Pointing the toes away from the body
- Dorsi Flexion
  - To pull the toes towards the body

Plantar and Dorsi Flexion

Protraction and Retraction

- Protraction
  - The shoulders are drawn forwards, rounding the shoulders
- Retraction
  - The shoulders are drawn back as if to bring the shoulder blades (scapulae) as close together as possible

Protraction and Retraction



The Life-course of the Musculoskeletal System

Level 2 Anatomy and Physiology for Exercise

The musculoskeletal system - special populations

- Young people in the 14 – 16 age range
  - Growing bone not fully ossified therefore vulnerable to damage
    - Avoid heavy, very strenuous or repetitive exercise
- Pregnancy
  - Stability of synovial joints affected by the hormone relaxin and altered centre of gravity
    - Avoid high impact exercise and fast changes of direction

The musculoskeletal system - special populations

- Ageing
  - Decreased bone density – susceptibility to fractures
  - Decreased synovial fluid
  - Thinning cartilage – reduced shock absorbency
  - Less elastic ligaments and tendons – reduced joint stability
    - Work on a case by case basis with individuals but bear these changes in mind
- Disability
  - Limitations will be specific to the disability
    - Work on a case by case basis with individuals but bear these changes in mind

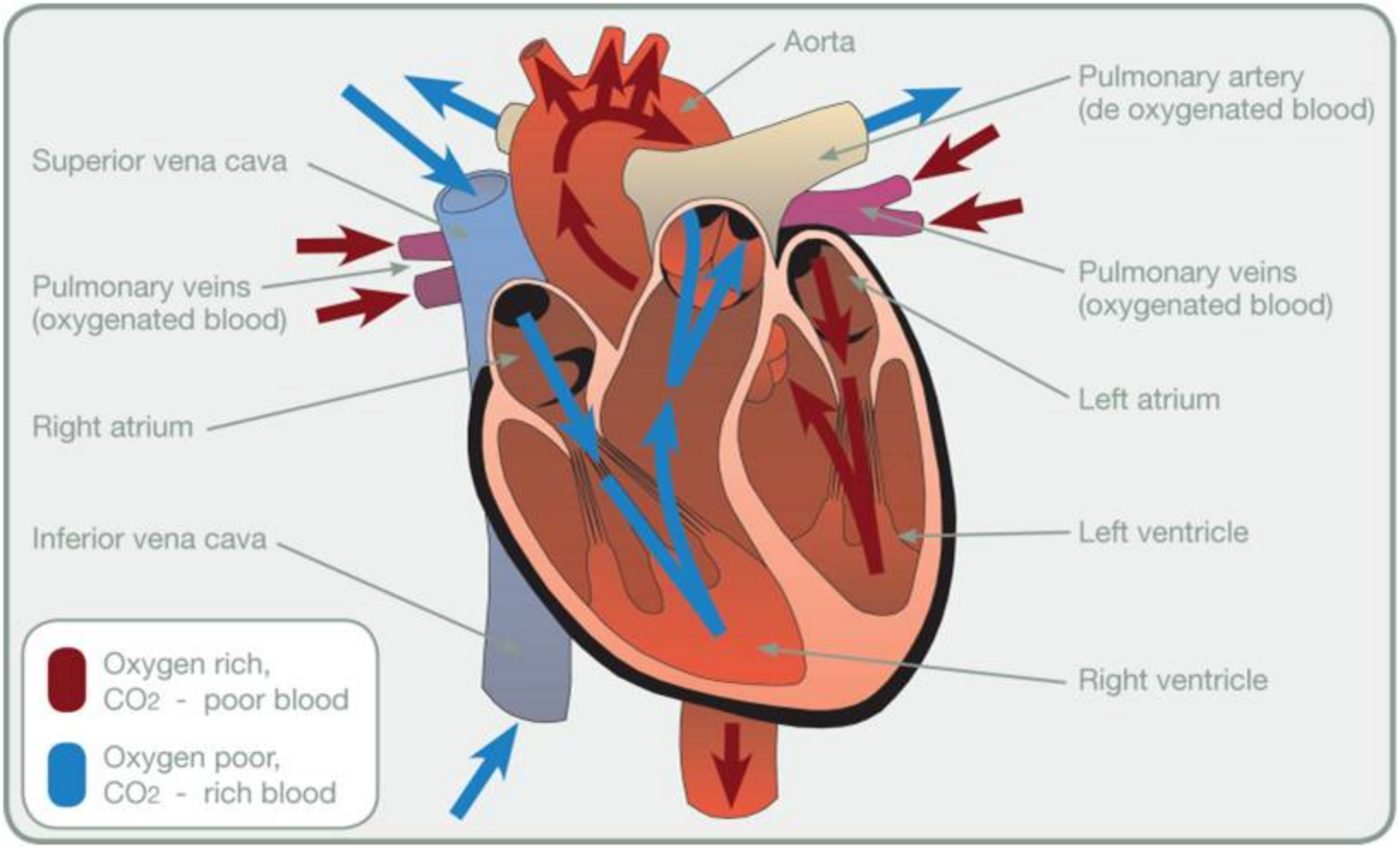
Learning Outcomes

- By the end of this section you will be able to:
  - Understand the structure and function of the circulatory system
  - Identify the location of the heart
  - Describe the function of the heart
  - Describe how blood moves through the heart
  - Describe the systemic and pulmonary circulation
  - Describe the structure and function of blood vessels
  - Define blood pressure classifications

The Heart

- Located in the chest, slightly to the left
- A pump to maintain circulation
- Two halves
  - Right, deoxygenated blood
  - Left, oxygenated blood
- Four chambers
  - 2 upper collecting chambers – atria
  - 2 lower pumping chambers – ventricles
- Valves ensure the flow is one way
- Coronary arteries supply the heart muscle with oxygenated blood

The Heart


Aorta
Pulmonary artery
(de oxygenated blood)
Superior vena cava
Pulmonary veins
(oxygenated blood)
Pulmonary veins
(oxygenated blood)
Right atrium
Left atrium
Inferior vena cava
Left ventricle
Right ventricle
Oxygen rich,
CO2 - poor blood
Oxygen poor,
CO2 - rich blood

Arteries

- Arteries carry oxygenated blood away from the heart supplying vital organs and tissues*
  - Remember ‘A’ = ‘A’way
- Thicker, muscular wall to allow blood to be shunted around the body
- Dealing with blood under high pressure

* except for the pulmonary artery - transports deoxygenated blood from the heart to the lungs

Veins

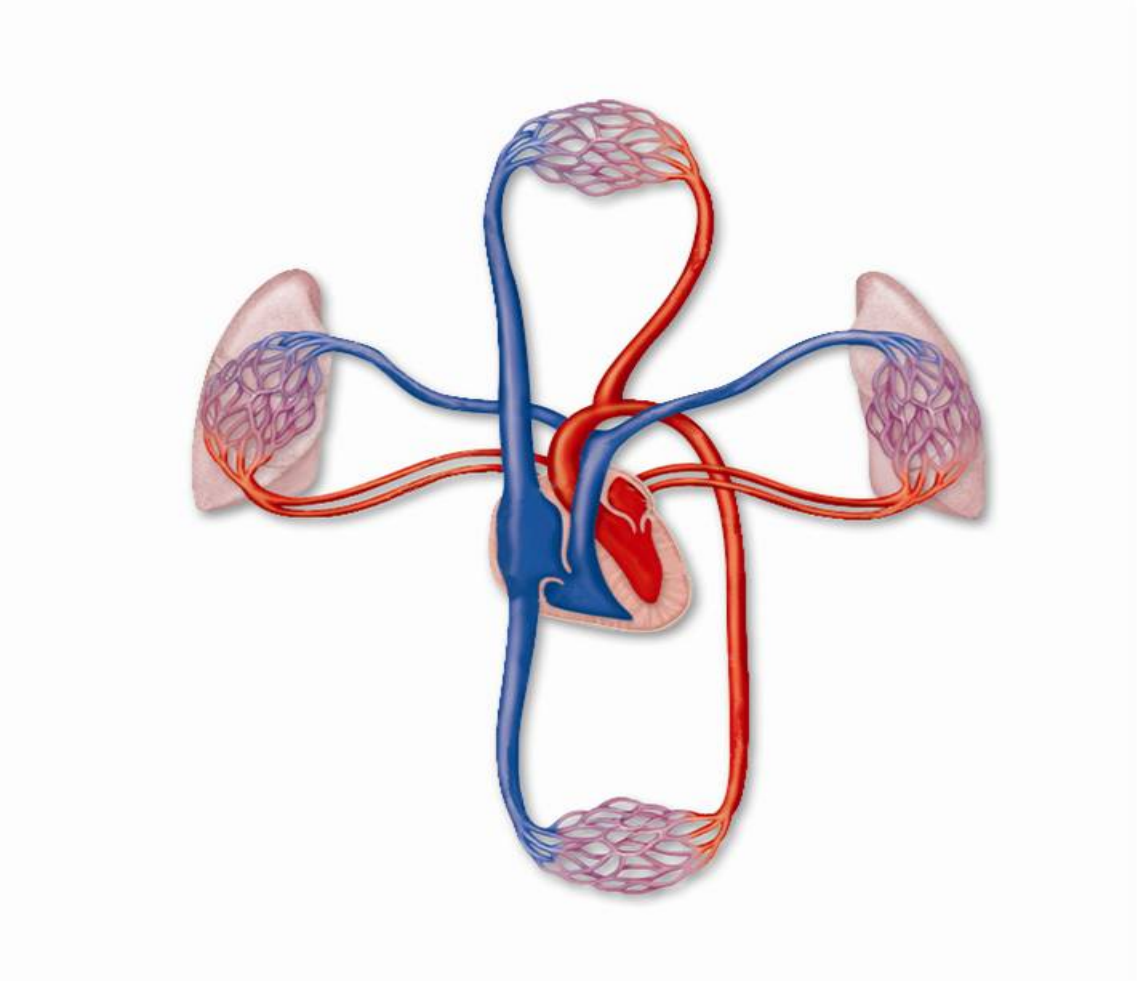
- Veins carry deoxygenated blood back towards the heart*
  - Remember ‘Ve-in’ = ‘way in’
- Thin muscular wall
- Valves to assist blood flow back to the heart and prevent back flow

* except for the pulmonary vein – transports oxygenated blood from the lungs to the heart

Capillaries

- Arteries become smaller to form arterioles which link to capillaries
- Capillaries are one cell thick to allow gaseous exchange
- From the capillaries, venules take blood into the veins, into the Vena Cava

The Circulatory System



The Pulmonary and Systemic Circulation

- The pulmonary circulation – the flow of blood from the right side of the heart to the lungs and then back to the left side of the heart. (Lower pressure)
- The systemic circulation – the flow of blood from the left side of the heart to all parts of the body. (Higher pressure)

Blood Pressure

- The pressure within the arteries
- Produced by the contraction of the heart
- Measured by:
  - Systolic pressure – when the heart contracts
  - Diastolic pressure – when the heart relaxes
- Regular exercise can lead to the reduction or normalising of high blood pressure

Blood Pressure Guidelines

- Blood pressure guidelines vary
- Source up to date and reliable guidelines

Classification of Blood Pressure for Adults		
BP Classification	Systolic BP (mmHg)	Diastolic BP (mmHg)
Normal	<120	And <80
Pre-hypertension	120-139	Or 80-89
Stage 1 Hypertension	140-159	Or 90-99
Stage 2 Hypertension	≥160	Or ≥100

The Respiratory System

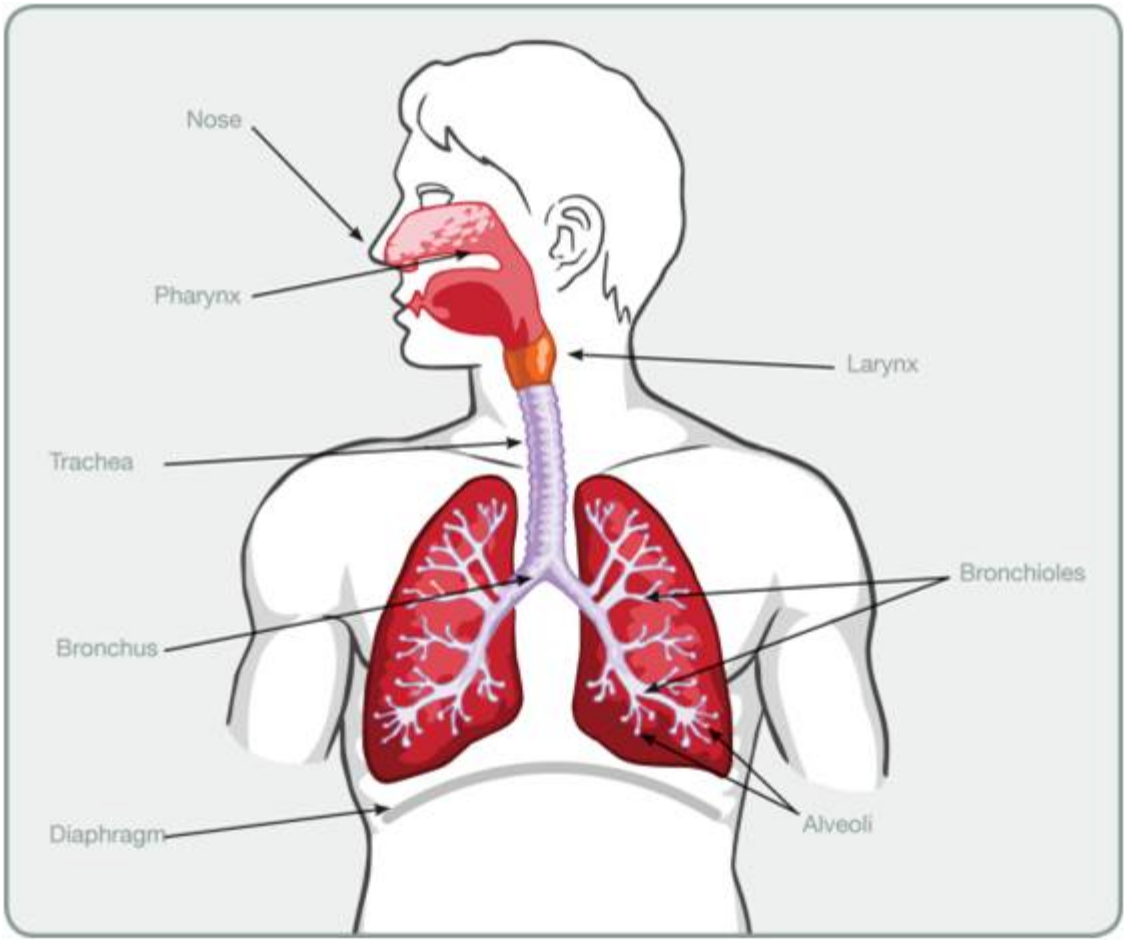
Level 2 Anatomy and Physiology for Exercise

Learning Outcomes

- By the end of this section you will be able to:
  - Understand the structure and function of the respiratory system
    - Identify the location of the lungs
    - Describe the function of the lungs
    - Describe the structure of the lungs
    - Identify the main muscles involved in breathing
    - Describe the passage of the air through the respiratory tract
    - Describe the process of gaseous exchange
    - Describe the effects of age, pregnancy and disability on the cardiovascular and respiratory systems

The Lungs

- Located in the thorax, protected by the ribs



The Air We Breathe

Normal Air	**Exhaled Air**
78% nitrogen	78% nitrogen
21% Oxygen	16% Oxygen
0.04% Carbon dioxide	4% Carbon Dioxide

Respiratory Muscles

- Diaphragm
- A dome-shaped muscle
- When it contracts, it flattens increasing the abdominal cavity

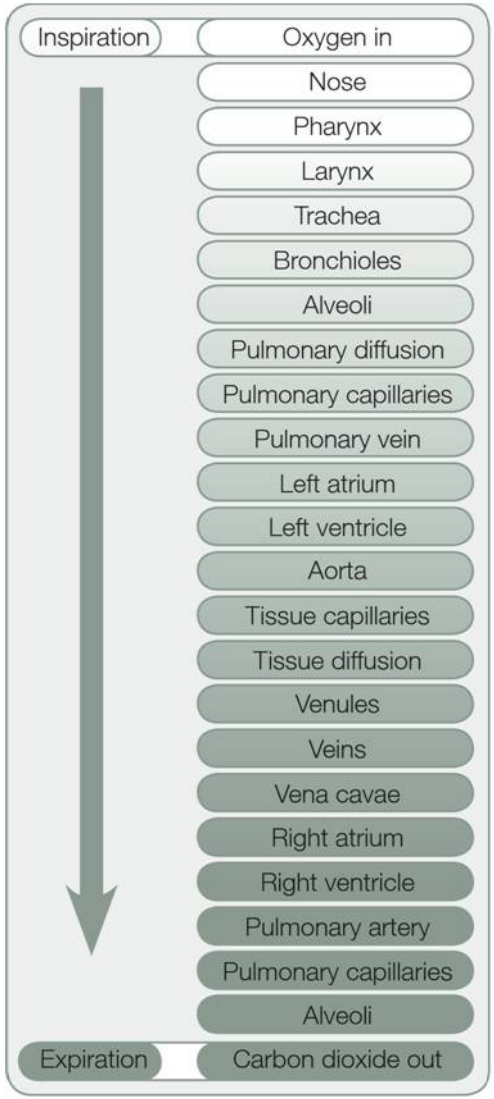
Respiratory Muscles

External intercostals

Internal intercostals

- Internal and external obliques
- External – pull the ribs upwards and outward
- Internal – pull the ribs downward and inward

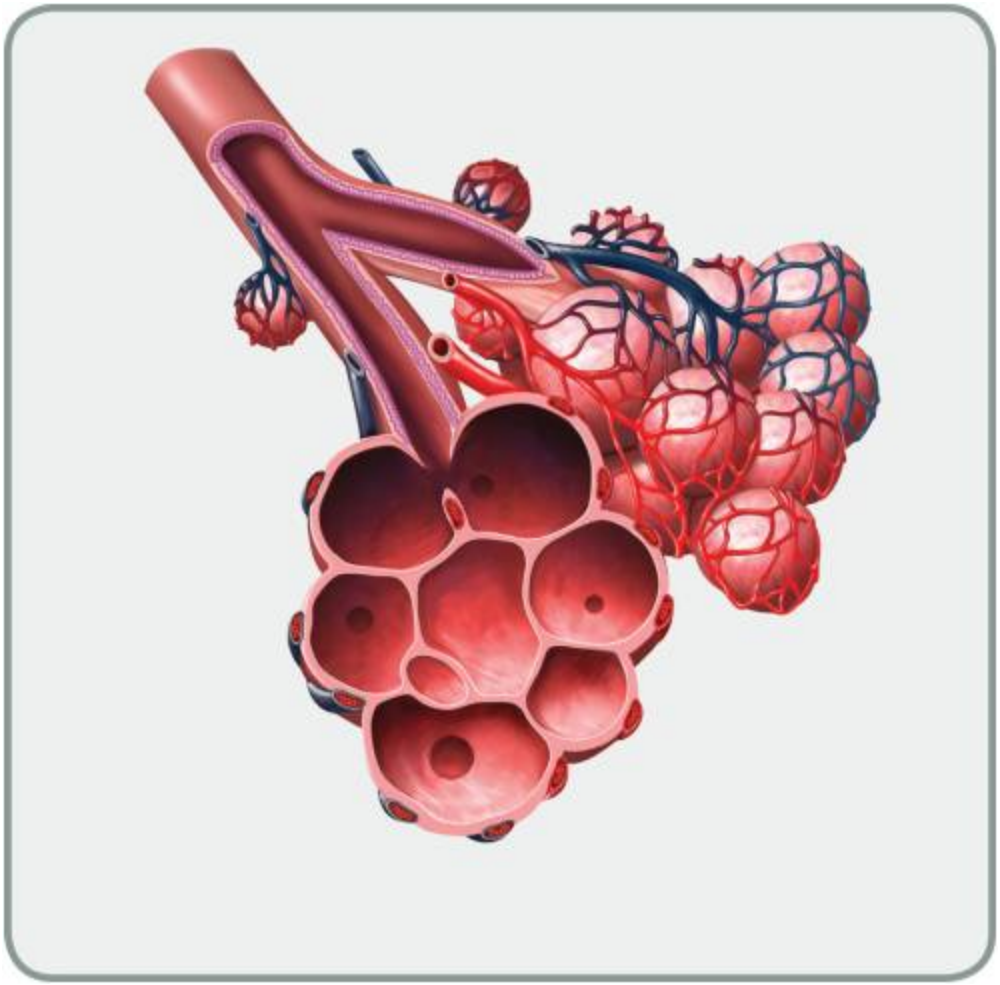
The Passage of Air



Gaseous Exchange

- Diffusion
  - The exchange of gases (oxygen and carbon dioxide) within the lungs
  - This occurs within the capillaries that surround the alveoli in the lungs

Gaseous Exchange



Cardio respiratory System – Special Populations

- Children
  - Lower blood volume
  - Less efficient temperature regulation
  - Heart chambers are smaller so heart rate is higher and stroke volume is lower
  - Less efficient in processing oxygen

Cardio respiratory System – Special Populations

- Pregnancy
  - Cardiovascular system is enhanced
  - Blood volume ↑
  - Stroke volume and cardiac output ↑
  - Resting heart rate ↑
  - Venous return ↓

Cardio respiratory System – Special Populations

- Ageing
  - Some of the age-related changes can be as follows:
    - Cardiac output ↓
    - VO2 Max ↓
    - Maximum heart rate ↓
    - Blood pressure ↑
    - General reduction in efficiency

Cardio respiratory System – Special Populations

- Disability
  - There are a range of medical conditions and disabilities which can have an impact on the function of the cardio and respiratory systems.
  - These will be specific to each individual

Learning Outcomes

- By the end of this section you will:

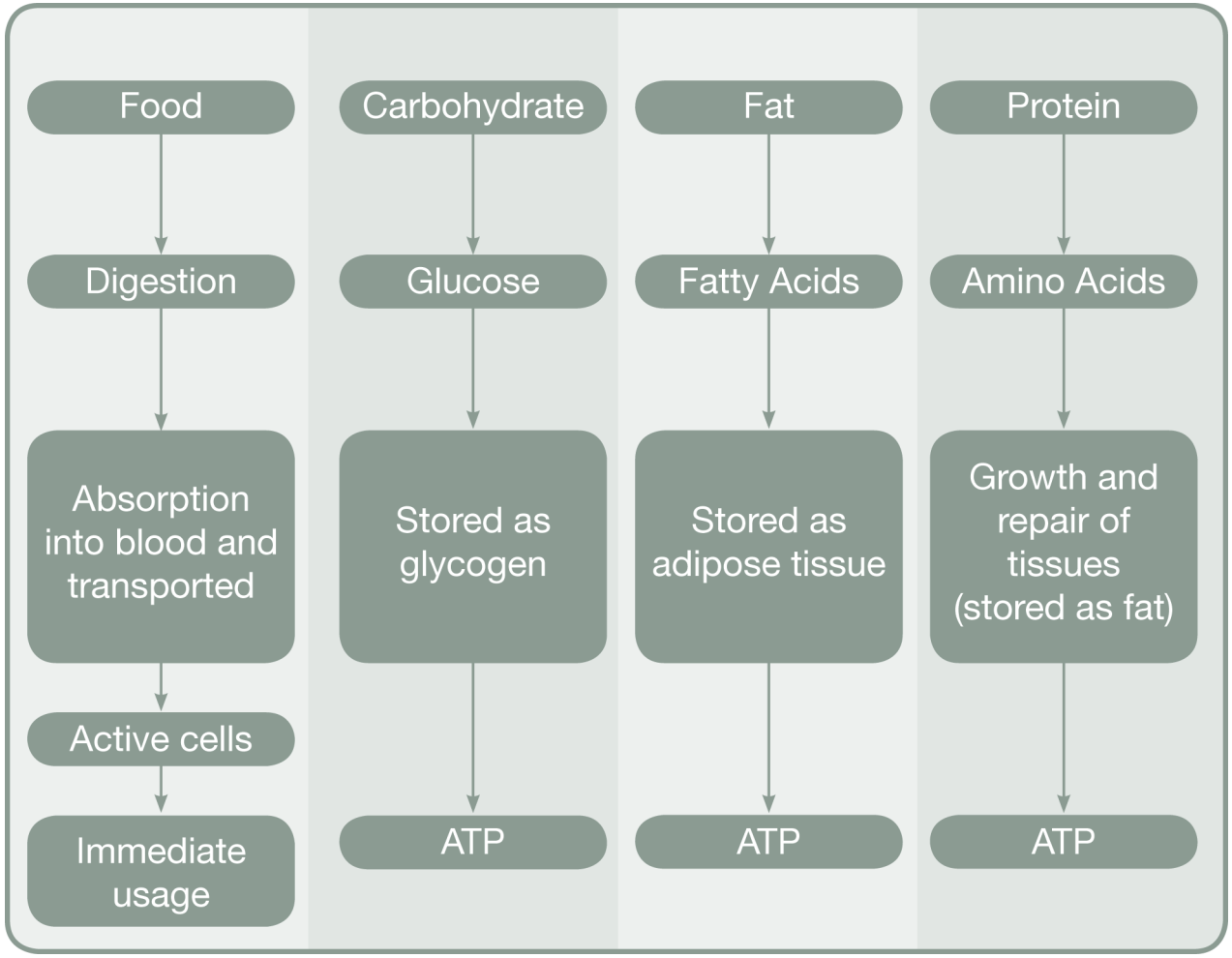
Understand energy systems and their relation to exercise

- Describe how carbohydrates, fats and proteins are used in the production of energy
- Explain the use of the three energy systems during aerobic and anaerobic respiration
- Describe the effects of age, pregnancy and disability on the energy systems

Energy

- Energy comes from the food we eat:
  - Carbohydrate
    - Stored in muscle and liver cells in the form of glycogen
  - Fat
    - Stored as adipose tissue
  - Protein
    - Used as the building material for growth and repair

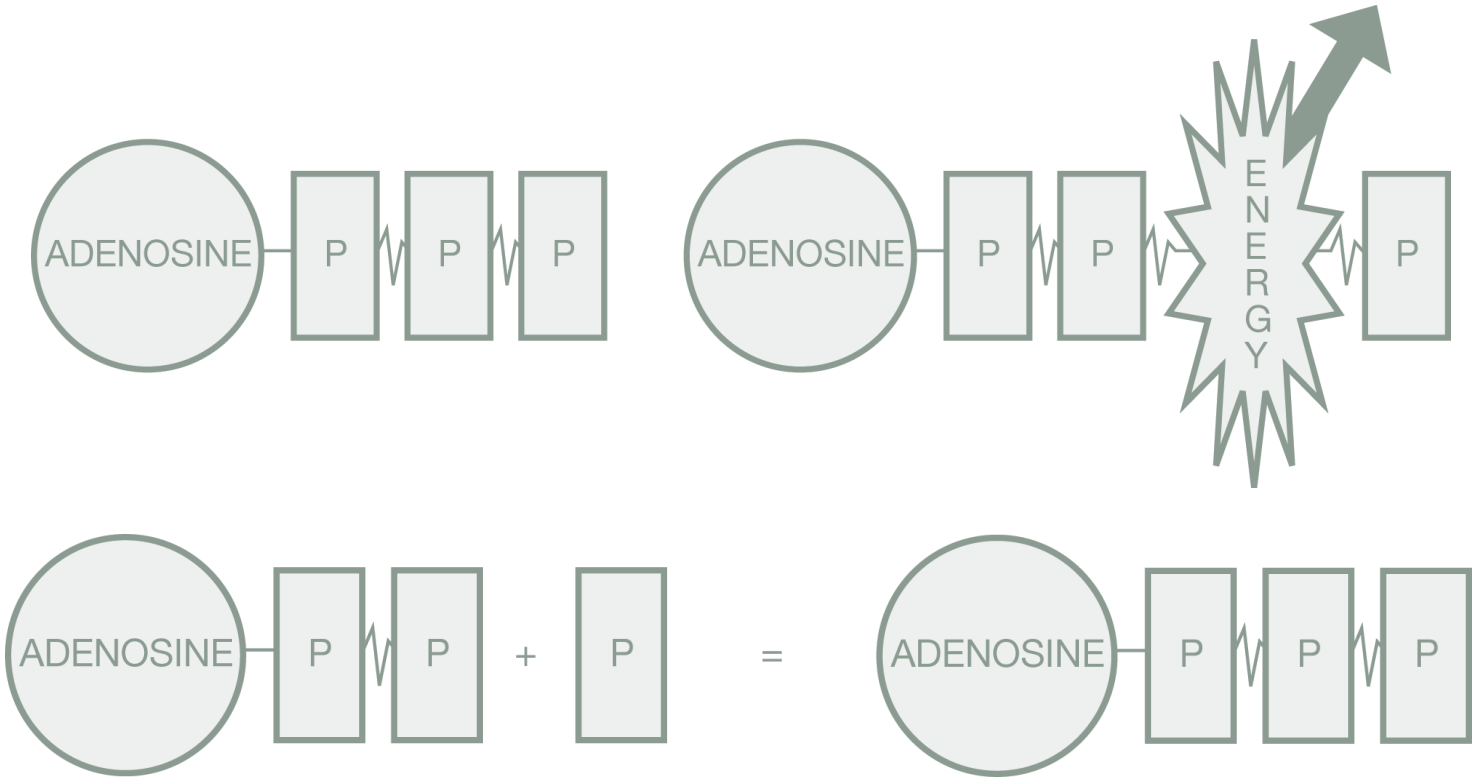
Energy


Food
Digestion
Absorption into blood and transported
Active cells
Immediate usage
Carbohydrate
Glucose
Stored as glycogen
ATP
Fat
Fatty Acids
Stored as adipose tissue
ATP
Protein
Amino Acids
Growth and repair of tissues (stored as fat)
ATP

Energy

- Energy is released in the body by the breakdown of carbohydrates, fat and protein to produce:
  - Adenosine Triphosphate (ATP)
  - The body's energy 'currency'

ATP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The Energy Systems

- Phosphocreatine system
  - Used for high intensity / short duration activities (about 6 – 10 seconds)
  - Anaerobic
  - Energy supplied by creatine phosphate

The Energy Systems

- Lactic acid system
  - Used for moderate to high intensity / short duration activities (about 90 seconds)
  - Anaerobic
  - Energy supplied by glycogen

The Energy Systems

- Aerobic system
  - Used for low to moderate intensity / longer duration activities (about 90 seconds)
  - Aerobic
  - Energy supplied by glycogen and fat

Learning Outcomes

- By the end of this section you will:

Understand the nervous system and its relation to exercise

- Describe the role and functions of the nervous system
- Describe the ‘all or none’ law / motor unit recruitment
- Describe how exercise can enhance neuromuscular connections and improve motor fitness

The Nervous System

- Functions
  - Controls all the actions of all bodily systems
  - Maintain ‘homeostasis’
    - The body maintaining balance to operate effectively

The Nervous System

- Sensory input
  - To sense changes inside and outside the body
- Interpretation
  - To analyse and interpret incoming information
- Motor output
  - To respond to the information by activating the relevant bodily system

The Nervous System – Structure

- Central nervous system (CNS)
  - The brain and the spinal cord
- The peripheral nervous system
  - 31 pairs of nerves that branch from the CNS
  - Sends messages back to the CNS
  - Two branches:
    - Somatic
    - Autonomic
      - Sympathetic
      - Parasympathetic

The Nervous System – Responses to training

- Strengthening/ growing new connections within the nervous system
- Speeding up the frequency of nerve impulses to the motor units
- Improved synchronous recruitment of motor units resulting in stronger muscle contractions

The Nervous System – Special Populations

- Many disabling neurological diseases and disorders that can affect the nervous system
- Ageing
  - Slower processing time
  - Increased risk of falls