SR1002 Assessment 1 Revision

Total Lectures:

1. Anatomy I
2. Anatomy II
3. Anatomy III
4. Respiration I
5. Respiration II
6. Respiration III
7. Respiration IV
8. Respiration V
9. Respiration VI

9 Lectures – Finish at least 6 and you’re set.

# Lecture 1 – Anatomy

Levels of structural organisation in the body

* Molecules
* Organelles
* Cells
* Tissues
* Organs
* Organ systems
* Organisms

Microscopic -> macroscopic

Simplest -> most complex

## Principle of complementarity

Function always reflects structure

What a structure can do depends on its specific form.

I.e. the structure of the heart was known be the 15th century, but it took 200 years until someone demonstrated that it pumped blood around the body.

When studying the body, we divide is to standard sections to make life easier.

Upper extremities

Back

Head and neck

Thorax

Abdomen

Pelvis and perineum

Lower extremity

## Keyhole surgery vs traditional surgery

A deeper understanding of anatomy has allowed us to more accurately locate where to operate, minimize trauma and speed up recovery. Keyhole surgery is used, where holes are made instead of making a deep incision for operation.

Anatomy helps when giving anaesthesia, for e.g. directly to the spinal cord. It is surrounded by nerves that cannot be regrown if damaged. Venepuncture is performed at specific sites where we know veins are near the surface, and usually no major or fragile struectures that could be damaged by the needle.

## Pathology

Clinical **pathology** is a medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of bodily fluids such as blood and urine, as well as tissues, using the tools of chemistry, clinical microbiology, hematology and molecular **pathology**

Tumours

Identify stages of disease

Monitor disease progress

Confirm disease before death

## Development and evolution

Same bones found in leg part of humans, dogs, seals, birds etc.

Humans and apes share many anatomical features, but move in different ways due to differing postures.

Anatomical comparisons show differences in muscle position, sizes and structure of the inner ear which controls balance. The development of these features make it easier for humans to stand.

## Sports and athletic performance

Gait analysis and biomechanics – understand the way people move, how much force is generated, identify problems with posture etc.

E.g. look at pole-vaulters and stuff like that.

Disability

Development of artificial/replacement body parts

Allows us to identify why damage in particular spinal segments causes loss of different physiological functions.

## Structure may indicate function

Cell shape/structure may indicate potential functions

Brain shape – folds

Fold of intestine and villi/microvilli

Skeletal muscle stripes

Bone matrix

## Brain

Anatomists try to map the brain and work out whether certain areas control certain body functions

Blood vessels in the brain can also work out what might happen if someone has a stroke or a bleed in the brain.

However, we still don’t know much about it.

Folds in brain cells allow many nerve cells to be packed into a relatively small space.

## Skeletal muscle

Stripes on skeletal muscle and regular arrangements indicate that they are strong and can generate a lot of force when contracted.

## Bone

Bone has a hollow hard component, but it also has flexible jelly-like marrow.

## Intestine

Lots of folds makes lots of surface area.

## Archaeology & art

Carbon dating, may establish gender, size, age, lifestyle.

## Virtuvian Man

Virtuvian man, by da Vinci. Human of average proportions

## Security

Biometrics, iris scanners

## Summary

Anatomy is an essential part of biologically related sciences

Applied in many ways.

Can be studied in the molecular until the organismal levels.

Anatomy II

Why study anatomy and physiology together?

Structure of the body allows performance of certain functions

E.g.

Bones of the skull join tightly to form a rigid case to protect the brain.

Bones of the finger by contrast are more loose, allowing for movements

Walls of the air sacs in the lungs are thin for oxygen movement

Lining of the urinary bladder is thick, yet stretchy as it fills with urine.

Sub disciplines of physiology

* Neurophysiology – Functional properties of nerve cells
* Endocrinology – Represents hormones in the blood and how they control body functions
* Cardiovascular physiology- functions of the heart and blood vessels
* Immunology – how body defends itself against disease-causing agents
* Respiratory physiology – functions of air passages and lungs
* Renal physiology- functions of the kidneys

# Levels of organisation

Atoms

Cells – Smallest living things

Tissues – Group of cells with similar function

Organs – Structure made of different tissue types to perform a specific function in the body

Organ systems – Group of organs cooperating to accomplish a common purpose. There are 11 organ systems in the body, each with a unique function.

## Organ system functions

Integumentary system- skin, nails hair etc. – protective function, insulates and cushions

Skeletal system – Body protection and motion

Muscular system – contraction, responsible for virtually all body movement

Nervous system – control and communication

Endocrine system – coordinates and directs cellular activity

Cardiovascular system – transportation of oxygen, nutrients, waste and hormones.

Lymphatic system – fluid transport, body defence and disease resistance

Respiratory system – exchange gases to supply oxygen and remove carbon dioxide

Digestive system – converts blood into raw materials that build and fuel the body

Urinary

Reproductive

## Necessary life functions

Maintaining boundaries

Movement

Responsiveness

Digestion

Metabolism

Excretion

Reproduction

Growth

Movement

Respiration

Sensitivity

Growth

Reproduction

Excretion

Nutrition

## Basis for anatomical terminology

We must be precise when describing the body

Official index for anatomical terminology

Latin is used for this

## Anatomical Position

Body erect

All facing forward, limbs at sides of body and palms directed forward

## Anatomical planes

Median – vertical, front to back in midline

Frontal

Horizontal

Sagittal

Medial – closer to median plane

Laterial – further from median plane

Anterior – Towards front of body

Posterior – towards back of body

Superior – Towards head

Superficial – towards the surface of the body

Deep – towards the center of the body

Terms of movement

Flex, extent, protraction, retraction, elevation, depression etcc

## Summary

Anatomy and physiology are intertwined

Humans can be studied at any level of the structural hierarchy

Human body is so complex that we must classify and name its parts precisely

Anatomy III

# How do genders vary in anatomy?

* Pelvis
* Musculature
* Hormones
* BMI/body size/fat/water
* Finger size
* Breast tissue
* XX female or XY chromosomes
* Sports performance
* Child bearing capacity
* Life length
* Structure of the brain

Diseases that occur more frequently in women:

* Osteoporosis
* Autoimmune disease
* Depression

Sex-based differences in disease found in most/all organ systems

Respiratory

Gastrointestinal

Renal

Skin

Reproducive/genitourinary

Potential causes of sex-based differences in normal physiology and disease

Societal

* Lifestyle/behaviour
* Environmental
* Healthcare

Genetic

* Linked to x or y chromosome

Effects of the sex steroids

* Androgems, estrogens etccc

## Sex hormones and life stages

Prenatal development

* Sexual differentiation

Maturation

Menstrual cycle

Pregnancy

Gradual decline is testosterone with aging, both men and women

Sex based differences in body composition and structure

Males have:

* Greater bone mass, muscle mass, lower body fat percentage

Females have:

* Heart, brain, gastrointestinal system

## Other differences

Men have lower heart rate

Higher blood pressure

Difference abolished after menopause

Kidney filtration rate lower in young women than age-matched men

May decline more rapidly with aging in men than women

## Differences in heart disease

Heart disease starts 10 years later in women than men

Stroke more common in women than men

Men have significantly greater left ventricular mass and chamber size than women.

Women have lower resting blood pressure but higher resting heart rate. Reduced tolerance to shifting posture or sudden changes in position.

## Signs of heart attack:

1. Chest discomfort of uncomfortable pressure
2. Spreading pain to arms, back, jaw or stomach
3. Cold sweats and nausea

However, gender can affect these symptoms.

Women don’t experience the “hallmarks” of heart attack, instead they experience:

* Shortness of breath,
* Nausea,
* Vomiting
* Sleeplessness
* Back pain or jaw pain
* Generalized weakness, fatigue

## Gender & Metabolism

Females have higher body fat percentage, lower muscle mass

Metabolise differently depending on their menstrual cycle.

Burn more fat and less carbohydrate and protein compared with males during endurance exercise

## Gender & lung capacity

Men have larger lungs, wider airways, greater lung diffusion capacity.

## Gender & the nervous system

Not that much actual difference, although there’s a lot of speculation.

Two areas of the hypothalamus have clear differences in male and female brains.

Skeletons can be used to determine gender. E.g. pelvis is a big difference.

## Summary

* Gender has profound effects on physiological and anatomical parameters
* Neither gender is superior, just different
* Gender has significant implications on life expectancy.

Respiration 1

The cardiovascular and respiratory systems function in an integrated manner. Together they ensure access to the oxygen for every cell in the body, also dispose CO2.

During exercise muscle requires more oxygen and the cardiovascular and respiratory systems must adapt to meet by redirecting blood, increasing cardiac output, respiratory rate and tidal volume.

* External respiration: movement of gasses between environment and the body’s cells.
* Cellular respiration: intracellular reaction of O2 with various molecules to produce C02, H20 and energy

# Respiratory system

Nose -> Pharynx (throat) -> Epiglottis (flap tissue) -> Larynx (vocal chords) -> Trachea (Entry to lungs) -> Bronchus (Moves from trachea into left and right bronchi) -> Lung

## Airways

The Trachea branches into two bronchi, one to each lung. Each bronchus branches 22 more times, terminating in a cluster of alveoli.

Alveoli are in a cluster, surrounded by elastic fibres and a network of capillaries. They have goblets to produce mucus to the surface, which traps inhaled particles.

Alveoli are composed of type I cells for gas exchange and type II cells that synthesize surfactant.

## Partial Pressure: the driving force of gas exchange.

Total pressure of a mixture of gases is the sum of pressures of the individual gases. Pressure of a single gas in a mixture is referred to as Partial Pressure (P).

Individual gases diffuse from the areas of higher to lower partial pressure. This **gradient the is primary driving force** of the lung-blood and blood-cells gas exchanges.

Airways connect lungs to the environment via about 20-30 branched generations. Alveolar surface area for gas exchange is about the area of a tennis court.

Pulmonary circulation is a high-flow, low-pressure system.

## Breathing

Occurs due to the thoracic cavity changes volume.

Uses external intercostal and diaphragm. (function of skeletal muscles)

Expiration is passive at rest, but uses internal intercostal and abdominals during severe respiratory load.

Diaphragm sits under the lungs, but contracts and relaxes changing thoracic volume. It is ‘up’ when it is relaxed.

**Intercostal** are skeletal muscles in between the ribs, making a ‘pump’ for the lungs.

Lung volume changes, can go up to total lung capacity when at full exertion.

The rate at which alveolar air is renewed, alveolar ventilation, is lower due to the effect of dead space. Dead space is everything from the mouth to the alveoli, this air is not used for oxygen.

Not even close to all alveolar air is changed each breath.

Pressure in the lung changes with diaphragm and the intercostal muscles.

Steps involved in respiration:

* Ventilation
* Gas exchange between alveolar air and lung capillaries
* Bulk transport via the circulation
* Gas exchange between capillaries and tissue cells
* Cellular utilization of O2 and production of CO2

## Ventilation and work

* Increased work is initially matched by increasing ventilation
* At low work rates, extra ventilation achieved largely by increased tidal volume
* As work continues to increase, breathing rate increases, tidal volume increases and more.

## Regulation of breathing

* Respiratory muscles are under neural control in the medulla oblongata and pons, in the brainstem and voluntary control.
* Central Chemoreceptors located in the brain monitor CO2 triggering inspiratory centre when levels rise
* Peripheral chemoreceptors located in the aortic arch and carotid artery
* Stretch receptors in air passages stimulate the expiratory centre to prevent lung over-inflation.

# Summary

* Aerobic metabolism in living cells consumes oxygen and produces CO2
* Gas exchange requires a large, thin, moist, exchange surface, a pump to move air in and out and a circulatory system to transport gases to and from the cells.
* Respiration is controlled via reflex pathways and central pattern generator with voluntary override.
* Respiratory system functions include gas exchange, pH regulation, vocalization and protection from foreign substances.

Circulation & Heart 3,4

Introduction

Cardiovascular system consist of two circuits:

**Pulmonary circulation** from the right ventricle to the lungs and then to the left atrium, and the

**Systemic circulation** from the left ventricle to all peripheral organs, tissues and then to the right atrium.

**Arteries** carry blood away from the heart, veins carry blood towards the heart.

In the **systemic circuit**, the large artery leaving the left heart is the aorta, and the large veins emptying into the right heart are the superior vena cava and the inferior vena cava.

Analogous vessels in the pulmonary circulation are the pulmonary trunk and the four pulmonary veins.

There’s a pressure gradient between veins and arteries.

The atrioventricular valves prevent flow from the ventricles back into the atria.

The pulmonary and aortic valves prevent flow from the pulmonary trunk into the right ventricle and from the aorta into the left ventricle.

Cardiac muscle cells are joined by gap junctions that permit action potentials to be conducted from cell to cell.

# Cellular and molecular mechanisms of the cardiac function

Action potential changes depolarization and repolarization. Na, K+ and Ca2+ ions play a critical role in the development of action potential in cardiac cells. There is a gradient of these ions across the cell membrane.

## Heart Beat

Membrane potential rises until it hits the threshold triggering action potential. Current leaves from the SA node and goes to ventricles etc. triggering the muscle. Na+ channels open, Ca2+ channels open then it goes back to resting potential.

Calcium enters from adjacent cells, enter into cytoplasm through voltage gated Ca2+ channels, the ca2+ triggers release of more Ca from sarcoplasmic reticulum. These ions bind to troponin to initiate contraction. Relaxation occurs when CA2+ unbinds from troponin ( made of actin and myosin). Ca is pumped back into the sarcoplasmic reticulum for storage, and CA2+ is exchanged with Na+ and the Na+ gradient is maintained by pumps and shit.

## Cardiac electrophysiology

Cardiac muscle cells must undergo action potentials for contraction to occur.

Rapid depolarization in atrial and ventricular cells is due to increase in cell membrane permeability to sodium and calcium.

Calcium, mainly released from the sarcoplasmic reticulum (SR), functions as the excitation- contraction coupler in cardiac muscle by combining with troponin.

Cardiac muscle cannot undergo summation of contractions as it has a long refractory period.

## Summary

SA node generates the current that leads to depolarization of all other cardiac muscle cells.

SA node manifests a pacemaker potential, which brings is membrane potential to threshold and initiates an action potential.

Impulse spreads from the SA node throughout both atria to the AV node, where a small delay occurs. The impulse then passes into the bundle of His, right and left bundle branches, purkinje fibres and nonconducting-system ventricular fibres.

## Cardiac cycle summary

Cycle is divided into systole (contraction) and diastole (relaxation)