Introduction

For the completion of the Applied Physiology assignment, students are asked to research and discuss the structure and function of three of the bodies systems, these systems are respiratory, cardiovascular and renal.

Research will then be done on the composition and function of blood, explaining the normal function of red and white blood cells and platelets. This will also include the destruction process and the normal clotting mechanism.

Students are also asked to describe the relationship between the three systems and homeostatic mechanisms in maintaining physiological function. This will also mean looking at the structure of the trachea and nose, the bronchi and the lungs and the heart and the lungs to explain homeostasis.

All of these systems may experience disorders within their normal mechanisms i.e. coronary heart disease, cardiovascular disease, chronic respiratory diseases and renal diseases.

Blood groups will also be identified and the Rhesus factor described, this will also include the causes of iron deficiency and anaemia.

Relate structure and function of the respiratory system, the cardiovascular system and the renal system

The respiratory system

The respiratory system consists of the nasal cavity, pharynx, larynx, trachea, bronchi, the lungs, alveoli, rib cage and the diaphragm. Working together with breathing muscles the respiratory system carries air in and out of the lungs.

The nasal cavity is the first of the respiratory organs and is made up of a large irregular cavity, divided by the septum. It is lined with ciliated epithelium, this ensures that the air is warm, filtered and moistened as it passes through the nose. As the air is warm as it passes through the nose any mucus which comes in contact with the nose will be filtered in the sense that dust particles and other impurities stick to the mucus membrane which lines the nasal cavity. The surface hairs called cilia also trap dust particles ready for them to be sneezed out. A similar membrane also lines the larynx and trachea; the cilia will move the particles towards the oropharynx to be swallowed.

Once the air has passed through the nose it moves into the pharynx (the throat). The pharynx is also a common passageway for food and water. It is a funnel shaped tube, which begins at the internal nasal passages; the tube is on average 12 to 14cm long and extends from the base of the skull to the level of the sixth cervical vertebra. It lies behind the nose, mouth and larynx and is wider at its upper end. The pharynx consists of three layers of tissue:

- Mucus membrane lining
- Fibrous tissue
- Muscle tissue

The pharynx is an organ, which is involved, in both respiratory and digestive system; air passes through the nasal and oral parts and food passes through the oral and laryngeal parts. Using the same methods, the air, which passes through the pharynx is filtered, warmed and moistened. When the air has passed through the pharynx it continues its journey through to the larynx.

The larynx is also known as the voice box. It is made up of pieces of cartilage, which are connected to by ligaments and moved by various muscles. The larynx produces a small bump in the neck, which is called the Adams apple. The larynx extends from the root of the tongue and the hyoid bone until it reaches the trachea. Until puberty is reached, we see very little difference in the size of the larynx between males and females. The larynx is larger in the male than it is in the female causing male voices to become deeper. The larynx provides a passageway for air in between the pharynx and the trachea, as air passes through; it continues to stay moistened, warm and filtered as it was in the nose. When swallowing the larynx moves upwards, occluding the opening into it. The pharynx makes sure that the food, which passes into and through the oesophagus, does not go into the lower respiratory passages.

The trachea or the windpipe is a cylindrical tube measuring around 10 to 12cm in length, it is made up of 16 to 20 incomplete c-shape rings of cartilage, these are joined together by fibrous and muscular tissue.

There are three layers of tissue, which ‘clothe’ the cartilages of the trachea:

- The outer layer consists of fibrous and elastic tissue
- The middle layer consists of cartilages and bands of smooth muscle, which wind around the trachea in a helical arrangement. There is also some areolar tissue, which contains blood and lymph vessels
- The inner lining consists of ciliated columnar epithelium, containing mucus – secreting goblet cells.

These three layers of the trachea help to keep it firm, strong and enables the air which passes through it keep warm, filtered and moistened, ready to be passed into the lungs. The mucus – secreting goblet cells line the trachea making sure that no unknown substances reach the lungs and cause irritation.

When the trachea divides, the two bronchi are formed. The right bronchus is shorter and wider than the left bronchus and lies in a more vertical position; it is around 2.5cm in length. After the bronchus enters the lung at the hilum it divides into three branches, one that passes to each lobe of the lung. The bronchi are made up of the same tissue as the trachea. They are lined with ciliated columnar epithelium, towards the distal end of the bronchi the cartilages become an irregular shape and are absent at the bronchiole level. The bronchi divide into: -

- Bronchioles
- Terminal bronchioles
- Respiratory bronchioles
- Alveolar ducts
- Alveoli – the alveoli are the sacs of the lungs. They are elastic, tin walled structures that are fed via a duct by respiratory bronchioles. On the inner surface of each alveoli are white blood cells, which are always present, these are macrophages, these white cells ingest and destroy airborne irritants such as bacteria, chemicals and dust. If a lung disorder occurs and destroys the alveoli sacs there is less surface areas for gas exchange and so breathlessness can occur.

There are two lungs, which lie on each side of the midline in the thoracic cavity. The lungs are of a cone shaped structure. The structures, which form the root of the lung, enter and leave at the hilus. These include: -

- 1 bronchus
- 1 pulmonary artery
- 2 pulmonary veins
- 1 bronchial artery
- Bronchial veins
- Lymph vessels
- Parasympathetic and sympathetic nerves

The diaphragm is the most important muscle in inspiration. It is a dome shaped sheet of muscle, which is attached to the lower ribs. During inspiration the diaphragm flattens making it press down on the abdominal contents, which lifts up the rib cage making the rib cage and the lung enlarge. Due to the lungs being enlarged, the air in the lungs occupies a greater volume and the alveolar pressure temporarily falls below atmospheric pressure. The diaphragm play an important role in the respiratory tract as it allows a large amount of air to fill up the lungs allowing a large amount of oxygen to enter the blood flow and a large amount of carbon dioxide to leave the body.

The lungs are made up of the bronchi and smaller air passages, alveoli, connective tissues, blood vessels, lymph vessels and nerves.

The right lung is divided into three lobes – these are superior, middle and inferior. The left lung is divided into two lobes – these are superior and inferior.

The cardiovascular system

The cardiovascular system is divided into two main parts:

- The blood circulatory system, consists of the heart, which acts as a pump and the blood vessels through which the blood circulates
- The lymphatic system, consisting of lymph nodes and lymph vessels through which colourless lymph flows. The two systems communicate with each other and are intimately associated.

The heart is a roughly coned – shaped hollow muscular organ. It is around 10cm long and is about the size of the owners fist. It weighs about 225g in women and is heavier in men.

The heart lies between the lungs in an area called the mediastinum, behind the body of the sternum with two thirds of its bulk on the left side.

The heart is a pump whose purpose is to drive the blood into and through the arteries, but the right and left sides of the heart function quite separately from one another. Blood from all parts of the body is returned to the right atrium through the two large veins, the superior and the inferior - vena cava. When it is full the right atrium contracts and drives the blood through the right atrio – ventricular valve into the right ventricle, which in turn contracts sending the blood through the pulmonary valve and into the pulmonary artery or trunk (the only artery in the body which carries deoxygenated blood). The pulmonary valve, formed by three semilunar cusps, guards the opening of the pulmonary artery. This valve prevents the flow back of blood into the right ventricle when the ventricular muscle relaxes. After leaving the heart the pulmonary artery divides into the left and right pulmonary arteries which carry the venous blood to the lungs where the interchange of gases takes place: carbon dioxide is excreted and oxygen is absorbed.

The renal system

The kidney is an organ, which fulfils a vital role in maintaining the volume and composition of the body fluids, meaning that it is a major regulator of the internal environment as it is also known as the 'ultimate regulator of homeostasis'. The kidneys regulate the amount of salt and water in the blood.

In the human body the kidneys are paired, compact organs, which lie one on either side of the vertebral column. Supporting connective tissue covers the anterior surfaces of each kidney. An external capsule of fibrous connective tissue covers each kidney. The kidneys contain millions of tubules, the outer part of which filter water and dissolved substances from the blood supplied by the renal artery. Most of the water and some substances are reabsorbed back into the blood further down the tubules; the remaining fluid contains waste products of metabolism and surplus water and salts also known as urine. In man the kidneys normally produce 0.9 – 1.5l of urine per day, containing some 50 – 70g of solids – mostly urea, creatine, uric acid and inorganic salts. Urine passes onto the pelvis of the kidneys and out through the ureters of the bladder. A hormone called vasopressin controls the reabsorption of water, taken from the pituitary gland.

The kidneys perform four main functions, they are: -

- The removal of the nitrogenous waste products of metabolism
- The regulation of acid – base and other electrolyte balances
- The maintanence of water balance

describe the composition and function of the blood

Blood is a thick red fluid; it is bright red in the arteries, where it is oxygenated and a dark purplish – red in the veins where it is deoxygenated, having given up some of its oxygen to the tissues and receives waste products taken in from them. It is slightly alkaline

Blood is composed of a straw – coloured transparent fluid, called plasma this where different types of cells are suspended. Plasma constitutes of about 55% and cells around 45% of blood volume.
92% of plasma is water; the rest consists of dissolved substances, which include:

- Proteins – albumin, globulin, fibrinogen
- Inorganic salts (mineral salts) – sodium chloride, sodium bicarbonate, potassium, magnesium, phosphorus, iron, calcium, copper, iodine, cobalt
- Nutrient materials from digested foods – monosaccharides from carbohydrates, amino acids from proteins, fatty acids and glycerol from fats and vitamins from most foods
- Organic waste materials – urea, uric acid, creatinine
- Hormones
- Enzymes -e.g. various clotting factors
- Antibodies
- Gases – carbon dioxide, nitrogen

(Wilson. K, 1990)

The cells are of three types; red blood cells (erythrocytes), white blood cells (leucocytes) and platelets (thrombocytes)

The formation of blood cells takes place in the bone marrow and the mature products are released into the blood stream. Eight different cells are formed from one type of pluripotent stem cell.

Red blood cells are minute disc – shaped bodies, concave on either side. They are very numerous, numbering about 5 000 000 per cubic millimetre of blood. They are very minute having a diameter of 7.2 micrometers only. They have no nucleus, but contain a special protein known as haemoglobin. This is a pigment and is yellow in colour, even though the massed effect of these numerous yellow bodies is to make the blood red.

White blood cells are larger than rd blood cells, measuring about 10um in di ameter, and they are less numerous. There are 7-10x10 to the power of 9 per litre of blood, this number will increase considerably to 30x10 to the power of 9 when an infection s present in the body. This in crease is known as leucocytosis.

The functions of blood are: -

- To carry nutrients to the tissues
- To carry oxygen to the tissues in oxyhaemglobin
- To carry water to the tissues
- To carry away waste products to the organs which excrete them
- To fight bacterial infections through the white cells and anti bodies
- To provide the materials from which glands make their secretion
- To distribute the secretions of ductless glands and enzymes
- To distribute heat evenly throughout the body, and so regulate the body temperature
- To arrest haemorrhage through clotting

Blood clotting

The process by which blood is lost from the body is prevented through the clotting of blood. This is called haemostasis, and consists of three stages working together: -

- Vascular spasm – narrowing of the lumen of the cut blood vessel to slow down the loss of blood
- Formation of a platelet plug – to stop the loss flow of the blood from the cut
- Clotting of fibrin – around the plug and retraction of fibrin – to seal the cut and pull the edges of the cut together

Blood clotting is the mechanism by which blood is converted from a liquid to a solid state, which normally occurs after injury to blood vessels and prevents blood loss. The process involves a number of chemical reactions between certain soluble proteins (clotting factors) in the blood, resulting in the formation of a fibrous protein (fibrin), which forms the basis of the blood clot. Platelets accumulate at the site of an injury, their presence being essential for the reactions to occur.

Blood groups

Sometimes the blood from two individuals can be mixed with no observable effects, but on mixing, the corpuscles sometimes clump together or agglutinate, this is caused because the erythrocytes have substances called antigens attached to there membranes and the plasma of different blood contains antibodies. The most important antigen is the ABO antigen.

The blood groups are as followed: -

- If a person has only A antigens they are said to have blood type A
- If a person has only B antigens they are said to have blood type B
- If a person has no antigens they are said to have blood type O
- If a person has A and B antigens they are said to have blood type AB

In each case the plasma has antibodies against the blood antigens that are not present:

- A person carrying only A antigens has anti – B antibodies
- A person carrying only B antigens has anti – A antibodies
- A person carrying no antigens has both anti – A and anti – B antibodies
- A person carrying both A and B antigens has no antibodies

What is the most common blood type: -

- O rh – pos = 38%
- O rh – neg = 7%
- A rh –pos = 34%
- A rh – neg = 6%
- B rh –pos = 9%

- B rh – neg = 2%
- AB rh – pos = 3%
- AB rh – neg = 1%

Rhesus factor

During pregnancy, doctors and midwives need to know whether the mother is are Rhesus positive, which means that she has a certain protein on the surface of her red blood cells, or Rhesus negative, which means that she doesn't. If she is Rhesus negative and her partner is positive, there's a chance that their baby will be Rh positive in which case her body might react to his blood as if it's a foreign substance, and start to destroy his red blood cells. In order to prevent this happening, she will be offered an injection of anti-D immunoglobulin at 28 weeks of pregnancy and another after she has given birth.

A blood test will also tell the patient if their haemoglobin levels are low which is a sign of anaemia. If they're anaemic, their GP or midwife will talk to them about the best foods to eat (such as lean meat and spinach) to boost their iron stores. They might also be prescribed iron tablets. If they suffer a lot from fatigue during pregnancy, a blood test can tell them whether they're tiredness is just a normal side effect of being pregnant, or whether it means that she is anaemic.

Anaemia

Anaemia is a deficiency of red blood cells, which can lead to a lack of oxygen-carrying ability, causing unusual tiredness and other symptoms. The deficiency occurs either through the reduced production or an increased loss of red blood cells. These cells are manufactured in the bone marrow and have a life expectancy of approximately four months.

(Taken from www.netdoctor.co.uk)

Symptoms of anaemia

The patient may not be aware that they have become anaemic, although fatigue is a common sign, and lack of energy. However, these are symptoms also experienced by many pregnant women who are not anaemic.

Doctor's will discuss diet with the patient to make sure that they are eating enough of the right kinds of food; he/she may be prescribed iron tablets.

Iron tablets can cause constipation, so it's important for them to have plenty of fibre in their diet while they're taking them. If constipation becomes a serious problem, the GP should offer an alternative tablet.

(Taken from www.babycentre.co.uk)

Describe the relationships between the systems and homeostatic mechanisms in maintaining physiological function

Homeostasis is the self-regulating process by which living organisms tend to maintain their bodies in a physiological state regardless of environmental extremes. The extent to which a particular group achieves this is a measure of its success.

The kidneys provide the third line of defence in maintaining the hydrogen ion, homeostasis. The renal mechanisms involved in acid based balance take hours to days to complete. The renal mechanisms, which operate against acidaemia, include the following: -

- Reabsorption of virtually all filtered hydrogen carbonate ions to restore the buffering capacity in extracellular fluid
- Excretion of the hydrogen ions of fixed acid
- Reclamation of the hydrogen carbonate ions originally consumed in buffering fixed acids
- Excretion of the anions of fixed acids which cannot be converted into carbon dioxide and therefore cannot be removed in respiration
- Compensation of acidosis by increasing tubular hydrogen ion secretion and vice versa in alkalotic states.

(Hincliffe, S. 1999)

Implications of disorders and diseases to the system, to the individual and society

Coronary heart disease

Coronary heart disease is the most common form of heart disease in the western world. It is caused by atherosclerosis of the coronary arteries, which reduces the blood flow to the heart. This may precipitate the formation of a blood clot in these arteries – coronary thrombosis.

The integrity of the cardiac muscle depends on the maintenance of an adequate oxygen supply for all levels of activity. Failure to maintain an adequate blood flow to cardiac muscle results in the muscle becoming ischaemic and may lead to death of the muscle tissue.

During coronary heart disease, the patient experiences sudden pain in the chest and the result maybe a heart attack, when the blood flow to the heart is suddenly stopped. Coronary heart disease is associated with smoking, lack of exercise, high fat diets, hypertension and middle age. It is more common in men.

Respiratory failure

Respiratory failure is said to occur when the lung fails to oxygenate the arterial blood adequately and/or prevent undue retention of carbon dioxide. Although there are no absolute values of the levels of arterial blood gases that indicate respiratory failure. Symptoms of respiratory failure include: -

- Disorientation
- Headache
- Weakness
- Malaise
- Hypertension

Treatment consists of providing adequate oxygenation and reversing acidosis using augmented inspired oxygen and/or assisted ventilation.

Renal failure

Renal failure is when the kidneys are unable to excrete the urea and so blood levels rise, resulting in uraemia.

Renal failure may be caused by tubular obstruction, which may be brought about by sloughing necrosis of the epithelium, lining the nephron due to ischaemic or toxic damage. This causes the hydrostatic pressure in the Bowman's capsule to rise, reducing the GRF.

Causes of acute renal failure

Type	**Causes**
Pre-renal failure	Hypovolaemia secondary to acute blood or plasma loss
	Fluid and electrolyte depletion
	Hypotension secondary to cardiogenic shock
	Hypotension secondary to sepsis
Intrinsic renal failure	Acute tubular necrosis due to prolonged renal hypoperfusion
	Acute tubular necrosis due to contrast nephropathy
	Acute glomerulonephritis
	Drug induced nephrotoxic damage
	Athero-embolic disease
	Acute pyelonephritis

Renal outflow obstruction	Calculi
	Blood clot
	Ureteric damage and ligation
	Prostatic hypertrophy

Biochemical changes of acute renal failure

- Hyponatraemia
- Hyperkalaemia
- Hypocalcaemia
- Metabolic acidosis

(Taken from www.surgical-tutor.org.uk)

Conclusion

The assignment was to look at three different body systems, looking at the way they work and how they can be affected during disease.

It was also asked of us to look at the blood groups and the composition of blood, seeing how important the Rhesus factor is and how pregnancy can be affected if the rhesus factors are different in a relationship.

Looking at the homeostasis was difficult when trying to link it to the different systems, I found difficulty in this.