Unit 1 Higher Human Biology Summary Notes

a. Cells → tissues → organs→ body systems

Division of labour occurs in multicellular organisms (rather than each cell carrying out every function)

Most cells become differentiated

Differentiation – when an unspecialised cell becomes altered and adapted to perform a specialised function

Cells make up tissues e.g. epithelial tissue, bone tissue, blood tissue, muscle tissue etc.

Tissues make up organs e.g. skin is an organ made up of epithelial, blood, muscle and nerve tissue

Tissues and organs make up body systems e.g. circulatory system is made up of blood tissue, heart and blood vessels

Each embryonic cell possesses all the genes for constructing a whole organism

At this stage, all the genes are switched on or have the potential to become switched on

The unspecialised cells of the early embryo undergo differentiation and become specialised

The ciliated epithelial cells of the windpipe are specialised to sweep mucus away from the lungs

Once a cell has become differentiated it only expresses the genes that code for the proteins specific to the working of that cell –

In a nerve cell, genes that code for a neurotransmitter substance are switched on but genes that code for mucus are switched off

Stem cells

1. Reproduce them while remaining undifferentiated

2. Differentiate into specialised cells when required

There are two types of stem cells, embryonic and tissue or adult stem cells

Embryonic stem cells

The blastocyst consists of a ball of embryonic stem cells

All of the genes in an embryonic stem cell have the potential to be switched on

The cell is capable of differentiating into all of the cell types in the body (>200)

Tissue/adult stem cells

Found in skin and red bone marrow

They have a much narrower differentiation potential than embryonic stem cells because many of their genes have been switched off

They are, however, able to replenish the supply of certain differentiated cells such as skin, blood and intestinal lining cells

Tissue/adult stem cells can only give rise to a limited range of cell types, closely related to the tissue in which they are found

E.g. stem cells in the red bone marrow give rise to red blood cells, white blood cells and platelets

Origin of blood cells

1. Pool of tissue/adult stem cells in red bone marrow undergoes continuous mitosis and cell division

2. Within some of these cells certain genes become switched off

3. Differentiation continues and certain genes remain switched on or become switched on

In red blood cells the gene for haemoglobin becomes switched on

In white blood cells –phagocytes and lymphocytes

Phagocytes e.g. neutrophils and monocytes – the genes for enzymes that digest microorganisms become switched on

Basophils – genes for the formation of anticoagulants are switched on

B-lymphocytes – the gene for producing antibodies is switched on

T- lymphocytes and Natural Killer cells – the genes for self- killing proteins are switched on

b. Differentiated cells (except reproductive cells) are called somatic cells

Somatic cells form different types of body tissue

1. Epithelial tissue

These tissues are made of cells that unite to form membranes

These tissues can be a single layer or many layers

Epithelium provides the body surface with a protective, multi-layered covering –the skin

Epithelium also lines the body cavities such as the blood vessels and the oesophagus

2. Connective tissue

Connective tissue has large quantities of extracellular material between its cells (bone, cartilage and blood)

Bone

The extracellular material is solid

Bone consists of concentric layers of calcified material laid down around blood vessels

Living bone cells within the calcified material receives oxygen and nutrients via microscopic canals in contact with the blood vessels

Cartilage

Extracellular material is fibrous or gelatinous

End of long bones – extracellular material is solid and smooth

Knee joint – extracellular has dense fibres, making the cartilage slightly flexible

Blood

In the blood, the extracellular material is plasma

3. Muscle tissue

Skeletal muscle

This type takes the form of striped fibres

Smooth muscle

The cells are spindle- shaped and are arranged in sheets

Smooth muscle forms part of the walls of large blood vessels and the alimentary canal

Cardiac muscle

In this type, each cell has one or more branches in contact with adjacent cells

4. Nervous tissue

This tissue is composed of a network of neurons which receive and transmit impulses and glial cells which support and maintain the neurons

Somatic cells divide during growth and repair

In humans, somatic cells are diploid

They contain 46 chromosomes, 23 pairs of homologous chromosomes

Prior to nuclear division, or mitosis, chromosomes replicate

Genetic material becomes doubled in quantity for a brief period of time

The genetic material is then divided equally between two daughter nuclei

The diploid chromosome number is maintained

Mutation

Mutation can occur in a somatic cell and may lead to a localised change in phenotype (e.g. 'mole' from a mutated skin cell)

This type of somatic cell mutation is not passed on

Germline cells

A germline cell is one that leads to gamete formation

A germline cell is diploid, 23 pairs of homologous chromosomes

Germline cells undergo a second form of nuclear division called meiosis

This type of nuclear division results in the formation four haploid gametes which have a single set of chromosomes

Mutation

If a mutation occurs in a germline cell, it is passed on to the offspring

A mutation on chromosome 7 results in the formation of thick, sticky mucus

If the gamete with this recessive allele fuses with a gamete with the same allele, the individual produced will have cystic fibrosis.

c. Stem cell – research value

Human stem cells can be grown in optimal culture conditions when certain growth factors are present

In the absence of these growth factors, then the stem cells differentiate rapidly

By investigating why stem cells continue to multiply in the presence of a certain chemical yet undergo differentiation in its absence, scientists are hoping to get a fuller understanding of growth and differentiation

Stem cells which are genetically identical to differentiated somatic cells can be used as model cells

They can be used to investigate how certain diseases develop

They can be used to investigate the response to new drugs

1. Bone Marrow Transplantation

Cancer of the blood is caused by uncontrolled proliferation of white blood cells (leukaemia)

Treatment involves destroying the patient's cancerous bone marrow (radiation or chemotherapy) and replacing it with a bone marrow transplant of blood forming stem cells

Haematopoietic stem cells HSCs can differentiate into a variety of specialised blood cells

HSCs are found in the bone marrow, peripheral (circulating) blood and umbilical cord blood

Most transplants use stem cells from the donor's peripheral blood

Prior to the harvest, the donor is injected with a chemical that causes additional HSCs to migrate from the bone marrow to the bloodstream

20% of the white blood cells collected in the sample are HSCs

Umbilical cord

Umbilical cord blood is rich in HSCs

The volume of blood is relatively small

Transplants are restricted to children and small adults

2. Skin graft

A skin graft using stem cells requires a small sample of skin to be taken to obtain stem cells

Enzymes are used to isolate and loosen the stem cells which are cultured to develop a 'suspension of new stem cells'

This suspension is then sprayed over the damaged area to replace missing skin

3. Cornea repair

Stem cells are grown from the patient's stem cells, located at the edge of the cornea

Since skin grafts and cornea repair use the patient's own cells – no risk of rejection

d. Future therapeutic use of stem cells

Embryonic stem cells grown on 'synthetic scaffolds' have been used to treat burns victims

The stem cells provide a source of 'temporary skin' while the patient is waiting for grafts of their own skin to develop

Embryonic stem cells can differentiate into any cell type

In the future they have the potential to provide treatment for diseases such as Diabetes, Parkinson's disease and Alzheimer's disease

Scientists have managed to generate nerve cells from embryonic stem cells – it is hoped that this will provide effective therapies for M.S.

Extraction of extraction of human embryonic stem cells results in the destruction of the embryo

Possible solutions?

1. Donated embryos

Patient undergoing fertility treatment may agree to donate 'extra embryos' to medical science

These embryos provide an immediate source of stem cells for research

2. Amniotic fluid

The amniotic fluid contains stem cells which are harvested during amniocentesis

Obtaining stem cells in this way does not harm the embryo

3. Induced Pluripotent Stem cells

A totipotent stem cell can grow into any cell type

A pluripotent stem cell can develop into many cell types

Induced pluripotent cells are differentiated cells (e.g. from human skin) that have been genetically reprogrammed to switch on, again, genes that have been switched off

These cells act as stem cells and can therefore be used for research

The problem is that viruses are used as ‘vectors’ in the process and have been shown to cause cancer

4. Nuclear transfer technique

The nucleus from a human skin cell can be introduced to an enucleated egg cell from e.g. a cow

The cell formed is called a Cytoplasmic Hybrid Cell

It divides and after approximately 5 days stem cells can be extracted and used for research

The practice allows the nucleus from a diseased human cell e.g. cancer to be put into an enucleated animal egg for study

Regulation

Embryo and cytoplasmic hybrid cell may be grown for up to 14 days

Why 14 days? – embryos implant in the uterus and begin to develop a nervous system at this time

e. Cancer

Cancer is the uncontrolled growth of cells

In normal healthy cells, cell division is controlled by factors such as cell cycle regulators and external chemical signals

Cancer cells divide to produce a mass of abnormal cells called a tumour

Benign

A tumour is benign if it remains as a discrete group of abnormal cells in one place within normal tissue e.g. warts are benign tumours

Benign tumours do not cause problems and can be successfully removed

Malignant

A tumour is malignant if some of its cells lose the surface molecules that keep them attached to the original cell group

They enter the circulatory system and spread through the body ‘seeding’ new tumours