Chapter 14 – Development in Animals

1. **General Information**
   - **Embryology –** the study of embryos, proves the evolutionary interrelationships among animals
   - Similarities among embryos suggest common ancestry
   - Differences among embryos suggest evolutionary changes
   - Most vertebrate eggs store a lot of food that is used during development
   - Human eggs have very little food, only enough for the egg to survive until it reaches the uterus
     - The mother's blood provides nourishment for the embryo, so the food is not needed
   - Cell functions are controlled by proteins, and ultimately to DNA (See Ch 10)
   - **Growth** – an increase in size due to an increased number of cells
   - **Development** – the specialization of cells to perform specific tasks

2. **Development of an Animal**
   - **Zygote** – the union of the haploid egg and the sperm nuclei into a single diploid cell during fertilization
   - **Growth** – several rounds of mitotic cell divisions that follow fertilization
   - **Differentiation** – as cells continue to grow, they become specialized, in both structure and function
     - A cell is completely differentiated when it possess all the features of a specific cell type
   - **Morphogenesis** – the organization of the specialized cells into tissues and organs
     - Responsible for generating shape and form within an embryo

3. **Cells - A Closer Look**
   - Cells are specialized to be good at doing only one specific task
   - **Skeletal Muscles** – long, cylindrical shape, contract to create movement for the organism
   - **Nerve Cells** – branched extensions of cell body, transmits chemical pulses throughout the body
   - **Red blood cells** – concave, disk shape cells, no nucleus, transports gas throughout the body
   - Proteins control cell processes. DNA controls protein synthesis
     - Nerve cells contain protein neurotransmitters that allow the transmission of nerve impulses
     - Muscle cells have the protein myosin that allow them to contract and relax
     - Red blood cells have hemoglobin that binds and transports O_2 and CO_2

4. **Multiplication of Cells, Growth, and Specialization – A Closer Look**
   - **Cleavage** – the process of producing many small, identical cells from the single zygote
   - **Blastula** – the ball of small cells that results at the end of cleavage
     - The size and arrangement of cells vary by animal, and the amount of yolk present
   - **Gastrula** – a blastula that has rearranged itself into a multi-layered embryo with three distinct cell groups
     - **The Primary Germ Layers** – three groups of distinct cells, will develop into specialized tissues
       - **Endoderm** – the innermost layer. Develops into lining of the bladder and digestive tracts
       - **Mesoderm** – the middle layer. Develops into muscles, bones, circulatory, digestive, reproductive systems, kidneys and ducts, connective tissue
       - **Ectoderm** – the outermost layer. Develops into skin, hair, nails
   - **Neurulation** – development of the nervous system – occurs after gastrulation
     - The primary neural tube develops; the three primary germ layers undergo more rearrangement
   - The primary germ layers then development into their respective specialized tissues

5. **Development in Humans**
   - **Blastocyst** – the human embryo after several mitotic divisions. Similar to the blastula in animals
     - Part of the blastocyst is the embryo itself
     - The other part develops into membranes that surround, protect, and nourish the embryo
       - **Amnion** – surrounds the embryo
       - **Allantois** – protects the embryo
       - **Yolk Sack** – nourishes the embryo
       - **Chorion** – the outermost membrane, developed from the outer wall of the blastocyst
         - Extends fingerlike projections, **or villi**, into the endometrium (See Ch 11)
         - The **placenta** forms at the point of conjunction between endometrium and villi
       - **Placenta** – an "organ" which nourishes the baby and removes waste
       - **Umbilical cord** – a tube that carries O_2 and waste from the placenta to the embryo
         - A layer of amnion surrounds the arteries in the umbilical cord
         - The remaining amnion develops into the amniotic sack (See Ch 11)
         - **Amniotic sack** – a "pouch" of fluid that surrounds/cushions the baby
   - **4 weeks into development –** brain, spine, heart, eyes, and ears begin to develop
   - **8 weeks –** arms, legs, limbuds, some internal organs. Known as a fetus from this point forward

Fetus – an 8-week or older embryo that can be recognized as a human

12 weeks – arms/legs start moving, fingers, toes, facial expressions developed, sex distinguishable

16 weeks – heartbeat detectable, muscles start developing, skin is transparent

20 – 24 weeks – baby starts sucking its thumb, starts hiccupping, grows some hair

28 – 32 weeks – a rapid addition of fat, and very active

36 – 38 weeks – less active, because no more room, rotates into birth position, lung develop last

Should weigh about 7 – 8 pounds at birth, 20 – 21 inches

Lactation – the mammary glands of the mother produce milk for the baby at the 8th month

Triggered by the hormone prolactin

The mother feels the most comfortable during the 2nd trimester. Abortions are illegal after the 5th month

6. Genes, Differentiation, and Controls

Selective Gene Loss Hypothesis – different cell types contain different sets of genes

Genetic Equivalence hypothesis – all cells contain the same genes, they differ in the types of proteins

Nuclear Transplantation Experiments – tried to prove both theories

Proved that when cells differentiate, no cells are LOST

However, differentiated cells can only express certain genes needed for that type of cell

Molecular Experiments – a more "modern" way to prove or disprove both theories

Molecular hybridization – heat up DNA, let it cool, let the shape reform so it can be examined

Allows scientists to compare two different strands of DNA to each other

Fusion – fusing together two cells to combine both their cytosol and nuclei

Molecular experiments also prove the genes are inactivated during differentiation, not lost

7. Mechanisms of Differentiation

How does differentiations work? Why do some cells express certain genes but not others?

In animals, time and location determines cell type

Determination – cells "committing" to their final status/fate (either nervous tissue, skin, etc)

Before cells "commit" to their final status, their position within the embryo determines their fate

After they "commit", which can be a few hours later, moving them around won't change their fate

Methods of Determination – The Influence of the Cytoplasm

The cytoplasm of the egg is not evenly distributed, so location in the cytoplasm is important

Different areas of the cytoplasm receive different signals and nourishment

Proteins that are synthesized in different areas of the cytoplasm are different

Methods of Determination – Induction

Dorsal Lip – a portion of the blastula when the first in folding of the gastrula appears

When the dorsal lip, which is made of undifferentiated cells, is transplanted into another location, it should turn into other types of tissue. However, when the dorsal lip is transplanted, a new embryo, a 2nd embryo, develops, and is joined to the 1st embryo at the abdomen.

The dorsal lip cells induce the normal cells to follow a different course of development

Very important in the development of the eyes and other features

8. **Cancer** – the second leading cause of death in the United States behind only heart disease

Cancer – a group of cells that grow out of control and without the normal regulations

Creates irregular cells, in both size and shape, that are useless to the body

Dedifferentiation – cells go from specialized to unspecialized, and thus useless

The cancer cells absorb all the resources, depriving the healthy cells of nourishment

Cancer cells also differ that they can grow anywhere, under all types of conditions

They reproduce very rapidly, die early, and are resistant to many antibiotics and other treatments

Tumor – a large group of irregular cells that result in a lump

Benign – little deviation from normal, don't spread, not life threatening

Malignant – very abnormal, they penetrate deeply, and spread throughout the body

Metastasis – the spreading of cancer cells

Origins of Cancer – scientists believe that cancer originates in the genes

Carcinoma – the cancer originates in epithelial (skin) tissue

Sarcoma – the cancer originates in bones, muscles, cartilage

Difficult to cure because they are so many different variation, and exact causes are unknown

Oncogenes – genes that are shown to cause cancer in laboratory animals

Carcinogens – cancer causing agents in the environment

Causes for cancer

Biological factors – heredity, age, gender, viruses, hormones

Women ages 1 – 55 are more likely to get cancer than men

Men 55 – 100 are more common to get cancer than women

Changes in hormones, such as menopause, tend to increase chances for cancer

Environmental factors – occupational exposure, stress, diet, smoking, drugs/alcohol, air, etc.

Treatments for Cancer

Chemotherapy – powerful chemicals are injected into the body to kill cancer cells

Not very effective, many healthy cells are killed, very hard on the body

Radiation – radiation therapy that targets specific tumors in order to kill cancer cells

Radiation therapy in itself can kill the patient, not very effective either

Gene Therapy – replace the oncogenes with new genes – unproven, not available widely

Preventing Cancer – live a healthy life

Eat healthy, keep fat levels down, exercise, avoid too much stress, don't smoke, drink, or use drugs, avoid too much exposure to the sun, etc.