

## CH. 1 : THE BASIS OF LIFE

### I. Keywords

- a. Absorption - The passage of nutrient molecules through lining of the digestive tracts
- b. Anabolic reactions - build up of large chemicals
- c. Assimilation - the building of new tissues from digested food
- d. Catabolic reaction - break down of large chemicals
- e. Digestion - the process of converting food into usable form
- f. Excretion - The removal of waste products
- g. Growth - Increase in size due to synthesis
- h. Homeostasis - The body's ability to change to adapt to external environment
- i. Ingestion - Acquisition of food and other raw materials
- j. Inorganic Compounds - Compounds that do not contain the element carbon
- k. Irritability - Ability to respond to a stimulus
- l. Metabolism - Sum of all chemical reactions occurring in the body
- m. Organic Compounds - made by living systems and contain carbon
- n. Photosynthesis - process by which plants convert  $\text{CO}_2$  and  $\text{H}_2\text{O}$  into carbohydrates
- o. Protoplasm - Substance of life
- p. Regulation - The control of physiological activities
- q. Reproduction - The generation of additional individuals of a species
- r. Respiration - The consumption of oxygen by the body
- s. Synthesis - The creation of complex molecules from simple ones.
- t. Transport - the circulation of essential compounds

### II. Types of Protein

- a. Simple - Composed entirely of amino acids
- b. Albumins and globulins - primarily globular in nature. Carriers or enzymes.
- c. Scleroproteins - fibrous in nature and act as structural protein. Collagen.
- d. Conjugated - Simple protein portion with nonprotein parts.
- e. Lipoprotein - protein bound to lipid
- f. Mucoprotein - protein bound to carbohydrate
- g. Chromoproteins - protein bound to pigmented molecules
- h. Metalloproteins - protein complexed around a metal ion
- i. Nucleoproteins - protein containing histone or protamine (bound to DNA)

### III. Cell Terminology

- a. Autolysis - rupture of lysosome membrane and cell suicides
- b. Brownian movement - Movement of particles due to kinetic energy which spreads small suspended particles throughout the cytoplasm of the cell
- c. Cyclosis - streaming movement within the cell

## Biochemistry

### I. General

- a. All living things composed of
  - i. Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur, and Phosphorus
  - ii. In trace amounts of magnesium, iodine, iron, calcium, and other minerals

### II. Carbohydrates

- a. General
  - i. Consists of carbon, hydrogen, and oxygen in 1:2:1 ratio
  - ii. It is a storage form of energy
  - iii. dehydration synthesis - joins saccharide units together by loss of a water molecule

- iv. Hydrolysis - break down of saccharide polymers
- b. Monosaccharide
  - i. Fructose, Glucose, Galactose, Mannose
- c. Disaccharide
  - i. Maltose and Sucrose
- d. Polysaccharide
  - i. Cellulose, Starch, Glycogen

### III. Lipids

- a. General
  - i. Consists of carbon, hydrogen, and oxygen.
  - ii. H:O ratio is 2:1 with a lot more hydrogen than oxygen
  - iii. Backbone structure consists of 3 fatty acid bonded to a single glycerol backbone.
  - iv. Three dehydration synthesis are required to form one fat molecule
  - v. Chief means of food storage in animals
  - vi. **Release more energy per gram weight than any other class of biological compounds**
  - vii. Provides insulation and protection against injury
- b. Derivatives
  - i. Phospholipids
    - 1. Contain glycerol, two fatty acids, phosphate group, and nitrogen containing alcohol
    - 2. Examples
      - a. Lecithin - major constituent of cell membranes
      - b. Cephalin - found in brain, nerves, and neural tissue
  - ii. Ester
    - 1. Esters of fatty acids and monohydroxylic alcohols
    - 2. Found as protective coating on skin, on fur, on leaves, on exoskeleton of insects
    - 3. Examples
      - a. Lanolin - a fatty substance obtained in wool and used in soaps, cosmetic, and ointments
  - iii. Steroids
    - 1. All have three fused cyclohexane rings and one fused cyclopentane ring
    - 2. Examples
      - a. Cholesterol -
      - b. Sex hormones - testosterone, estrogen
      - c. Corticosteroids -
  - iv. Carotenoids
    - 1. Fataty acid-like carbon chains containing conjugated double bonds and carry a 6 carbon ring at the end
    - 2. Pigments that produces colors in animals and plants
    - 3. Examples
      - a. Carotenes
      - b. Xanthophylls
  - v. Porphyrins
    - 1. Called tetra-pyrroles which contains 4 joined pyrrole rings
    - 2. Often complexed with metal.
    - 3. In **hemoglobin**, porphyrin heme is complexed with **Iron**
    - 4. In **chlorophylls**, porphyrin is complexed with **Magnesium**

### IV. Proteins

- a. General

- i. Consists of Carbon, Hydrogen, Oxygen, and Nitrogen. May contain Phosphorus and Sulfur.
  - ii. Polymers of amino acid joined by peptide bonds via dehydration synthesis.
- b. Protein Functions
  - i. Hormones - chemical messengers
    - 1. Examples
      - a. ACTH - Adrenocorticotrophic Hormone secreted by anterior pituitary
      - b. Insulin
  - ii. Enzymes - increases rate of reactions
    - 1. Examples
      - a. Amylase, lipase, ATPASE
  - iii. Structural proteins - physical support of a cell or tissue
    - 1. Examples
      - a. Collagen
  - iv. Transport proteins - carriers of important materials
    - 1. Examples
      - a. Hemoglobin - blood
      - b. Cytochromes - carries electrons during cellular respiration
  - v. Antibodies - Binds to foreign particles

## V. Enzymes

- a. General
  - i. Protein organic catalysts
  - ii. Substrates are the reactants, and it binds to the active site.
  - iii. Enzymes can be used for both forward and reverse reactions
- b. Two models of binding
  - i. Lock and Key
  - ii. Induced Fit
- c. Enzyme requirements
  - i. Temperature - Optimal temperature is around 40 degrees and enzyme activity increases up to this point but then denaturation would occur after.
  - ii. pH - there is optimal pH. In human, it's around 7.2 except in the stomach where Pepsin needs 2 and pancreas where it is around 8.5
  - iii. Concentration - higher the substrate concentration, faster the reaction will go until active sites are full.
  - iv. Cofactors - metal cations which make the enzyme active
- d. Enzyme Activities
  - i. Hydrolysis
  - ii. Synthesis

## VI. Nucleic Acids

- a. General
  - i. Contains Carbon, Hydrogen, Oxygen, Nitrogen, and Phosphorus
  - ii. Polymers of nucleotides
  - iii. Stores all information required by an organism to produce proteins and replicate

## Cell Biology

### I. Cell Theory

- a. All living things are composed of cells
- b. The cell is the basic functional unit of life
- c. Cell arises only from pre-existing cells
- d. Cells carry genetic information in the form of DNA and is passed from parent cell to daughter cell.

## II. Studying the Cell

### a. Microscopy

- i. Compound light microscope
  1. Staining usually kills the cell
- ii. Phase contrast microscopy
  1. Does not kill the specimen
- iii. Electron microscopy
  1. Kills the specimen

### b. Centrifugation

- i. Separate the parts of a cell based on their density

## III. Differences

### a. Prokaryote and eukaryote

- i. Bacteria vs higher life forms (protists, fungi, plants, and animals)
- ii. Cell wall present in all prokaryotes (with peptidoglycans)
- iii. No nucleus in prokaryotes
- iv. Different ribosome subunits
- v. No membrane bound organelle in prokaryotes such as nucleus, lysosomes, vesicles, ER, and mitochondria.
- vi. Cellular respiration of prokaryotes occur at cell membrane. In eukaryotes, it occurs across mitochondrial membrane.

### b. Plants and Animals

- i. No centrosome in plants
- ii. Cell walls composed of cellulose in plants
- iii. Chloroplasts in plants
- iv. Many vacuoles in plants

## IV. Parts of a cell

### a. Cell Membrane

- i. Selective permeability - regulates the passage of materials in and out
- ii. Fluid mosaic model - consists of a phospholipid bilayer with proteins embedded throughout and they can move freely
- iii. Readily permeable to small non-polar molecules and VERY small polar molecules like water.
- iv. Larger charged molecules need the assistance of carrier proteins.

### b. Nucleus

- i. Controls the activities of the cell
- ii. Surrounded by a nuclear membrane (1 layer)
- iii. DNA is complexed with histones to form chromosomes
- iv. Nucleolus is a dense structure where ribosomal RNA synthesis occurs

### c. Ribosome

- i. Site of protein production
- ii. Synthesized by nucleolus
- iii. Found in cytoplasm and rough endoplasmic reticulum

### d. Endoplasmic Reticulum

- i. Network of membrane enclosed space involved in transport of materials

### e. Golgi Apparatus

- i. Receives vesicles and their contents from the smooth ER, modifies them via glycosylation, repackage them into vesicles, and ship them out via exocytosis.

### f. Mitochondria

- i. Site of aerobic respiration within the cell
- ii. Surrounded by outer and inner phospholipid bilayer (2 layers)

### g. Cytoplasm

- i. Transport within the cytoplasm occurs by cyclosis

- h. Vacuole
  - i. Membrane bound sacs involved in the transport and storage of materials.
- i. Centrioles
  - i. Specialized microtubules involved in cell division.
  - ii. Plants do not have centrioles
- j. Lysosome
  - i. Membrane bound vesicles that contain hydrolytic enzymes for intracellular digestion.
- k. Cytoskeleton
  - i. Composed of microtubules and microfilaments
  - ii. For structure, shape, support and cell motility

#### V. Modes of transport

- a. Diffusion
- b. Osmosis
  - i. Plasmolysis - cell is hypertonic to the medium and loses water
- c. Facilitated diffusion
- d. Active transport
  - i. Sodium/Potassium pump - moves 3 Na out for every 2 K in. Inhibition of such would cause increase of Na inside cell. With more solute inside cell, water will diffuse in, causing it to swell then lyse.

#### VI. Circulation

- a. Intracellular circulation
  - i. Brownian movement - Movement of particles due to kinetic energy which spreads small suspended particles throughout the cytoplasm of the cell
  - ii. Cyclosis - circular motion of cytoplasm around the cell that transports molecules
  - iii. Endoplasmic reticulum - provides channels throughout the cytoplasm and a **direct passageway from plasma membrane to the nuclear membrane**
- b. Extracellular circulation
  - i. Diffusion - food goes in and out if close to the medium
  - ii. Circulatory system - vessels with a pump (heart) to transport fluids

## CH.2: REPRODUCTION

### II. Key words

- b. Anther - terminal sac of stamen that makes the spore (male)
- d. Apical Meristem - tip of root/stems
- e. Auxins - synthetic plant hormones that makes root develop faster
- f. Bulbs - Make new plant with several bulbs
- g. Chromatin - DNA is called this when uncoiled
- h. Corpus Luteum - makes estrogen and progesterone. From ruptured follicle
- i. Cotyledons - seed leaves. Dicot have 2, monocot has 1.
- j. Cytokinesis - cell division
- k. Ejaculatory Duct - the path to the urethra
- l. Endometrium - uterine wall (thickened by Estrogen)
- m. Endosperm - grows and feeds the embryo.
  - ii. In dicots, cotyledon absorbs the endosperm
- n. Epicotyl - precursor to upper stem and leaves
- o. Epididymis - the thing that tests is attached to
- p. Filament (stamen) - a stalk that holds the anther
- q. Follicle (ovary) - sac of cells. Protects, nourishes immature cells. Produce estrogen
- r. Follicular phase - FSH from anterior pituitary stimulates growth of follicle
- s. Karyokinesis - Nuclear division
- t. Lateral Meristem - Cambium. This allows growth in diameter
- u. Luteal Phase - Luteinizing hormone causes follicle to turn into corpus luteum
- a. Menstruation - if ovum is not fertilized, corpus luteum atrophies, endometrium expelled
- c. Meristems - undifferentiated tissues in plants that can grow to be an adult plant
- d. Ovary (plant) - enlarged base of the pistil. Contains ovary
- e. Ovulation - luteinizing hormone surge and follicle bursts releasing ovum
- f. Parthenogenesis - development of unfertilized egg
- g. Petals - specialized leaves that protects the pistil. Attracts birds and insects
- h. Pistil - female organ of the flower
- i. Rhizomes - woody underground stems that can develop upright stems
- j. Runners - stems running above and along the ground like lawn
- a. Seed Coat - develops from outer covering of the ovule.
- c. Seminiferous tubules - Sperms made here
- d. Sepal - the green leafy part outside of the main flower
- b. Stamen - male organ of the flower
- a. Stigma - sticky top part that catches pollen (spores)
- b. Style - the tube like structure that guides the pollen along
- b. Testosterone - regulates secondary male sex characteristics
- b. Tubers - underground stems with buds that can develop into adult
- c. Urethra - right before the penis, it's shared by both reproductive and excretory
- d. Vas Deferens - What the epididymis is attached to
- e. Hypocotyl - develops into stem and root

### II. Cell Division

- b. In unicellular organisms, cell division is reproduction while in multicellular organism, it's for growth and repair.
- a. Two types, mitosis and meiosis.
- b. Stages of Mitosis
  - ii. Interphase
    - 1. 90% of cell life in interphase.

- iv. Prophase
  - 1. Chromosomes condenses
  - 1. Centrioles separate and move toward opposite poles of cells
  - 1. Spindal apparatus forms between the centriole and nuclear membrane dissolves
- vii. Metaphase
  - 1. Centriole pairs are at opposite pair of the poles
  - 1. The chromosome are at the center of the cell called metaphase plate
- i. Anaphase
  - 1. The centromeres are split so each chromatid has its own distinct centromere
- ii. Telophase
  - 1. The spindle apparatus disappears.
  - 2. Nuclear membrane forms
  - 1. Chromosomes uncoil
- ii. Cytokinesis
  - 1. The cytoplasm divides into two daughter cells
  - 4. Cleavage furrow forms and pinches through the cell.
- iv. Difference with Plant Cells
  - 1. Plants lack centriole, so the spindle apparatus is synthesized by microtubule organizing centers
  - 3. Plants form a cell plate that divides the cells
- b. Stages of Meiosis
  - ii. Interphase
    - 1. Chromosomes are replicated into 2N number of sister chromatids
  - ii. Prophase I
    - 1. Chromatin condenses into chromosomes
    - 1. Spindle apparatus forms
    - 3. Nucleoli and nuclear membrane disappears
    - 4. Homologous chromosomes come together and synapsis, crossing over occurs
    - 2. Tetrads are formed
  - vi. Metaphse I
    - 1. The homologous pairs align at the equatorial plate
  - ii. Anaphase I
    - 1. Disjunction, or the homologous pairs separate and pulled to the opposite poles occurs
  - ii. Telophase I
    - 1. The nuclear membrane forms around each new nucleus
  - ii. Prophase II
    - 1. They line up again
  - i. Metaphse II
    - 1. Aligned at the equatorial plate
  - iii. Anaphase II
    - 1. The sister chromatids separate
  - i. Telophase II
    - 1. The nuclear membrane forms again.

## Asexual Reproductive Mechanisms

### I. General

- a. Production of offspring without fertilization
- b. Carbon copies of parent except when mutation occurs
- b. Prevalent amongst invertebrate, not vertebrates in animals
- b. All plants go through asexual reproduction in some form

## II. Non-Plants

- a. Fission
  - i. Seen in prokaryotic organisms
  - ii. DNA replicates, and new plasma membrane and cell wall grows and divides the cell.
  - vi. Happens in amoebae, paramecia, algae, bacteria
- a. Budding
  - i. Replication of nucleus followed by unequal cytokinesis
  - iii. Cell membrane pinches inward to form a new cell that is smaller but identical to parent
  - iv. The new cell may separate immediately or be just an outgrowth and separate later
  - i. Happens in hydra and yeast
- b. Regeneration
  - i. Regrowth of lost or injured body part via Mitosis
  - i. Hydra and Starfish can regenerate entire body from just the arm as long as it contains a piece of central disk
- b. Parthenogenesis
  - i. Development of an unfertilized egg into an adult organism
  - iv. Happens in bees and ants where worker bees and queen are from fertilized while normal males are from unfertilized
  - v. Artificial parthenogenesis can happen to animals via electric shock

## II. Plants

- a. General
  - i. All plants have alternation of generations where it goes from diploid to haploid
- b. Spore Formation
  - i. Diploid sporophyte generation produces haploid spores
  - i. Haploid spores develop into the haploid gametophyte generation which would need to be fertilized to go back to sporophyte generation
- b. Vegetative propagation
  - i. Meristems, undifferentiated tissues in plants that can grow into an adult plant
- b. Natural Vegetative Propagation
  - i. Bulbs - growth that split to form several bulbs and can then grow into adult
    - 1. Happens with tulips and daffodils
  - i. Tubers - underground stems with buds that can grow into adult
  - i. Runners - stems running above and along the ground that can produce new roots
    - 1. Strawberry and lawn grass
  - i. Rhizomes (stolons) - woody, underground stems that can develop new upright stems
    - 1. Ferns and iris plants
- a. Artificial Vegetative Propagation
  - i. A cut from stem can grow with help of hormone called auxins
  - iii. Stems of certain plants will grow and take root if bent to the ground, this is called layering.
  - iv. Stem of one plant called the scion can be attached to another called stock and new plant results.



## Sexual Reproductive Mechanisms

### I. General

- a. Two parents are involved and result in genetically unique offspring
- c. Requires two gametes fertilizing each other

### IV. Sexual Reproduction in Animals

#### a. Gonads

- i. Gametes are produced in the specialized organs called gonads.
- iii. Male gonads are called testes, produces sperm in the seminiferous tubules
- iv. Female gonads are called ovaries, produce oocytes
- v. Hermaphrodites have both functional male and female gonads
  - 1. Earthworms and hydra have both

#### b. Spermatogenesis

- i. Sperm production happens in seminiferous tubules
- vii. Spermatogonia (diploid) undergoes meiosis to produce 4 sperms
- i. Sperm
  - 1. Consists of head, tail, neck and body
    - a. Head consists of almost entirely of nucleus with paternal genome
    - I. Tail (flagellum) propels the sperm
    - I. Neck and body are full of mitochondria for energy

#### b. Oogenesis

- i. Production of females gametes in ovaries
- i. One diploid female sex cells undergoes meiosis to produce single mature egg
  - 1. Each meiotic division produces a polar body
  - 1. Polar body is a small cell that contains little more than nucleus
  - 1. Polar bodies usually die quickly
- v. Mature ovum contains most of the cytoplasm, RNA, organelles, and nutrients needed by developing embryo

#### c. Fertilization

- i. General
  - 1. Species that care for their young, produces far fewer eggs
- iii. External
  - 1. Vertebrates that reproduce in water (fish and amphibian)
  - 1. Females lay the eggs and the males deposits sperm in the vicinity
- v. Internal
  - 1. Practiced by terrestrial vertebrates and provides direct route for sperm
  - 1. Females need not produce so many eggs

### II. Human Reproduction

#### a. Male Reproductive Physiology

- i. Testes located in pouch called scrotum which keeps the testes 2-4 degrees lower in temperature
- iv. Sperms get out of the penis in the following order
  - 1. Seminiferous Tubules - made here
  - 1. Epididymis - The thing that testes is attached to
  - 1. Vas deferens - the thing that's attached to the epididymis
  - 1. Ejaculatory Duct - the path to exit
  - 1. Urethra - right before the exit
  - 1. Penis - The final stretch
- i. Urethra is common passageway for both reproductive and excretory system
- i. Testes are also site of testosterone production
  - 1. Testosterone regulates secondary male characteristics

- a. Facial and pubic hair, and voice changes
- b. Female Reproductive Anatomy
  - i. Ovaries are found in the abdominal cavity, below the digestive system
    - 1. Consists of thousands of follicles
    - 1. Follicles are multi-layered sac of cells that contains, nourishes, and protects an immature ovum
      - a. Follicles produces estrogen
  - i. Once a month, immature ovum is released into nearby oviduct and it leads via the fallopian tube to the uterus.
  - iii. Uterus is the site of fetal development.
  - i. Closer to the vagina is the cervix
  - i. The vagina canal is the site of sperm deposition during intercourse
  - i. At birth, all the eggs a female will ovulate are already present in the ovaries

e. Female Sex Hormones

- i. Ovaries produces and secrete estrogens and progesterone
  - 1. Ovaries is regulated by LH, FSH
  - 1. Production of LH and FSH is regulated by GnRH
- iii. Estrogen
  - 1. Steroid hormones necessary for normal female maturation
  - 1. Stimulate the develop of female reproductive tracts
  - 1. Stimulates the thickening of endometrium (uterine wall)
  - 1. Contributes to secondary sexual characteristics and sex drive

Secreted by ovarian follicles and corpus luteum

- I. Progesterone
  - 1. Secreted by corpus luteum during luteal phase of the menstrual cycle
  - I. Stimulates the development an maintenance of the endometrial walls to prepare for implantation

b. Menstrual Cycle

- i. Secretions by ovaries, hypothalamus, and anterior pituitary all play a role in the reproductive cycles
- I. From puberty to menopause, these hormones result in monthly pattern PMS
- i. Can be divided into follicular phase, ovulation, luteal phase, and menstration
  - 1. Follicular phase
    - a. Starts with cessation of menstrual flow from previous cycle
    - a. Folliculation stimulating hormones (FSH) from anterior pituitary promotes the development of follicles
    - a. Development of follicles causes secretion of estrogen
  - 1. Ovulation
    - a. Caused by surge of luteinizing hormone (which is caused by peaking of estrogen level)
    - a. Midway through the cycle, ovulation occurs
    - a. A mature ovarian follicle bursts and releases an ovum
  - 1. Luteal phase
    - a. Luteinizing hormone induces the ruptured follicle to turn into corpus luteum
    - a. Corpus luteum secretes estrogen and progesterone
    - a. Progesterone causes the glands of endometrium to mature and produces secretions that prepare endometrium for implantation
  - 1. Menstruation
    - a. If ovum is not fertilized, corpus luteum atrophies
    - a. The lack of progesterone and estrogen causes the endometrium to become weak and slough off

- a. This causes the menstrual flow
- b. If fertilization occurs, the developing placenta produces hCG (human chorionic gonadotropic) which would maintain the corpus luteum.
- a. Until the placenta is developed, the corpus luteum will stay and keep estrogen and progesterone coming

## II. Sexual Reproduction in Plants

### a. General

- i. Characterized by alternating between diploid sporophyte and haploid gametophyte generations
- ii. Sporophyte, via evolution, are becoming more dominate
- ii. The order > Sporophyte (2N) >> Spores (1N) >> Gametophyte (1N) >> fertilization >> Sporophyte (2N)

### b. Gametophyte Generation

- i. Haploid gametophyte produces gametes by mitosis
- ii. Thus, gametophyte reproduces sexually while sporophyte reproduces asexually
- ii. Gametophyte is dominate generation in mosses.
  - 1. The sporophyte of mosses is dependent on the gametophyte to survive

### b. Sporophyte Generation

- i. The sporophyte produces spores via meiosis
  - 1. In ferns, sporophytes are dominate
  - 1. In angiosperms (flowering plants), sporophytes are dominate

## II. Sexual Reproduction in Angiosperms

### a. General

- i. The flower is the reproductive structure
- ii. Some species have flower that contain only male or female. Some have both

### b. Parts of a flower

#### i. Stamen

- 1. Male organ of the flower and consists of stalk like filament with a sac called anther.
- 2. Anther is what produces the haploid spores that become a pollen grain

#### ii. Pistil

- 1. Female organ of the flower, consists of stigma, style, and ovary
- 2. Stigma is the stick part that catches spores
- 2. Style - tube that guides the pollens along
- 2. Ovary - enlarged base of pistil

#### ii. Petals and Sepals

- 1. Decorations

### b. Fertilization

- i. Pollen grains goes from anther to the stigma, and the sperm nucleic splits and makes the male gametes
- ii. Female gametophyte - developed in ovules from one out of 4 spores
- ii. This is the embryo sac and contains nucleic including two polar nucleic
- ii. Fertilization occurs when sperm nucleus fuses with the egg nucleus to develop into embryo.
- ii. Other sperm nucleus fuses with 2 polar bodies to form endosperm.

### b. Seed Formation

#### i. Embryo consists of

- 1. Epicotyl - precursor to upper stem and leaves
- 1. Cotyledons - seed leaves. Dicot have 2, monocot has 1.
- 1. Hypocotyl - develops into stem and root
- 1. Endosperm - grows and feeds the embryo.

- a. In dicots, cotyledon absorbs the endosperm
    - 1. Seed Coat - develops from outer covering of the ovule.
- b. Seed Dispersal
  - i. Fruits is the usual seed carrier
    - 1. Formed from ovary walls, base of the flower, and other flower components
  - ii. The seed is released from the ovary, and will germinate under the right conditions
- b. Plant development
  - i. Growth in advanced plants depends on meristem cells.
  - ii. Eventually, meristem cells would elongate and differentiate into different cell types
  - ii. Apical meristem - found on the tip of the roots and stems, growth only here
  - i. Lateral meristem - cambium in another word, located between xylem and phloem.
    - 1. Permits growth in diameter
    - 1. Can differentiate into either xylem or phloem cell
    - 1. Not active in monocots (grasses) or herbaceous dicots.

## CH. 3 : GENETICS

### II. Keywords

- e. Allele - alternative forms of gene
- f. Colchicine - inhibits spindle formation
- g. Down Syndrom - classic trisomy of chromosome 21
- h. Episome - plasmids capable of integration into bacterial genome
- i. Filial - F generation in genetic crossing
- j. Gene - basic unit of heredity, composed of DNA and located on chromosome
- k. Genotype - genetic makeup of the individual
- l. Monosomy - somatic cells having  $2N-1$  chromosomes
- m. Operon - consists of structural gene, operator gene, and promoter gene
- n. Phenotype - the physical manifestation of the genotype
- o. Plasmids - contain one or more genes, cytoplasmic DNA
- p. Provirus - viral DNA phages into bacteria and become integrated to host bacteria
- q. Purine - Guanine and Adenine
- r. Pyrimidine - Cytosine and thymine
- s. Testcross - Only recessive phenotype can genotype be predicted 100%, test cross determines the genotype of a dominant phenotype
- t. Trisomy - somatic cells having  $2N+1$  chromosomes
- u. True-breeding - self-crossed would produce progeny with the parental phenotype

### Mendelian Genetics

#### III. Mendel's First Law - Law of Segregation

- b. Genes exist in alternative forms and each organism has two alleles for each trait
- v. During meiosis, the two alleles segregate, resulting in gamete with only one allele
- b. If two alleles are different, the expressed is dominant, the other is recessive
- d. Mendel's Law of Dominance - dominant allele appears in the phenotype

#### II. Mendel's Second Law - Law of Independent Assortment

- b. As long as two genes are on separate chromosomes, they will assort independently during meiosis.

#### II. Non-Mendelian Inheritance Patterns

- d. Incomplete Dominance
  - i. Blends of phenotype, red + white = pink
- g. Codominance
  - iv. Both expressed at the same time
  - l. Blood type is a very classic example

#### II. Sex Determination

- b. Sex determined by a pair of sex chromosomes while the rest are autosomes
- j. Human gender is determined by the genetic contribution of **male** only
- k. Sex-linked traits are genes located on the X or Y chromosomes

#### IV. Sex-linkage

- b. If X-recessive, it'd always be expressed in males
  - v. Hemophilia and color blindness are two examples
- d. Sex-linked trait skip a generation because father cannot pass to son, only daughter. So the daughter would be carrier and then the grandson would be afflicted.

#### II. Drosophila Melanogaster

- b. Short life cycle
- c. Large sample size
- b. Chromosomes are large and easily recognizable

- c. Few chromosomes ( $2n = 8$ )
- c. Mutations occur frequently
- II. Environmental factors
  - c. Environment can affect the expression of a gene
  - d. Examples
    - iii. *Drosophila* with crooked wings at low temperature and straight wings at high
    - i. Himalayan hare has white hair in warmer part, and black in colder part

## Genetic Problems

- II. Nondisjunction
  - c. Failure of chromosomes to separate
  - f. Trisomy - having  $2N+1$  somatic chromosomes
  - b. Monosomy - somatic cells having  $2N-1$  chromosomes
- II. Chromosomal Breakage
  - b. Exposure to mutagenic agents or X-rays where chromosomes would lose a fragment
- II. Mutations
  - b. Changes in the genetic information of a cell
  - b. Mutations in the somatic cells can lead to tumors
  - b. Mutations in the sex cells would be passed to offspring
  - b. Mutagenic Agents
    - iv. Induces mutations
    - viii. Cosmic rays, X-rays, UV rays, radioactivity
    - ii. Chemical compounds like colchicine (inhibits spindle formation)
    - iii. Mustard gas
    - ii. Usually carcinogenic
  - b. Mutation Types
    - vi. Added - a base is added
    - iii. Deleted - base is deleted
    - ii. Substituted - base is changed
    - v. Frameshift
  - b. Examples of Diseases
    - i. Phenylketonuria (PKU) - molecular disease caused by inability to produce the proper enzyme for metabolism of phenylalanine.
    - i. Sickle cell anemia - blood cells sickle and cannot carry oxygen

## Molecular Genetics

- II. General
  - b. Genes are composed of DNA
  - b. Has ability to self-replicate
  - b. DNA is basis for heredity
  - b. DNA is mutable and can be changed
- II. Structure of DNA
  - b. Basic unit of DNA is made of nucleotide
  - b. Nucleotide consists of deoxyribose, bonded to a phosphate and a base
  - b. The bases are of two types
    - ii. Purines
      - 1. Adenine and Guanine

- iii. Pyrimidines
    - 1. Cytosine, thymine (uracil)
- b. Double-stranded helix with sugar-phosphate chains on the outside and bases on the inside
- b. Thymine forms **2** hydrogen bonds with Adenine
- b. Guanine forms **3** hydrogen bonds with Cytosine

## DNA & RNA

### II. DNA Replication

- f. The double helix is split open and each act as a template for complementary base pairing
- b. DNA replication is semiconservative

### II. Genetic Code

- g. G, C, A, T make up the letters of the DNA and together, they can write 20 different words or amino acids
- c. DNA must be translated into mRNA and this is universal for almost all organism
- c. Amino acids are degenerate - each amino acids have more than one codon
- c. Condons are unambiguous - each triplet codes for one amino acid only

### III. Structure of RNA

- b. Same as DNA except it uses a ribose sugar and contains uracil instead of thymine
- b. Usually single stranded instead of double
- b. Many types - mRNA, tRNA, rRNA
  - ii. Messenger mRNA
    - 1. Carries the complement of DNA and transport it to the ribosomes for translation
  - i. Transfer RNA
    - 1. Brings the amino acids to the ribosomes for protein synthesis
  - iv. Ribosomal RNA
    - 1. Synthesized in the nucleolus, it makes up the ribosomes

### II. Protein synthesis

- k. Transcription
  - ii. DNA is transcribed into strand of mRNA and goes out into cytoplasm through nuclear pores
- c. Translation
  - iv. Initiation
    - 1. Ribosome binds to the mRNA near its 5' end and gets up to the start codon, AUG
    - 1. Brings in the initiator aminoacyl-tRNA complex, or methionine-tRNA would base pair with the start codon
  - ii. Elongation
    - 1. Hydrogen bonds form between mRNA codon in the A site and the complementary anti-codon from the aminoacyl-tRNA complex
    - 1. Peptide bond is formed that'd join the new amino acid in the A site and the P site.
  - v. Translocation
    - 1. The ribosome would advance three nucleotides along the mRNA in 5' to 3' direction
    - 1. Uncharged tRNA is expelled through the E site, and the chain moves from the A site to P site.

- i. Termination
    - 1. Terminates when we reaches three special mRNA termination codons, UAA, UAG, UGA
  - c. Polyribosome
    - ii. Multiple ribosomes synthesizing polypeptides with one mRNA
  - b. Primary sequence is made, and through interactions, goes into secondary to tertiary
- II. Other type of DNA and inheritance
  - b. DNA is found in chloroplast and mitochondria, they can interact with nuclear genes and can be changed
  - c. Plasmids - contain one or more genes



## CH. 4 : Vertebrate Embryology

### II. Keywords

- b. Allantois - sac-like structure that's involved in respiration and excretion and contains blood vessels to transport gas, and waste
- a. Amnion - encloses the amniotic fluid. Provides the aqueous environment that protects the developing embryo
- c. Blastocoel - when morula develops the cavity
- e. Blastula - hollow sphere of cells evolved from blastocoel
- g. Blastulation - process of morula developing a fluid-filled cavity
- h. Chorion - lining of inside the shell. A moist membrane that permits gas exchange. Envelops the amnion
- i. Determinate cleavage - cells whose future pathways are determined early
- j. Ectoderm - outer layer. Integument, hair, nails, skin, lens of eye, retina, CNS
- k. Endoderm - inner outer layer. Lining of digestive and respiratory tracts, parts of liver, pancreas, thyroid, and bladder lining.
- l. Fraternal Twins - more than one egg fertilized during fertilization
- m. Gastrulation - process of 1 layer blastula to 3 layered structure called gastrula
- n. Identical Twins - results of indeterminate cleavage
- o. Indeterminate cleavage - cells maintain ability to develop into complete organism
- p. Mesoderm - musculoskeletal, circulatory, excretory systems. Gonads, connective tissues, and portions of digestive and respiratory organs.
- q. Morula - solid ball of embryonic cells that hasn't developed a fluid-filled cavity
- r. Yolk sac - encloses the yolk. The yolk sac blood vessels gives food to developing embryo

## Early Developmental Stages

### II. General

- c. Embryology is the study of development of zygote into complete cellular organism.

### II. Fertilization

- c. Happens within 12-24 hours following ovulation

### II. Cleavage

- c. Rapid divisions without growth in cell protoplasm
  - i. Results in smaller and smaller cells
  - l. Increasing ratio of nuclear to cytoplasmic material
  - l. Increases surface-to-volume ratio
- w. First complete cleavage happens 32 hours after fertilization, then second at 60, third at 72.
- c. At 72 hours, the 8 celled embryo will reach uterus
- e. With more cell division, it'd be called morula, which is right before development of fluid filled cavity
- c. Next comes blastulation where the morula develops the cavity, which turns it into blastocoel and soon turns into blastula.

### III. Gastrulation

- a. The process is the transformation of a single cell layer of blastula into 3-layered structure
- h. Each of the three layers develops into different parts of the body.
- h. The ectoderm forms the "outer layer" of the body like the skin, hair, lens of the eye, retina, nervous system, surface of nose, mouth, and anal canal

- g. The endoderm forms the "inner outer layer" of the body, like the lining of the digestive and respiratory tracts, and parts of the liver, pancreas, thyroid, and bladder lining
- k. The mesoderm forms the guts like the musculoskeletal system, circulator system, excretory system, gonads, connective tissue, and portions of digestive and respiratory systems.

## II. Development

- c. There are different types of development for zygote, external, non-placental internal, and placental internal
  - a. External development
    - v. Occurs outside of the body in fish and amphibians
      - 2. Basically, females lay eggs and male comes around to fertilize them
    - I. Reptiles, birds, and some mammals would have internal fertilization then the eggs are laid
    - I. Egg structure
      - 3. Chorion - lining of inside the shell. A moist membrane that permits gas exchange. Envelops the amnion
      - 1. Allantois - sac-like structure that's involved in respiration and excretion and contains blood vessels to transport gas, and waste
      - 1. Amnion - encloses the amniotic fluid. Provides the aqueous environment that protects the developing embryo
      - 1. Yolk sac - encloses the yolk. The yolk sac blood vessels gives food to developing embryo
- d. Non-placental internal development
  - i. Happens in marsupials and some tropical fish
  - iv. Basically develops in mother without placenta thus the transfer of food and oxygen between mother and embryo is limited
- e. Placental internal development
  - i. The fetus receives oxygen, nutrients and expels CO<sub>2</sub> and wastes via a special circulatory system between mother and embryo.
    - 1. Placenta and the umbilical cord are responsible
      - a. Outgrowths of 4 extra-embryonic membranes formed during development
        - I. Amnion
        - I. Chorion
        - I. Allantois
        - I. Yolk sac
      - a. Placenta development begins with the chorion
      - a. Allantois develops as an outpocketing of the gut
        - I. The blood vessels develops into umbilical vessels that connects the fetus and the plaenta
      - a. Yolk sac is associated with the umbilical vessels

## II. Birth and Maturation

- d. Childbirth happens with labor, a series of strong uterine contractors
- c. Labor has three distinct stages
  - iv. Stage 1 -
    - 1. Cervix thins and dilates and amniotic sac ruptures (water broke!)
    - 1. Contractions are mild
  - iii. Stage 2 -
    - 1. Rapid contractions, baby is expelled along with umbilical cord
  - iv. Stage 3 -
    - 1. The uterus contracts and placenta and umbilical cords are fully expelled
- b. Maturation

- v. In some animals, maturation can be suspended
- ii. Mammals develop uninterrupted

## CH. 5 : Vascular systems in Animals and Plants

### Key Words

- II. Active Immunity - production of antibodies during immune response
- II. Agglutinate - clumping of antigens called by antibodies (Igs)
- II. Allergy - inappropriate responses to certain foods and pollens that causes immune response
- II. Aorta - largest blood vessel
- II. Aortic Loops - 5 pairs of vessels that act as an additional blood pump in earthworms
- II. Arteries - branched off of Aorta
- II. Arterioles - branched off of arteries
- II. Antigen - non-self entities like bacteria, toxins, foreign blood cells, etc
- II. B cells - produces antibodies
- II. Blood - 4-6 liters in human body. 55% liquid (plasma), 45% cellular component
- II. Capillaries - branched off of arterioles
- II. Coronary Sinus - deoxygenated blood from heart muscles
- III. Erythroblastosis fetalis - caused by Rh factor. Mother has immune response to fetal blood
- III. Fibrin - comes from fibrinogen, comes in threads and would trap blood cells to form clot
- II. Fibrinogen - converted into fibrin by thrombin
- II. Granulocytes - inflammatory response that phagocytize antigenic material
- II. Humoral immunity - production of antibodies against antigens
- III. Immunoglobulins - large proteins that recognize and bind to specific antigen for removal
- II. Inferior Vena Cava - deoxygenated blood from the lower half of the blood
- III. Interferons - proteins produced by cell under viral attack that diffuse and help other cells
- IV. Left Atrium - receives blood from the 4 pulmonary veins (2 from each lung). Pumps blood through mitral valve
- II. Left Ventricle - receives blood from the left atrium, through the mitral valve, and pumps blood through the semi-lunar valves of aorta to the rest of the body
- II. Leukocytes - white blood cells, phagocytic. Larger than erythrocytes
- III. Lung Pathway - nose > pharynx > larynx > trachea > bronchi > bronchioles > alveoli
- II. Lymph - interstitial fluid
- III. Lymph nodes - swellings along lymph vessels containing leukocytes that filter the lymph, removing and destroying foreign particles and pathogens
- V. Mitral valve - the door between left atrium and left ventricle (bicuspid)
- II. Passive Immunity - transfer of antibodies from another individual or organism, short lasting
- III. Plasma - 55% of blood - nutrients, salts, gasses, wastes, hormones, blood proteins
- II. Platelets - cell fragments that lack nuclei and involved in clot formation
- III. Prothrombin - activated by thromboplastin into thrombin, made in liver
- II. Pulmonary Circulation - toward the lung to oxygenate the blood
- II. Right Atrium - receives the deoxygenated blood through 3 sources
- III. Right ventricle - receives blood from the right atrium through the right-atrio-ventricular opening. Pumps blood out to the pulmonary artery through the semi-lunar valves of pulmonary artery
- II. Semi-lunar valves - valves to prevent backflow into the left or right ventricles
- II. Sinus - a location for open circulatory system to exchange nutrients and wastes (arthropods)
- II. Superior Vena Cava - deoxygenated blood from the arm, thorax, and head region
- IV. Systemic Circulation - pumping oxygenated blood throughout the body
- III. T Cells - cytotoxic of infected cells
- III. Thrombin - activated form of prothrombin, converts fibrinogen into fibrin
- II. Thromboplastin - clotting factor that interacts with prothrombin, activating it
- III. Vaccination - individual injected with another form of antigen and antibodies build up
- II. Vein - Converged from venules
- II. Venules - converged from capillaries

## Plants

- II. Cambium cells - two layers thick and differentiates into xylem or phloem. Lateral meristem
- II. Companion Cells - a type of phloem cell
- II. Capillary Action - water in narrow space naturally goes up due to hydrogen-bond properties
- II. Fibrovascular bundle - runs up and down stem, contains xylem, phloem, and cambium cells
- II. Heartwood - inner layer of xylem that's dead and can be used for lumber
- II. Meristem - actively dividing, undifferentiated cells of a plant
- III. Phloem - thin-walled cells that transport nutrients down the stem
- II. Pith - the innermost layer, involved in storage of nutrients and plant support
- III. Root - absorbs materials and anchor the plant. Apical meristem at the tip
- II. Root hair - increases surface area for absorption of water and mineral
- II. Root pressure - water entering root hair exerts pressure which pushes water up
- II. Sapwood - outer layer of xylem that's alive
- II. Sieve tube cells - a type of phloem cell
- III. Stem - primary organ of transport
- II. Tracheids - a type of xylem cell
- II. Translocation - circulation
- II. Transpiration - water evaporate from leaves, creating vacuum that sucks up water from stem
- II. Vessel Cell - a type of xylem cell

## Circulation in Invertebrates

- II. Protozoans
  - b. Diffusion within the cell
- II. Cnidarians
  - b. Hydra and other cnidarians only have cell wall as thick as 2 cells, so any cell is in direct contact with internal or external environment
- V. Arthropods (insects, crustacean, arachnids, myriapods)
  - b. Open circulatory system
    - ii. Blood (interstitial fluid) is in direct contact with the body tissues
    - iii. Flow of blood via body movement
    - ii. The exchange happens in the "sinus" and the blood flows through the dorsal vessel into these sinus
- II. Annelids (earthworms)
  - b. Closed circulator system
    - ii. Blood confined in blood vessels
    - iii. Blood moved toward the head via the dorsal vessels via coordinated contractions
    - iii. Aortic loops connects the dorsal vessel to the ventral vessel and functions as additional pump
    - v. No red blood cell, but does have hemoglobin-like pigments

## Circulation in Humans

- II. General
  - b. Composed of
    - ii. a heart with 4 chambers
    - ii. Blood vessels
    - vi. Blood
  - b. Blood pumped through aorta (going away from heart)

- b. Blood returns through vein (coming to heart)
- a. Blood vessel branching
  - i. Aorta branches off into series of arteries
  - i. Arteries branches off into arterioles
  - iii. Arterioles branches off into microscopic capillaries
  - iii. Capillaries converges into venules
  - iii. Venules converges into veins
- b. Exchange happens through the capillaries via diffusion

## II. The Heart

- b. The right side
  - i. Responsible for oxygenating the blood, this is called pulmonary circulation
  - ii. Right Atrium
    - 1. Thin walled
    - 1. Receives the deoxygenated blood from 3 sources
      - I. Superior vena cava - from head, arms, and thorax
      - a. Inferior vena cava - lower parts of the body
      - a. Coronary sinus - blood from walls of the heart
  - iii. Right ventricle
    - 1. Muscular
    - 1. Receives blood from the right atrium
      - I. Through the right atrio-ventricular opening
    - 1. Pumps the blood through pulmonary arteries to the lungs
      - I. The opening of this is guarded by a tri-cuspid valve called "semi-lunar valves of pulmonary artery"
      - I. When the ventricle contracts, the semi-lunar valve closes and blood is forced past through the pulmonary artery
- a. The left side
  - ii. Responsible for circulation of oxygenated blood, this is called systemic circulation
  - ii. Left Atrium
    - 1. Thin walled
    - 1. Receives oxygenated blood from the lung via 4 pulmonary veins
    - 1. Pumps the blood through mitral valve to the left ventricle
  - ii. Left ventricle
    - 1. Extremely muscular
    - 1. Receives blood from left atrium through the mitral valve
    - 1. Pumps oxygenated blood to the rest of the body through aorta and the semi-lunar valve of aorta

## II. Blood Vessels

- b. Three types of blood vessels
  - ii. Arteries
    - 2. Thick-walled, muscular, elastic
    - 1. Transports blood away from the heart
  - vi. Veins
    - 2. Thin-walled, inelastic
    - 1. Transport blood to the heart
    - 1. Blood flow depends on compression by skeletal muscles during movement
    - 1. Larger veins have valves that prevent backflow
  - iv. Capillaries
    - 1. Very thin walls composed of a single layer of endothelial cells
    - 1. Gas, nutrient, enzymes, hormones, wastes can readily diffuse
    - 1. Red blood cells must often pass through them single file

## II. Lymph vessels

- a. Called the secondary circulatory system
- b. Transports excess interstitial fluid called lymph
- d. Lymph nodes are swellings along lymph vessels containing white blood cells that filter the lymph and destroy foreign particles
- a. It also absorbs chylomicrons from small intestine and deliver them to the cardiovascular circulation

## II. Blood

### b. General

- i. On average, human body contains 4-6 liters of blood
- iv. Blood consist of 55% liquid and 45% cellular components
  - 1. Plasma is the liquid portion
    - a. Consists of salts, nutrients, respiratory gases, wastes, hormones, blood proteins
  - 1. Cellular components
    - a. Erythrocytes (red blood cell)
    - I. Leukocytes (white blood cell)
    - I. Platelets
- d. Erythrocytes (red blood cell)
  - ii. One cell contains approximately 250 million molecules of hemoglobin
  - i. When hemoglobin binds oxygen, it's called oxyhemoglobin
  - i. Formed by stem cells in the bone marrow where they lose nuclei, mitochondria, and membranous organelles
  - ii. Lives for about 120 days
    - 2. Phagocytized by special cells in spleen and liver
- h. Leukocytes (white blood cell)
  - ii. Larger than erythrocytes
  - ii. Phagocytize foreign matter and organisms such as bacteria
  - ii. Some migrate from blood to tissues where they mature into stationary cells called macrophages
  - iii. Lymphocytes - involved in immune response and production of antibodies or cytolysis of infected cells
    - i. B cells - produces antibodies
  - iii. T cells - cytolysis of infected cells
- b. Platelets - cell fragments that lack nuclei and involved in clot formation

## Functions of the Circulatory System

## II. Transport of gases

- b. Hemoglobin transports O<sub>2</sub> and CO<sub>2</sub>

## VI. Transport of nutrients and wastes

- b. Amino acids and simple sugars
  - ii. Are absorbed into the bloodstream at the intestine
  - ii. After processing, delivered to the rest of the body
- d. Waste products
  - ii. Diffuse into capillaries
  - ii. Delivered to appropriate excretory organs

## VII. Clotting

- b. Steps for clotting
  - ii. Platelets meet exposed collagen of damaged vessel
    - 2. Release a chemical that causes neighboring platelets to stick together

- a. Forms a platelet plug
- ii. Both platelets and damage tissues releases thromboplastin
  - 2. Thromboplastin is a clotting factor
  - 2. Thromboplastin with calcium and vitamin K, converts prothrombin to active thrombin
- ii. The active thrombin would convert fibrinogen into fibrin
- iii. Fibrin would form threads into a coat to stop the flow of blood to form clot

#### Immunological Reactions

- b. The body can distinguish between "self" and "nonself" and remember the non-self that it has encountered before
- b. The immune system is two different mechanisms
  - ii. Lymphocytes are responsible for
    - 2. Humoral immunity
      - a. Produces antibodies
    - II. Cell-mediated immunity
      - a. Cells that combat fungal and viral infection
- c. Immune Cell types
  - ii. B cells - produces antibodies
  - II. Cytotoxic T cells - destroy infected cell
  - ii. Suppressor T cells - regulates activity of B and T cells
  - ii. Helper T cells - activate B and T cells
- b. Humoral immunity
  - ii. Produces antibodies and very specific to the antigens
  - ii. Antibodies are also called immunoglobulins (Igs)
    - 1. Recognize and bind to specific antigen
    - 2. Calls for white blood cells (leukocytes) to phagocytize the antigen
    - 2. Causes antigens to clump together into large insoluble complex
      - a. This clumping is called agglutinate
  - ii. Active immunity
    - 2. Production of antibodies during immune response
    - 2. Can be given with vaccination
      - b. Individual is injected with weakened, inactive form of the antigen and this stimulates the body to produce specific antibodies against it
  - ii. Passive immunity
    - 2. Only last as long as the antibodies circulate in the blood system
    - 2. Transfer of antibodies from another individual or organism
      - b. ie - maternal antibodies cross the placenta and enters fetal circulation
      - I. Gamma globulin - contains wide variety of antibodies
- b. Nonspecific Defense Mechanism
  - ii. Skin
    - 1. physical barrier against bacterial invasion
    - 2. Sweat attacks bacterial cell wall
  - ii. Mucous-coated epithelia
    - 2. Lines passages like respiratory
    - 2. Filter and trap foreign particles
  - i. Macrophages
    - 1. Engulf and destroy foreign particle
  - iii. Inflammatory
    - 2. Initiated by the body in response to physical damage
    - 1. Histamine is what causes the inflammation



- a. Blood vessels dilate and increase blood flow
- 1. Granulocytes
  - a. Attracted to injury site and phagocytize antigenic material
- 1. Often fever accompanies such
- iii. Interferons
  - 1. Proteins produced by cells under viral attack
  - 1. Diffuse to other cells and prevent the spread of virus
- ii. Allergy
  - 2. Inappropriate response to foods and pollens that causes the body to form antibodies and release histamine
- a. Rejection of Transplants
  - ii. Immune response to foreign organs or tissues causing transplant to be rejected
  - iii. Immuno-suppressing drugs can be used to lower the immune response
- c. Blood
  - ii. Red blood cells have characteristic cell-surface proteins (antigens)
  - ii. ABO Group
    - 1. Blood type A has A Antigen and produces anti-B antibodies
    - 1. Blood type B has B antigen and produces anti-A antibodies
    - 3. AB (universal recipient), has A and B antigen, produces no antibodies
    - 3. O (universal donor), has no antigen, produces anti-A and anti-B
  - ii. Rh factor
    - 1. Rh+ - possesses Rh antigen
    - 1. Rh- - lacking the Rh antigen
    - 1. Rh- woman with Rh+ fetus has an immune response. The next time she carries a Rh+ fetus, the blood that goes into fetal circulation will destroy fetal red blood cell
      - a. This causes erythroblastosis fetalis

## Transport Systems in Plants

### II. General

- b. Circulation is called "translocation"
- b. Stem is the primary organ of transport
- b. Fibrovascular bundles - run up and down the stem
  - ii. Contains xylem, phloem, and cambium cells

### II. Xylem

- b. Cells
  - ii. Thick-walled
  - iii. Hollow
  - i. Located on the inside of the vascular bundle
  - ii. Two types of Xylem Cells
    - 1. Vessel cells
    - 2. Tracheids
- b. Carries water and minerals **up** the plant and give the plant the rigid support
- b. When older xylem cells die, they form heartwood (lumber)
- c. The living portion is called sapwood
- b. How water is pulled up through the xylem cells
  - i. Transpiration pull - as water evaporates from the leaves of plants, vacuum is created which pulls up the water from stem
  - i. Capillary action - any liquid in a thin tube will rise due to surface tension and the interactions between liquid and the tube

iii. Root Pressure - water going into root hairs exert pressure which push water up

## II. Phloem

- a. Thin-walled cells on the outside of the vascular bundle
- b. Transports nutrients down the stem
- b. Two types of phloem cells
  - i. Sieve tube cells
  - ii. Companion cells
- b. If a stripe of bark around the trunk is removed (girdled), the tree will die

## III. Cambium

- a. Two layers thick
  - i. Divide and differentiates into either xylem or phloem
    - 1. This differentiation depends on if it's closer to xylem or phloem
- c. Situated between xylem and phloem layer

## II. Gross structure of a woody stem

- a. Epidermis (outerbark) > cortex > phloem > cambium, xylem > pith
- a. Pith is involved in the storage of nutrients and plant support

## II. Root

- a. Function
  - i. Absorb material through root hairs
  - iii. Anchor plants
  - ii. Provide storage
- b. Root hairs
  - i. Specialized cells of the root to increase surface area for absorption of water and mineral

## II. Regions of Growth in the Plant

- a. Meristem - active dividing undifferentiated cells of a plant
  - i. Cambium - lateral meristem
  - ii. Apical meristem - tip of roots and stems for elongation

## CH. 6 : Endocrinology

### Keywords

- II. Acromegaly - disorder in adult with overproduction of growth hormone - overgrowth of bone
- II. Adrenal Cortex - produces corticosteroids in response to stress
- II. Adrenal Glands - atop of kidney. Adrenal cortex and adrenal medulla are part of it
- III. Adrenal Medulla - produces epinephrine and norepinephrine for flight or fight response
- III. Adreno-corticotrophic hormone (ACTH) - produced by anterior or pituitary gland. Stimulates glucocorticoids and cortical sex hormones. Regulated by corticotrophin releasing factor (CRF)
- III. Aldosterone - regulate plasma levels of sodium and potassium and ultimately total excreted water volume. Might cause hypertension. Produced in adrenal cortex
- III. Androgen - secreted by testes and adrenal cortex (minute amount). For masculinity
- III. Anterior Pituitary - synthesizes direct and tropic hormones. Direct hormones: growth, prolactin, endorphines. Tropic hormones: ACTH, TSH, LH, FSH, MSH
- III. Antidiuretic hormone - Increases the permeability of the nephron collecting duct and thus promotes water reabsorption and increases blood volume. Produced in hypothalamus, stored in posterior pituitary.
- III. Auxin - plant hormone responsible for phototropism, geotropism, and inhibition of lateral buds
- III. Bile - produced by gall bladder into small intestine and digests fat
- III. Calcitonin - secreted by thyroid. Decreases plasma calcium level.
- III. Cholecystokinin - released by small intestine in response to fat and causes release of bile
- III. Chyme - partially digested food
- IV. Cortisol/Cortisone - produces in adrenal cortex. Involved in glucose regulation
- IV. Cretinism - hypothyroidism in infants
- III. Diabete mellitus - high blood glucose level, insulin out of whack
- III. Endocrine glands - synthesize and secrete hormones directly into circulatory system
- III. Endorphines - direct hormone inhibit the perception of pain secreted by anterior pituitary
- IV. Ethylene - stimulates fruit ripening.
- III. Exocrine glands - secrete substance transported by ducts
- IV. Follicle-stimulating Hormone (FSH) - causes maturation of ovarian follicles and thus production of estrogen. In males, stimulates maturation of seminiferous tubules and production of sperm. Produced in anterior pituitary and is a tropic hormone.
- V. Gastrin - produced by stomach and induces production of HCl
- III. Geotropism - growth of plants away from gravity.
- III. Gibberellins - stimulate rapid stem elongation. Inhibit formation of new roots. Terminates dormancy of seeds and buds. Stimulate production of phloem.
- IV. Glucagon - increases blood glucose level. Produced by alpha cells of pancrea
- III. Gluconeogenesis - formation of glucose from non-carb source like amino acids, glycerol
- IV. Goiter - bulge in neck resulting from hyperthyroidism
- VI. Hyperthyroidism - thyroid overstimulated, increased metabolism
- III. Hypothalamus - located directly above the pituitary glands. Controlled by brain, and produces hormones to interact with both pituitary glands.
- IV. Hypothyroidism - thyroid hormones are undersecreted, causes decrease metabolism
- III. Insulin - lowers blood sugar level
- IV. Islets of Langerhans - small glandular structure in pancrea that makes glucagon and insulin
- III. Kidney - when blood volume is low, produces Renin which would cause aldosterone production
- III. Kinin - promote cell division.
- IV. Luteinizing Hormone (LH) - in females, stimulates ovulation and formation of corpus luteum. In males, stimulates testes to make testosterone. Produced in anterior pituitary.

- III. Melanocyte-Stimulating Hormone (MSH) - produced by intermediate lobe that doesn't do anything. Useful in frogs.
- III. Melatonin - secreted by pineal gland, might have something to do with circadian rhythm
- III. Oxytocin - produced by hypothalamus, stored in posterior pituitary. It increases contractions during labor and also stimulates milk production.
- V. Pancreas - both exocrine and endocrine organ. Exocrine when producing digestive enzyme and transport through ducts to small intestine. Endocrine when producing insulin or glucagon.
- IV. Parathyroid Gland - secretes PTH that offsets the effect of calcitonin
- IV. Parathyroid Hormone - increases the concentration of plasma calcium
- III. Pineal Gland - tiny gland at base of brain that secretes melatonin
- IV. Pituitary Gland - 3 lobes, middle lobe is rudimentary. Located at base of brain.
- III. Phototropism - plant's tendency to grow toward sun. Indoleacetic acid is the auxin responsible
- III. Posterior Pituitary - also called neurohypophysis. Doesn't synthesize own hormone. Stores and secretes oxytocin and ADH.
- III. Prolactin - direct hormone stimulates milk production secreted by anterior pituitary
- III. Renin - secreted by the kidney, it converts a series of plasma protein that would stimulate the adrenal cortex to secrete aldosterone
- III. Secretin - released by small intestine that triggers secretion of alkaline bicarbonate to neutralize acidic chyme
- III. Somatotropin - direct growth hormone secreted by anterior pituitary
- III. Thyroid - located on ventral surface of the trachea
- IV. Thyroid Hormones - consists of thyroxine and tri-iodothyronine
- III. Thyroid-stimulating hormone (TSH) - tropic hormone produced by anterior pituitary. Stimulates thyroids.

## Chemical Regulation in Animals

### II. General

#### a. Endocrine system

- i. Means of internal communication, coordinating the activities of the organ systems
- i. Endocrine glands synthesize and secrete hormones directly into circulatory system
- i. ie - pituitary, hypothalamus, thyroid, parathyroids, adrenals, pancreas, testes, ovaries, pineal, kidney, gastrointestinal glands, heart, and thymus
- i. Some hormone regulate single type of cell or organ, some regulates wide range of actions
  - 1. Specificity determined by the presence of receptors on target cells

#### a. Exocrine glands

- i. Secrete substances that are transported by ducts
- i. ie - gall bladder

### IV. Adrenal Glands

- a. Situated on top of the kidney and consist of the adrenal cortex and adrenal medulla

#### a. Adrenal Cortex

- iv. Stimulated by ACTH (**adrenocorticotrophic hormone**) in response to stress and produces corticosteroids
- v. Derived from cholesterol, there are three kinds of corticosteroids
  - 1. Glucocorticoids
    - I. Involved in glucose regulation and protein metabolism
    - I. Raises blood glucose levels by protein breakdown and gluconeogenesis and decreasing protein synthesis

- I. Raises the plasma glucose levels and reverse the effect of insulin
    - a. ie - cortisol and cortisone
  - 4. Mineralocorticoids
    - I. Aldosterone is the major type of mineralocorticoids
      - I. Regulate plasma levels of sodium and potassium and total extracellular water volume
      - I. Causes active reabsorption of water in the nephron (kidney)
      - I. This causes raise in blood volume and blood pressure
      - I. In excess, it can cause excess retention of water and results in hypertension
  - 1. Cortical sex hormones
    - I. Secretes androgens like androstenedione and dehydroepiandrosterone
    - a. Androgens produced mostly in testes in male
    - a. Over production in female may have masculinizing effects
  - b. Adrenal Medulla
    - i. Produces epinephrine (adrenaline) and norepinephrine (noradrenaline)
      - 1. Belong in the catecholamine class - amino acid derived
        - I. Fight or flight response elicited
          - I. Increase conversion of glycogen to glucose in liver and muscle tissue
          - I. Rise in blood glucose level
          - I. Increase in basal metabolic rate
          - I. Increase the rate and strength of heartbeat
          - I. Dilate and constrict blood vessels to increase blood supply to skeletal muscle, heart, and brain and decreasing supply to kidneys, skin, and digestive tracts
      - a. Both are neurotransmitters
  - d. Control of Adrenal Hormones
    - i. Under the control of AdrenoCorticoTrophic Hormone
      - 1. Stimulates production of glucocorticoids and sex steroids
- II. Pituitary Gland
  - c. General
    - iii. Pituitary - also known as hypophysis
      - 1. Small tri-lobed gland
      - 1. Located at base of brain
      - 1. Contains two main lobes, anterior and posterior
        - I. The third lobe is rudimentary and doesn't do anything
  - c. Anterior Pituitary
    - iii. General
      - 1. Synthesize direct hormones which directly stimulate target organs
      - 1. Synthesize tropic hormones which stimulate other endocrine glands to release hormones
      - 1. Controlled by hypothalamic secretions called releasing/inhibiting hormones/factors
    - iii. Direct hormones
      - 1. Growth Hormones
        - I. Also known as somatotropin
        - b. Promotes bone and muscle growth
        - b. Deficiency leads to dwarfism in children
        - a. Overproduction leads to gigantism in children

- I. Overproduction in adult leads to acromegaly
      - I. Disproportionate overgrowth of bone in skull, jaw, feet, hands
    - 2. Prolactin
      - II. Stimulates milk production and secretion in female mammary glands
    - 2. Endorphines
      - I. Inhibit the perception of pain
  - i. Tropic Hormone
    - 2. Adrenocorticotrophic hormone (ACTH)
      - II. Stimulates adrenal cortex to synthesize and secrete glucocorticoids. Regulated by corticotrophin releasing factor (CRF)
    - 1. Thyroid-stimulating hormone (TSH)
      - I. Stimulates the thyroid gland to synthesize and release thyroid hormone including thyroxin
    - 2. Luteinizing Hormone (LH)
      - I. Females - stimulates ovulation and formation of the corpus luteum
      - I. Males - stimulates interstitial cells of the testes to produce testosterone
    - 1. Follicle-stimulating hormone (FSH)
      - I. Females - causes maturation of ovarian follicles which then secretes estrogen
      - I. Males - stimulates maturation of seminiferous tubules and sperm production
    - 2. Melanocyte-Stimulating Hormone (MSH)
      - I. Secreted by intermediate lobe of the pituitary
        - I. Doesn't do anything in mammals
        - I. In frogs, it darken the skin via dispersion of molecules of pigment in melanophore cells
  - c. Posterior Pituitary (neurohypophysis)
    - ii. General
      - 3. Does not synthesize hormones, rather it stores and releases different kinds of hormone produced by the neurosecretory cells of the hypothalamus
      - 1. Secretion is controlled by action potentials coming from hypothalamus
    - ii. Oxytocin
      - 2. Secreted during childbirth
      - 2. Increases the strength and frequency of uterine muscle contractions
      - 2. Induced also by suckling because it stimulates milk secretion
    - v. Antidiuretic hormone (ADH, vasopressin)
      - 1. Increases the permeability of the nephron's collecting duct to water
        - a. Thus promotes water reabsorption and increasing blood volume
      - 2. Secreted when plasma osmolarity increases or if blood volume decreases
- II. Hypothalamus
  - b. General
    - ii. Part of the forebrain and located directly above pituitary gland
    - iii. Receives instructions from brain (and elsewhere) that would trigger the neurosecretory cells
      - 2. This in turn controls the posterior pituitary gland via negative feedback mechanisms and the actions of inhibiting and releasing hormones.
  - c. Interactions with Anterior Pituitary
    - ii. Releases hormones that stimulate or inhibits secretions of anterior pituitary

1. GnRH - stimulates anterior pituitary to secrete FSH and LH
  - a. This hormone travels through the hypothalamic-hypophyseal portal system
    - I. Blood from capillary bed flows through a portal vein into the anterior pituitary so any hormone from hypothalamus goes to anterior pituitary immediately
  - i. Controlled via negative feedback. When concentration of said glucose is too high, or aldosterone -- glucose or steroids will act as an inhibitor to hypothalamus.
- b. Interactions with Posterior Pituitary
  - i. Hypothalamus synthesizes both oxytocin and ADH and transports them via their axons for storage and secretion in the posterior pituitary.

### III. Thyroid

- c. General
  - i. Bi-lobed structure located on the ventral surface of the trachea
  - v. Produces and secretes
    1. Thyroxine
    2. Triiodothyronine
    2. Calcitonin
- b. Thyroid Hormones
  - iii. General
    1. Thyroxine and tri-iodo thyronine are derived from iodination of tyrosine
    1. Necessary for growth and neurological development in children
    1. Increases metabolism throughout the body
  - ii. Hypothyroidism
    1. Hormones undersecreted
    1. Symptoms
      - a. Slowed heart rate and respiratory rate, Fatigue, Cold intolerance, Weight gain
    1. In infants, is called cretinism
      - b. Can cause mental retardation and short stature
  - iii. Hyperthyroidism
    3. Hormone oversecreted
    1. Symptoms
      - a. Increase metabolism, feeling of excessive warmth, profuse sweating, palpitations, weight loss, and protruding eyes
      - I. Thyroid often enlarges, forming bulge called goiter
- I. Calcitonin
  - iii. Decreases the plasma  $\text{Ca}^{2+}$  concentration by inhibiting the release of calcium ion from bone.
  - iv. Regulated by plasma calcium ion level.
  - ii. Antagonistic to parathyroid hormone

### VII. Pancreas

- b. General
  - ii. Both exocrine and endocrine organ
  - iii. Exocrine function when cells secrete digestive enzymes into the small intestine via ducts
  - i. Endocrine function when small glandular structures produce glucagon and insulin for the blood.
- f. Islets of Langerhans
  - ii. Small glandular structure composed of alpha and beta cells
  - i. Alpha cells produce and secrete glucagon
    1. Stimulates protein and fat degradation

1. Conversion of glycogen to glucose
3. Gluconeogenesis
1. Increases blood glucose levels
- iv. Beta cells produce and secrete insulin
  1. Protein hormone that stimulates uptake of glucose by muscle and adipose cells, and the storage of glucose as glycogen in muscle and liver cells

Lowers glucose level

- I. Stimulates the synthesis of fats from glucose and uptake of amino acids.
- III. Underproduction of insulin results to diabetes mellitus
  - a. Hyperglycemia (high blood glucose levels)

## II. Parathyroid Glands

- b. 4 small pea-shaped structures in the posterior surface of the thyroid
- b. Synthesize and secrete parathyroid hormone (PTH) that regulates plasma calcium level
- b. Increases the calcium level of the plasma by stimulating calcium releases from bone and decreasing calcium excretion in kidney
- b. Breakdown of bone releases both calcium and phosphate, and PTH stimulates excretion of phosphate by kidney.

## II. Kidney

- b. Produces Renin
  - ii. When body's blood volume is low, kidney produces renin
  3. Coverts plasma protein angiotensinogen to angiotensin I.
    - c. Then angiotensin I is converted to angiotensin II
      - II. Angiotensin II stimulates adrenal cortex to secrete aldosterone
  - iii. Aldosterone helps restore blood volume by increasing sodium reabsorption at the kidney leading to an increase in water.

## II. Gastrointestinal Hormones

- b. Gastrin
  - ii. Ingested food stimulates stomach to secrete gastrin
  - ii. Carried to the gastric glands and they'd secrete HCl
  3. The pancreatic juice are also under this control
- b. Secretin
  - ii. Released by small intestine when acidic food enters
  - ii. Stimulates the secretion of alkaline bicarbonate from pancreas to neutralize the partially digested food (chyme)
- b. Cholecystokinin
  - ii. Released by small intestine in response to presence of fat
    2. Causes the contraction of gallbladder and release of bile
      - b. Bile helps digestion of fat

## II. Pineal Gland

- b. Located at the base of brain
- c. Secretes melatonin
  - ii. Possibly regulation of the circadian rhythms
  - ii. Secretion regulated by light and dark cycles
  - iii. Lightens the skin in primitive vertebrates

## Mechanism of Hormone Action



## II. General

- b. Hormones are classified based on their chemical structures
  - ii. Peptide hormones
  - ii. Steroid Hormones
- b. Two ways which hormones affect the activities of target cells
  - ii. Extracellular receptors
  - iv. Intracellular receptors

## II. Peptides

- b. These hormones ranges from short peptides such as ADH to big ones like insulin
- c. Acts as messengers
- b. Binds to specific receptors on surface of target cells and triggers series of enzymatic reactions
  - i. The result of each reaction acts as the next messenger for the next reaction
    - 1. Inhibition usually occurs with the final product inhibiting the starting sequence

## II. Steroid

- b. These hormones are like estrogen and aldosterone
- c. Composed of ring structures and produced by places we mentioned earlier
- b. Because they are lipid soluble, they enter directly into the target and bind to receptor in the cytoplasm
  - i. This receptor-hormone complex then enters the nucleus and directly activates a gene expression and makes new proteins!

## Regulation in Plants

### II. General

- b. Plant hormones are usually involved in growth only
- b. Produced usually by growing parts of the plan like the meristematic tissues in the apical region.
- b. Also produced in young, growing leaves and developing seeds

### II. Auxins

- b. Phototropism
  - i. Auxins are responsible for the tendency of the plants to bend toward the sun
    - 1. When light strikes the plant on one side, the auxin supply on that side is reduced.
    - 1. The illuminated side of the plant grows more slowly than the shaded side
    - 2. This causes the stem to bend towards the light
    - 4. Indoleacetic acid is an auxin associated
- b. Geotropism
  - i. Negative
    - 1. Causes shoots to grow upward away from gravity.
      - I. Thus if plant is turned to side, it's turn itself about to grow up
      - a. Gravity increases the concentration of auxin on the lower side of the horizontal plant and this stimulates lower side to grow faster and the plant to grow vertically.
  - iii. Positive
    - 1. Causes roots to grow towards gravity
    - 2. Same as shoot, except effects are opposite
- c. Inhibition of Laterla buds
  - i. In terminal bud of plant's growing tip, auxin moves downward and inhibit the development of lateral buds

- i. Auxin also initiate formation of lateral roots while inhibiting root elongation

### III. Gibberellins

- b. Stimulates rapid stem elongation especially in plants that are stubby
- b. Inhibits formation of new roots
- c. Stimulates the production of new phloem cells by the cambium
- b. Terminate the dormancy of seeds and buds
- b. Induce biennial plants to flower during first year of growth

### II. Kinins

- b. Promotes cell division.
- c. Kinetin is a type of cytokinin
- d. Ratio of kinetin to auxin is important in determining the timing of differentiation of new cells

### II. Ethylene

- b. Stimulates fruits ripening
- c. Induces senescence, or aging

### II. Inhibitors

- b. Blocks cell division and serve in growth regulation
  - i. Important to maintain dormancy in autumn and winter
- a. Absciscic acid is one of the inhibitors and breaks down over time

### II. Anti-auxins

- a. Regulates the activity of auxins
  - i. ie - indoleacetic acid oxidase regulates the concentration of indoleacetic acid

## CH. 7 : Neuroscience

### Keywords

#### II. General

- b. Nervous system - a collective of nerve ending that enables organisms to receive and respond to stimuli from external and internal environment
- d. Neurons - functional units of nervous system. Converts stimuli into eletrochemical signals.

#### IV. Neuron

- b. Action Potential - when a threshold is reached (-50 mv), series of action causes impulse to travel down the axon and invade the nerve terminal, causing neurotransmitter to synapse
- f. Axon - long cellular process that transmits impulse away from cell body to next neuron
- g. Cell body - contains the nucleus and controls the metabolic activity of the neuron
- h. Dendrite - cytoplasmic extensions that receives the information and transmit it to cell body
- i. Depolarization - voltage-gated sodium channel opens to allow rapid depolarization, sending signal down the axon
- j. Myelin - allows axons to conduct impulses faster, sheath the axon
- k. Neurotransmitter - a chemical substance that transmit nerve impulse across synapse
- l. Nodes of Ranvier - gaps between segments of myelin
- m. Oligodendrocytes - produce myelin in the central nervous system
- n. Refractory period - immediately following action potential, a period of rest
- o. Repolarization - when voltage-gated potassium channel opens to return cell to negative potential after firing.
- p. Resting potential - the potential difference between inside and outside of cell -70 mv
- q. Schwann cells - produce the myelin in the peripheral nervous system
- r. Synapse - gap between axon terminals of one cell and dendrite of the next cell
- s. Synaptic terminals - swellings at the end of axon that releases neurotransmitters

#### IV. Synapse

- c. Acetylcholine - chemicals in vesicles called neurotransmitter
- a. Anti-cholinesterases - inhibit activity of acetylcholinesterase enzyme, causing undegradable neurotransmitter and causing uncoordinated muscular contractions
- b. Botulism toxin - prevents the release of acetylcholine, leads to paralysis
- c. Curare - blocks the post-synaptic acetylcholine receptors, leads to paralysis

#### VI. Vertebrate Nervous system

- b. Afferent neurons - neurons that carry sensory information
- e. Autonomic Nervous system - Involuntary. Regulates internal environment.
- f. Aqueous humor - formed by eye and exits through ducts to join the venous blood
- g. Auditory canal - part of the outer ear
- h. Auricle - external ear
- i. Basiliar membrane - hair cells here are stimulated by cochlea and transduces pressure into action potential
- a. Blindspot - the location where optic nerve exits the eye
- b. Brainstem - consists of midbrain, pons, and medulla
- c. Cerebellum - helps modulate motor impulses initiated by cerebral cortex (hindbrain)
- a. Choroid - under the sclera layer that helps supply retina with blood, reduces reflection
- a. Ciliary muscles - controls the shape and focal length of the lens
- a. Cochlea - inner ear, fluid here is pressured by vibration in ossicles
- a. Cones - type of photoreceptors responding to high-illumination
- a. Cornea - front of eye and bends/focuses light ray

- b. Diencephalon - contains the thalamus and hypothalamus (forebrain)
- c. Dorsal horn - sensory information enters spinal cord here
- d. Dorsal root ganglia - cell bodies of the sensory neuron
- a. Efferent neurons - neurons that carry motor information
- a. Forebrain - prosencephalon consists of telencephalon and diencephalon
- a. Fovea - spot of cone concentration on retina for vision acuity
- a. Ganglia - cluster of neuronal cell bodies in the periphery nervous system
- a. Hindbrain - rhombencephalon, consists of cerebellum, the pons, and medulla
- a. Hypothalamus - visceral functions and control of endocrine system (forebrain)
- a. Medulla - controls autonomic functions like breathing, heart rate (hindbrain)
- b. Midbrain - mesencephalon, relay center for visual and auditory impulses
- a. Nuclei - cluster of neuronal cell bodies in the central nervous system
- a. Olfactory bulb - center for reception and integration of olfactory input
- a. Ossicles - three bones consist of malleus, incus, and stapes that amplifies the sound
- a. Parasympathetic nervous system - acts to conserve energy and restore the body. Part of the autonomic nervous system
- a. Plexus - network of nerve fibers
- a. Pons - relay center to allow the cortex to communicate with cerebellum (hindbrain)
- b. Pupil - with help of iris, controls how much light comes through
- b. Retina - innermost layer of eye that contain the photoreceptors
- b. Rhodopsin - rod pigment that absorbs single wavelength
- b. Rods - detects low-intensity illumination and important for night vision
- b. Sclera - the thick outer opaque layer, called white of the eye
- a. Sympathetic Nervous system - responsible for flight or fight response. Uses norepinephrine as primary neurotransmitters. In the Autonomic Nervous System.
- b. Thalamus - relay and integration center for spinal cord and cerebral cortex (forebrain)
- b. Telencephalon - part of forebrain, major component is the cerebral cortex which processes and integrates sensory and motor. Cognitive thinking. (forebrain)
- b. Tympanic membrane - the eardrum and start of middle ear
- b. Vagus nerve - parasympathetic nervous system for the gut area
- b. Ventral horn - all motor information exits spinal cord here
- b. Vestibular apparatus - involved in maintaining equilibrium
- c. Vitreous humor - jellylike material in eye that helps maintain shape and optical properties

## Neuron

### II. Structure

- c. Dendrite
  - i. Cytoplasmic extensions that receive information and transmit it to cell body
- c. Cell Body (soma)
  - ii. Contains the nucleus and controls the metabolic activity of neuron
- b. Single Axon
  - i. Long cellular process that transmits impulses away from cell body
  - iv. Sheathed by insulating substance known as myelin
    - 1. Produced by cells known as glial cells
      - a. In the CNS, oligodendrocytes produces the myelin
      - b. In the peripheral nervous system, Schwann cells produces the myelin
    - 1. Gaps between myelin is called nodes of the Ranvier
  - iii. Ends in swellings known as synaptic terminals (synaptic boutons)

1. Neurotransmitters are released from these terminals into the synapse
  - I. Synapse - gaps between axon terminals of one cell and dendrites of the next cells

## II. Function

- a. Receive signals, pass them to the next neuron
- c. Resting Potential
  - i. When neuron is at rest, the potential difference between extracellular and intracellular space is called the resting potential
  - iii. Neuron is polarized even at rest
    1. Due to unequal distribution of ions between inside and outside of cell
    2. Typical resting membrane potential is -70 millivolts
      - I. Inside of neuron is more negative than outside
    - a. Due to selective ionic permeability of the neuronal cell membrane
      - I. Potassium can diffuse past, sodium can't
      - I. Concentration of potassium is higher inside neuron than outside
      - I. Concentration of sodium is higher outside neuron than inside
    1. Maintained by the active transport of sodium potassium pump
    2. Negative charged protein trapped inside cell
  - iii. Each time action potential fires, the ionic gradient is disrupted and it must be restored by the sodium potassium pump. Transports 3 sodium out for every 2 potassium into the cell
- b. Action potentials
  - i. Can be impulses that travel the length of the axon and invade the nerve terminal
    1. Causes the release of neurotransmitter into the synapse
  - iii. Nerve cell receives both excitatory and inhibitory impulses
  - iv. If cell becomes sufficiently excited or depolarized where the inside the cell becomes less negative, action potential is generated
  - ii. The minimum threshold membrane is around -50 millivolts, after this threshold is reached, the **voltage-gated sodium channel** is opened
  - iii. This causes sodium ion to flood into cell down the electrochemical gradient, causing a further depolarization and release of the neurotransmitter
  - iv. The voltage-gated sodium channel will then close, and the voltage-gated potassium channel open to allow potassium to rush out and balance the charge. This is known as repolarization.
  - ii. Following repolarization, the neuron will need a resting period known as refractory period.
- d. Impulse propagation
  - i. Information transfer from dendrite to synaptic terminal direction only (even if its capable of going in reverse)
  - ii. Action potential propagation goes at different speed depending on the diameter of the axon.
    1. Greater the diameter, the more heavily it is myelinated and faster it'd travel
    1. Myelin increases the conduction velocity by insulating segments so the membrane is only permeable in the nodes of Ranvier
      - I. So the action potential jumps from node to node.

## Synapse

## IV. Synapse

- d. Gap between the axon terminal of one neuron and the dendrite of another neuron

- ii. The axon terminal of one neuron is called presynaptic neuron
  - iii. The dendrite of another neuron is called postsynaptic neuron
- c. The axon terminal contains thousands of membrane-bound vesicles full of chemical messenger known as **neurotransmitter**
  - ii. When the axon action potential reaches the nerve terminal and depolarize it, the synaptic vesicles fuse with the presynaptic membrane and neurotransmitters are released
  - ii. The neurotransmitters diffuses across the synapse and acts on receptor proteins and depolarize them until they reach threshold and consequently firing of an action potential
  - iii. Neurotransmitter is then removed from synapse
    - 1. Taken back up into nerve terminal via protein known as the uptake carrier
    - 2. Degraded by enzyme located in synapse
      - I. Acetylcholinesterase inactivates the neurotransmitter acetylcholine
    - 3. Simply diffuse out of the synapse
- b. Drugs may have effects on the Synapse
  - iii. Curare - blocks the post-synaptic acetylcholine receptors so acetylcholine is unable to interact with receptor leading to paralysis.
  - v. Botulism toxin - prevents release of acetylcholine from presynaptic membrane, leads to paralysis
  - vii. Anti-cholinesterases - inhibits the activity of acetylcholinesterase enzyme and acetylcholine is not degraded in the synapse. This continues to affect the post-synaptic membrane and no coordinated muscular contractions can take place.

## Invertebrate Nervous System

- II. Protozoa
  - b. Single cell organisms possess no organized nervous system.
  - d. May respond to stimuli like touch, heat, light, and chemicals
- II. Cnidaria
  - b. Have simple nervous system called nerve net.
  - b. Limited centralization
  - d. Jellyfish have clusters of cells and pathways that coordinate complex swimming movement
- V. Annelida
  - b. Earthworms possess primitive central nervous system consisting of
    - ii. Defined ventral nerve cord
    - ii. Anterior "brain" of fused ganglia
    - iv. Definite nerve pathways leading from receptors to effectors
- II. Arthropoda
  - b. Brain similar to annelida but with more specialized sense organs

## Vertebrate Nervous System

- III. General
  - c. Afferent neurons - neurons that carry sensory information about external or internal environment to the brain
  - e. Efferent neurons - neurons that carry motor information to the brain or spinal cord
  - c. Interneurons - local circuits, linking sensory and motor neurons in the brain
  - a. Division of the nervous system

- ii. Nerves are essentially bundles of axons covered with connective tissues
- vi. A network of nerves is called a plexus
- iii. Cluster of plexus is called **ganglia** in periphery, **nuclei** in central nervous system
- iii. Nervous system
  - 1. Central Nervous System
    - I. Brain and Spinal Cord
  - 1. Peripheral Nervous System
    - I. Sensory
    - I. Motor
      - I. Somatic
      - I. Autonomic
        - I. Sympathetic
        - I. Parasympathetic

## II. Central Nervous System

### c. Brain

- iv. Mass of neurons that resides in the skull
- ii. Interprets sensory information, forming motor plans, and cognitive thinking
- iv. Consists of
  - 2. outer portion called gray matter
  - 2. Inner portion called inner white matter (myelinated axons)
- iv. Divided into three parts
  - i. Forebrain (Prosencephalon)
    - 2. Telencephalon
      - II. Cerebral cortex
        - II. Highly convoluted gray matter on surface of brain
        - I. Processes and integrates sensory input and motor responses
        - I. Important for memory and creative thoughts
      - I. Olfactory bulb
        - I. Center for reception and integration of olfactory input
    - 1. Diencephalon
      - II. Contains the thalamus and hypothalamus
      - I. Thalamus
        - I. Relay and integration center for spinal cord and cerebral cortex
      - I. Hypothalamus
        - I. Controls visceral functions
        - I. Hunger, thirst, sex drive, water balance, blood pressure, temperature regulation
        - I. Control of endocrine system
  - iv. Midbrain (mesencephalon)
    - 2. Relay center for auditory impulses
    - 2. Role in motor control
  - v. Hindbrain (rhombencephalon)
    - 2. Posterior part of the brain

### Cerebellum

- II. Helps modulate motor impulses initiated by cerebral cortex
- I. Important in the maintenance of balance
- I. Hand eye coordination
- I. Timing of rapid movement
- I. Pons
  - II. Relay center to allow cortex to communicate with the cerebellum

1. Medulla (medulla oblongata)
  - II. Controls vital functions such as breathing, heart rate, and gastrointestinal activity
  - i. Both midbrain and hindbrain together forms the brainstem
- a. Spinal Cord
  - iii. Elongate extension of the brain
  - iv. Acts as conduit for sensory information to the brain and motor information from the brain
  - i. Can integrate simple motor responses (reflexes) by itself
  - iii. Cross section of spinal cord
    4. Outer white matter area
      - I. Motor and sensory axons
    1. Inner gray matter area
      - a. Nerve cell bodies
  - iii. Sensory information enters the spinal cord through dorsal horn
    2. The cell bodies are located in the dorsal root ganglia
  - i. All motor information exits the spinal cord through the ventral horn
  - i. For simple reflexes, sensory fibers synapse directly on ventral horn motor fibers
- II. Peripheral Nervous System
  - c. Somatic Nervous System
    - iii. Nerves inside skeletal muscles and responsible for voluntary movement
  - b. Autonomic Nervous System
    - ii. Involuntary nervous system
      1. Because it regulates body's internal environment without conscious control
    - iv. Includes
      2. Cardiac
        1. smooth muscles
          - b. Blood vessels, digestive tract, bladder, bronchi
      1. Motor fibers
      1. Sensory fibers
    - i. Sympathetic
      2. Responsible for "flight or fight" response
        1. Increases the blood pressure and heart rate
        1. Increases blood flow to skeletal muscle and decreases gut motility
        1. Dilates the bronchioles to increase gas exchange
        1. Uses norepinephrine as primary neurotransmitter
    - i. Parasympathetic
      1. Acts to conserve energy and restore body to resting activity levels after exertion
      1. Lower heart rate and increase gut motility
      1. Most important nerve is the vagus nerve, this innervates many of the thoracic and abdominal viscera





## CH. 8 : Respiration

### Keywords

#### II. Overview of Cellular Respiration

- h. External Respiration - entrance of air into lungs and gas exchange between alveoli and blood
- g. Internal Respiration - includes the exchange of gas between blood and cells
- h. Respiration - utilization of oxygen by an organism

#### IV. Glucose Catabolism

- a. Pyruvate - 2 is formed for every glucose burned
- j. Glyceraldehyde 3-phosphate (PGAL) - 2 is formed for every glucose burned, precursor to pyruvate
- k. Substrate level phosphorylation - producing ATP with enzymes

#### IV. Cellular Respiration

- i. Citric Acid Cycle - Krebs Cycle, 6 NADH, 2 FADH<sub>2</sub>, and 2 ATP formed
- m. Cytochrome - electron carriers in the electron transport chain
- n. Electron Transport Chain - series of complex carrier mechanisms that makes ATP from ADP. Total of 32 ATP produced here.
- o. Pyruvate Decarboxylation - 2 NADH formed, pyruvate turns into Acetyl CoA

#### IV. Alternative Energy Sources

- i. Lipases - enzyme that reduces fat to fatty acids and glycerol
- q. Oxidative deamination - ammonia molecules comes directly from the amino acid and is excreted as waste
- r. Transamination reaction - process in which amino acid becomes acetyl coA or other intermediate in the citric acid cycle to produce ATP
- s. TriCarboxylic Acid Cycle - TCA cycle (also called Krebs cycle), reduces Acetyl CoA

#### IV. Respiration in Invertebrates

- j. Spiracle - openings where the tracheae converges and the gas exchange take place
- t. Tracheae - used by arthropods, they are tubules where branches reach every cell

#### V. Respiration in Human

- c. Alveoli - gas exchanges take place here via simple diffusion due to partial pressure difference
- c. Bronchi - the split from the trachea
- d. Bronchioles - splits from the bronchi
- d. Epiglottis - the next location after the throat (analogous to esophagus)
- f. Larynx - voice box
- g. Nare - the nose
- h. Pharynx - the throat
- i. Trachea - the main lung tube, splits into two

### Overview of Cellular Respiration

#### II. General

- i. Photosynthesis - converts energy of sun into chemical energy of glucose
- j. Respiration - conversion of chemical energy in glucose into the usable energy needed to drive the process of living cells
- b. Favored Fuel in Body
  - iii. Carbohydrates and fats
    - 2. When hydrogen is removed, energy is made available
    - i. C-H is capable of releasing the largest amount of energy per mole

- d. Carbon dioxide contains little usable energy and is the stable, "energy exhausted" end product of respiration
- b. Steps to harnessing energy of hydrogen
  - iv. Dehydrogenation - breaks the hydrogen bond in an oxidation reaction step
    - 2. Energy released is stored in high energy phosphate bond in ATP
  - i. Done in electron transport chain to fully harness the energy of the redox reaction

## Glucose Catabolism

### II. Glycolysis

#### b. General

- iii. Series of reactions that leads to oxidative breakdown of glucose into
  - 1. 2x Pyruvate
  - 1. 2x ATP
  - 1. 2x NADH
- iv. Occurs in the cytoplasm with help of enzymes

#### c. Glycolytic Pathway

- iii. One molecule of glucose is changed into fructose 1,6 diphosphate
  - i. Fructose 1,6 diphosphate is broken down into
    - 1. Dihydroxyacetone phosphate

This is later isomerized into PGAL as well

- 1. Glyceraldehyde 3-phosphate (PGAL)
- i. Glyceraldehyde 3-phosphate eventually turns into pyruvate
  - II. 2 is obtained for every glucose
    - 1. 2 ATP is used, but 4 ATP are generated, netting +2 ATP
    - II. Substrate Level phosphorylation - ATP synthesis by enzyme, not with electron transport chain
  - 1. 2 NADH is obtained for every glucose as PGAL turns into pyruvate
- iv. In anaerobic conditions, the pyruvate will be reduced via fermentation
- v. In aerobic conditions, the pyruvate will be further oxidized in mitochondria

#### b. Fermentation

##### II. General

- II. NAD<sup>+</sup> must be regenerated for glycolysis to continue in absence of O<sub>2</sub>, so by reducing pyruvate, NAD<sup>+</sup> is regenerated.
  - 1. Fermentation only produces 2 ATP per glucose molecule
- i. Alcohol fermentation
  - 2. Occurs in yeasts and bacteria
  - 2. Pyruvate produced in glycolysis is converted to ethanol
- i. Lactic Acid Fermentation
  - 1. Occurs in fungi, bacteria, and human muscle cells during heavy exercise
  - 1. Pyruvate produced is converted to lactic acid to regenerate NAD<sup>+</sup>

### IV. Cellular Respiration

#### b. General

- v. Most efficient catabolic pathway used by organisms to gain back energy stored in glucose
- i. Glycolysis yields only 2 ATP, cellular respiration can yield 36~38 ATP.
  - 1. Requires oxygen since it's the final electron acceptor
  - 1. Catalyzed by many enzymes
- i. Cellular Respiration can be split into 3 stages - pyruvate decarboxylation, citric acid cycle, and electron transport chain

#### c. Pyruvate decarboxylation

- iv. The pyruvate formed during glycolysis is transported into the mitochondrial matrix and here, it is decarboxylated (loses CO<sub>2</sub> and coenzyme A attaches)
    - i. NAD<sup>+</sup> is reduced to NADH here
    - iv. Net result is +2 NADH
  - c. Citric Acid Cycle
    - ii. Also known as the Krebs cycle.
    - i. Begins when acetyl CoA (once pyruvate) combines with oxaloacetate
      - 1. Forms 6-carbon citrate
    - i. After a series of reactions, 2 CO<sub>2</sub> are released and oxaloacetate is regenerated
    - v. Each turn of the citric acid cycle produces
      - 1. 1 ATP
      - 2. 1 FADH<sub>2</sub>
      - 3. 3 NADH
      - 4. 2 CO<sub>2</sub>
    - i. Consumes 4 H<sub>2</sub>O
  - d. Electron Transport Chain
    - ii. Complex carrier mechanism located inside the inner mitochondrial membrane
    - i. With ATP synthase, high energy potential electrons are transferred from NADH and FADH<sub>2</sub> to oxygen via carriers called cytochromes
    - i. The central functional unit is an iron atom that can be reduced and oxidized
    - v. Sequential redox reactions occur as electrons are transferred from one cytochrome to the next. With each reduction and oxidation, an ADP becomes ATP
    - iv. The final electron acceptor is oxygen.
- IV. Total Energy Production
- a. Substrate Level Phosphorylation
    - i. Degradation of glucose yields 2 ATP from glycolysis
    - iv. Krebs cycle yields 1 ATP for each turn
    - v. Total of 4 ATP produced
  - d. Oxidative Phosphorylation
    - v. 2 pyruvate decarboxylation yields 2 NADH
    - iv. Each turn of Krebs cycle yields 3 NADH and 1 FADH<sub>2</sub>
    - iv. Each NADH generates 3 ATP
    - ii. Each FADH<sub>2</sub> generates 2 ATP
    - iii. Total of 32 ATP produced
  - d. Prokaryotes
    - iii. 38 ATP yielded
  - c. Eukaryotes
    - ii. 36 ATP yielded (2 NADH from glycolysis has to go inside the membrane, thus loses 2 potential ATP)

### Alternative Energy Sources

- II. General
  - b. Energy source preference order
    - ii. Other carbohydrates
    - iv. Fats
    - iv. Protein
  - e. All the energy source must be turned into glucose or glucose intermediate
- II. Carbohydrates
  - c. Disaccharides and polysaccharides are degraded/hydrolyzed into monosaccharides

- VII. Fats
  - b. Stored in adipose tissues in form of triglyceride
  - b. When needed, it is hydrolyzed by lipase to fatty acids and glycerol
  - d. Glycerol
    - ii. Must first be converted into PGAL, glycolytic intermediate
  - c. Fatty acid
    - ii. Must first be activated in the cytoplasm
      - 2. Requires 2 ATP
    - i. Taken into mitochondria, then with series of beta-oxidation cycle, it'd be converted into 2-carbon fragments
    - iii. The carbon fragments are then converted into acetyl CoA
    - ii. The acetyl CoA then enters the TCA (tri-carboxylic acid) cycle
    - iv. With each round of beta-oxidation, 1 NADH and 1 FADH<sub>2</sub> are generated
- II. Proteins
  - c. Body degrades protein only when there aren't any carbs or fat around
  - e. Amino acids undergo transamination reaction where they lose an amino group to form alpha-keto acid
  - b. The carbon atom are converted into Acetyl CoA, pyruvate, or an intermediate of the Citric Acid cycle.
    - i. This then produces ATP
  - b. Oxidative deamination
    - i. Removes ammonia molecule directly from amino acid

## Respiration in Invertebrates

- II. Unicellular and Simple Multicellular Organisms
  - c. Protozoa and Hydra
  - c. Every cell in contact with external environment (or internal)
  - c. Gases exchanged directly between cell via simple diffusion
- II. Annelids
  - d. Mucus secreted provides surface for gas exchange via diffusion
  - c. Circulatory system brings O<sub>2</sub> to cells and waste products such as CO<sub>2</sub> back to skin
- II. Arthropod
  - c. They have series of respiratory tubules called tracheae
    - i. Branches of these reaches every cell
  - a. Tubes open to the surface in openings called spiracles
  - c. Gas exchange via diffusion with the spiracles
  - e. The efficiency of this system allows insects to have inefficient open circulatory system

## Respiration in Humans

- II. General
  - d. Trachea branches off into 2 large passage ways called bronchi
  - a. Bronchi branches off into bronchioles
    - iii. The air is brought to the alveoli, millions of them, where gas exchange occurs
  - b. The complete passage goes > nose > pharynx (throat) > larynx > trachea > bronchi > bronchioles > alveoli
- III. Ventilation
  - b. When you breathe in, the air comes in through the nose and mouth and is pulled through the wind pipe or trachea

- ii. Diaphragm contracts = lung capacity grows = breathing in (inhalation)
  - iv. Diaphragm expands = lung capacity shrinks = breathing out (exhalation)
- II. Control of Ventilation
  - d. Regulated by neurons located in medulla oblongata
    - ii. Rhythmic discharges stimulate the intercostal muscles and diaphragm to contract
    - ii. If partial pressure of carbon dioxide increases, the medulla oblongata stimulates increase in rate of ventilation
- IV. Gas Exchange
  - c. Occurs in the pulmonary capillaries with simple diffusion across the capillaries wall
  - c. Basically, with partial pressure, O<sub>2</sub> is moved into the red blood cell, and CO<sub>2</sub> is released out

## Respiration in Plants

- III. General
  - d. Happens day and night
  - d. Photosynthesis happens only in the day
  - b. Plants undergo aerobic respiration just like animals
  - c. Gases diffuse through air opening called stomata of leaves
    - ii. Or lenticels of woody stem



## CH. 9 : Autotrophic Nutrition

### III. General

- d. Autotroph is any organism that manufactures its own food from inorganic
- c. Photosynthesis - autotrophs harnessing the energy from the sun
- e. Chemosynthesis - autotrophs harnessing energy from chemicals to obtain energy

### Keywords

### II. Photosynthesis

- a. Chlorophyll - the pigments where the magic happens
- e. Cyclic Electron Flow - excited electron of P700 moves along series of electron carriers, producing ATP from ADP.
- h. Dark Reactions - incorporates CO<sub>2</sub> into organic molecule via carbon fixation
- i. Ferredoxin - one of the early electron carriers in the electron chain transport
- h. Grana - stacks of thylakoid sacs
- k. Light Reaction - also called photolysis. Convert solar energy to ATP and NADPH
- l. Photoionization - escape of high energy electrons from chlorophyll molecule
- k. Photosystem - light capturing unit of the thylakoid
- n. Ribulose biphosphate - start of calvin cycle, 5 carbon sugar that CO<sub>2</sub> fixed to
- o. Stroma - the fluid matrix of the chloroplast
- p. Thylakoid membranes - where the chlorophyll resides

### Photosynthesis

### II. General

- b. Take place in plants in a specialized organelle called chloroplast
- o. Photosynthetic bacteria that lack chloroplast have cell membranes that function the same way

### V. Structure of a chloroplast

- e. Chloroplast is really a plastid containing the chlorophyll pigment
- s. Bound by two membranes
  - v. Contains within a network of membranes called thylakoid membranes
  - l. Chlorophyll found within the thylakoid membrane
  - l. Thylakoid sacs are stacked into columns called grana
- u. The fluid matrix of the chloroplast is called the stroma
- a. Chlorophyll is usually complexed with metal magnesium
- d. Light and its role
  - v. When chlorophyll absorbs light, electrons are excited and harnessed to drive reactions of photosynthesis
  - l. Chlorophyll absorbs in the red and blue wavelengths (thus green)
- e. Two main types of chlorophyll
  - iii. Chlorophyll A
  - l. Chlorophyll B
- h. Chlorophyll molecules are part of 2 different photosystems
- i. Photosystem
  - iv. Light capturing unit of the thylakoid membrane
  - l. Center of the photosystem is a single chlorophyll molecule coupled to proteins that is excited by the absorbed photons
  - l. Photosystem I
    - 1. chlorophyll A absorbs best at 700 nm, called P700



#### I. Photosystem II

1. Chlorophyll B absorbs best at 680 nm, called P680

#### IV. Overview of Photosynthesis

- d. Reduces CO<sub>2</sub> to carbohydrate
- v. Releases oxygen from water as byproduct
- e. Reaction is the reverse of respiration
  - i.  $6 \text{ CO}_2 + 12 \text{ H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{ O}_2 + 6 \text{ H}_2\text{O}$
- c. Can be divided into two reactions
  - ii. Light reaction - converts solar energy into chemical in form of ATP and NADPH
  - ii. Dark reaction - coupled to light reaction and incorporates CO<sub>2</sub> into organic molecules called carbon fixation.
    1. Also called reduction synthesis because carbohydrates are produced by reducing CO<sub>2</sub>
  - iii. Both happens in chloroplasts

#### IV. Light Reactions

- c. Begins with absorption of light by chlorophyll molecule
- b. The excited electron of the chlorophyll can flow along 2 pathways
- d. Cyclic Electron Flow
  - iii. The excited electron of P700 move along a chain of electron carriers
  - ii. Via a series of redox reaction, electron eventually goes back to P700
  - ii. Produces ATP in the process called cyclic photophosphorylation
  - ii. Uses a coenzyme carrier called ferredoxin, an early electron carrier in this chain
- b. Noncyclic electron flow
  - i. Key pathway of the light reaction and involves both photosystem
  - iv. Instead of electron returning to P700, it goes to electron acceptor NADP<sup>+</sup>.
    1. P700 is left with electron "holes" and becomes powerful oxidizing agent
  - v. When light strikes P680 in photosystem 2, electrons are excited again.
    1. The electrons would fill the holes in the P700
    1. P680 is strong enough to oxidize water and fill its hole
    1. Water is split into two hydrogen ions and oxygen atom.
      - I. Oxygen combine to form O<sub>2</sub>
  - viii. The net result is the production of NADPH and ATP and break down of water, releasing oxygen.

#### IV. Chemical Aspects of Photosynthesis

- c. Oxygen produced in photosynthesis comes from water, not carbon dioxide.
- b. Photoionization - escape of high energy electrons from chlorophyll

#### IV. The Dark Reaction

- a. Uses ATP and NADPH from light reaction to reduce CO<sub>2</sub> to carbohydrate
- b. Although doesn't directly require light, it only happens during day
- a. Also called calvin cycle, carbon-fixation/reduction synthesis
- b. Product of the cycle is three carbon sugar Phosphoglyceraldehyde (PGAL)
  - i. Cycle must take place three times to make 3 carbon sugar
- b. Cycle begins with CO<sub>2</sub> added to ribulose biphosphate
  - i. This produces 6-carbon intermediate
  - ii. Splits into 2 3-carbon molecules
    1. 3 carbon molecules called 3-phosphoglyceric acid
    1. Phosphorylated by ATP, reduced by NADPH to give glyceraldehyde 3-phosphate (PGAL)
    1. 2 PGAL converted to glucose

#### III. Summary of Calvin Cycle

- d. In 6 turns of Calvin Cycle
  - iv. 12 PGAL form 6 ribulose biphosphate

- i. 1 molecule of glucose

## Plant Structure

### III. The Leaf

- d. Waxy cuticle - reduce transpiration and conserve water on upper surface.
- b. Palisade - layer of elongated chloroplast-containing cells spread over a large surface area. Well exposed to light.
- c. Spongy Layer - stomata opens into air spaces that allows more air into internal moist surface with loosely packed spongy layer cells.
- c. Guard Cells - surround each of the stomata on the lower surface of the leaves (opens or closes the stomata)
  - i. During the day, produces glucose
    - 1. High glucose content causes swelling and produce a curvature of opening
  - ii. When photosynthesis stops, cell turgor decreases and stomate closes
- c. Stomata - openings in the lower epidermis that permits diffusion of carbon dioxide, water vapor, and oxygen between leaf and the atmosphere
  - iii. Size of stomate opening regulated by guard cells
  - ii. Opens during day to admit CO<sub>2</sub>, close at night to limit loss of water vapor
- c. Vascular Bundle
  - iv. Veins containing xylem and phloem to bring water to leaf (xylem) and carry food out of leaf (phloem)

### II. The Root

- b. Specialized root hairs found in root and increases surface for absorption of water and minerals by diffusion and active transport



## CH. 10 : Muscles and Locomotion

### Introduction

#### II. Muscles and Locomotion

- c. The musculoskeletal forms the basic internal framework for vertebrates body
- i. Muscle and bone work together to produce voluntary movement
- j. Muscle and bone independently do a lot too
- i. Unicellular organisms rely on specialized organelles for locomotion and invertebrates have numerous ways of getting about
- l. Functions of muscles and skeleton in vertebrate is support and locomotion

### Keywords

#### II. Unicellular Locomotion

- a. Cilia - hair on the cell surface that moves the cells
- m. Flagella - long tail that moves protozoans or algae
- l. Pseudopodia - extending cell membrane for movement

#### IV. Invertebrate Locomotion

- e. Chitin - hard exoskeleton that offers some protection in arthropods
- p. Molting - Required for growth in arthropods with chitin exoskeleton
- q. Planaria - two layers of muscle, longitudinal and circular
- p. Setae - bristles in lower part of segment that anchors the earthworm as it moves

#### VI. Vertebrate Skeleton

- e. Appendicular skeleton - bones of appendages, and the pectoral and pelvic girdles.
- t. Axial skeleton - framework of body, show point of attachment, appendicular skeleton
- t. Bone - mineralized connective tissue for withstanding stress and support
- t. Cartilage - connective tissue that's soft and flexible
- v. Compact bone - dense bone that does not have any cavities when seen by naked eye
- b. Endochondral ossification - cartilage replaced by bone
- e. Endoskeleton - framework of vertebrate organism
- e. Extension - straightening of a joint
- f. Flexion - bending of a joint
- g. Haversian Canal - microscopic channel inside osteons, surrounded by lamellae
- i. Insertion - point of attachment of muscle to bone that moves
- j. Intramembranous ossification - mesenchymal (undifferentiated) connective tissue is transformed into bone
- j. Lamellae - concentric circles of bony matrix surrounding haversian canal
- k. Ligaments - bone to bone connector
- c. Origin - point of attachment of a muscle to a stationary bone
- b. Osteoblasts - synthesize and secrete organic makings of bone matrix
- f. Osteoclasts - mass of cells that does bone resorption
- d. Osteocytes - two types, osteoblasts and osteoclasts, found in bone tissues
- b. Osteons - structural units of bony matrix in compact bone
- b. Spicules - interconnecting lattice inside spongy bone
- a. Spongy Bones - Loose structure with bone marrow (produces blood)
- c. Sutures - immovable joints holding the bone of skull together

#### IV. Muscular System

- b. A band - spans entire length of thick filament, even including thin filament
- d. Absolute refractory period - right after contraction, muscle fiber unresponsive
- e. Actin - makes up the thin filaments in sarcomere

- b. Arginine phosphate - high energy compound temporarily stored in muscle of invertebrates
- c. Calcium Ion - released by sarcoplasmic reticulum to initiate contraction
- b. Cardiac Muscle - composed of skeletal and smooth muscle and have only 1 or 2 nuclei. Myogenic.
- b. Contractile fibers - make up the muscle tissue
- b. Creatine Phosphate - temporary storage unit for vertebrates in muscle and some invertebrate
- c. H zone - region containing only thick filament
- b. I Band - region containing only thin filament
- b. M line - center of the sarcomere
- c. Myofibrils - filaments in muscle fiber, divided up into sarcomere. Contains a lot of mitochondria
- a. Myogenic - contracting without stimulation from nerve cells
- c. Myoglobin - hemoglobin like that supply oxygen to muscles.
- b. Myosin - make up the thick filaments in sarcomere
- c. Neuromuscular junction - synaptic cleft between nerve terminal and sarcolemma
- c. Sarcolemma - cell membrane of muscle fiber, propagates action potential
- c. Sarcomeres - contractile units in myofibrils
- d. Sarcoplasm - cytoplasm of muscle fiber
- c. Sarcoplasmic reticulum - envelops the myofibrils and stores calcium ions
- a. Skeletal muscle - voluntary and innervated by somatic nervous system with multinucleated cell. Contain myofibrils and is striated.
- d. Smooth muscle - one centrally located nucleus, innervated by autonomic nervous system. Are myogenic
- c. Summation - contractions continuous and so frequent that muscle cannot relax
- d. Tetanus - prolonged contraction, muscle will fatigue and contraction weaken
- d. Tonus - state of partial contraction
- c. Z lines - boundary of the sarcomere, anchors the thin filaments

## Unicellular Locomotion

### II. Structure

- b. Cilia
  - ii. Contains a cylindrical stalk of eleven microtubules
  - i. Nine paired microtubules arranged in circle with two single microtubules in the center
  - iii. Moves by beating all the cilia in an unison
- d. Flagella
  - ii. Contains a cylindrical stalk of eleven microtubules
  - ii. Nine paired microtubules arranged in circle with two single microtubules in the center
  - ii. Moves by power stroke
- a. Pseudopodia
  - ii. Amoeboid movement where cell membrane extends forward and rest of the body follows

## Invertebrate Locomotion

### III. Hydrostatic Skeletons

- b. Flatworms
    - i. Arranged in two antagonistic layers
      - 1. Longitudinal
        - I. Contraction here shortens the animal
      - 1. Circular
        - I. Contraction here causes the incompressible fluid to flow longitudinally
    - iii. The muscles contract against the resistance of the incompressible fluid within the tissue
      - 2. The fluid is the hydrostatic skeleton
    - iv. The same type of locomotion persists in annelids
      - i. Planaria is the best example, flat worm
  - c. Segmented Worms (Annelids)
    - v. Earthworms advance by muscles on the hydrostatic skeleton
      - i. Bristle called setae, anchors the earthworm temporarily which muscles inches it ahead
- II. Exoskeleton
- b. Hard skeleton that covers all muscles and organs of some invertebrates
  - b. Found principally in arthropods
    - i. Composed usually of chitin
      - 1. Noncellular material secreted by the epidermis
      - 1. Imposes limitation on growth
        - I. Thus periodic molting is required for body growth
      - 1. Offers protection

## Vertebrate Skeleton

- II. General
- b. Endoskeleton
    - i. Framework of the organism
    - ii. Provides protection by surrounding delicate organs in bone
      - 1. Rib protects heart and lungs
      - 2. Skull protects brain
      - 1. Vertebral column protects spinal cord
  - c. Muscles attached to bone, permitting movement
  - f. Two major components are bone and cartilage
- III. Structure of the Skeleton
- d. Cartilage
    - iii. Type of connective tissue
      - 2. Softer and more flexible than bone
    - ii. Retained in adults where firmness and flexibility required
    - ii. Examples
      - 2. External ear, nose, walls of larynx and trachea
      - 1. Skeletal joints
  - d. Bone
    - ii. Mineralized connective tissue
      - 2. Ability to withstand physical stress
    - ii. Ideally designed for body support
      - 2. Tissue is hard and strong
      - 2. Somewhat elastic and lightweight
    - iii. Two types, compact bone and spongy bone

- ii. Compact Bone
  - 1. Dense bone without any cavities when observed by naked eye
  - 1. Bony matrix deposited in structural units called osteons
  - 1. Osteons consists of a central microscopic channel called Haversian canal
  - 1. Haversian canal is surrounded by concentric circles of bony matrix called lamellae
- iii. Spongy Bone
  - 1. Less dense and consists of interconnecting lattice of bony spicules
  - 1. Cavities in between spicules are filled with yellow or red bone marrow
  - 1. Yellow marrow - inactive and infiltrated by adipose tissue
  - 1. Red Marrow - blood cell formation
- e. Osteocytes
  - ii. Osteoblasts
    - 3. Synthesize and secrete organic constituents of bone matrix
  - ii. Osteoclasts
    - 2. Large cells that reabsorbs bone
- b. Bone Formation
  - ii. Endochondral ossification
    - 2. Existing cartilage is replaced by bone
    - III. Usually how long bones came about
  - iv. Intramembranous ossification
    - 3. Mesenchymal (embryonic and undifferentiated) connective tissue is transformed into bone
- II. Organization of Vertebrate Skeleton
  - b. Axial Skeleton
    - iii. Basic framework of the body
      - 3. Skull, vertebral column, rib cage
    - i. Point of attachment of appendicular skeleton
  - c. Appendicular Skeleton
    - ii. Bones of appendages, pectoral, and pelvic girdles
  - a. Holding bones together
    - ii. Sutures
      - 2. Immoveable joints holding bones of skull together
    - v. Movable Joints
      - 1. Bones that move relative to one another
      - 1. Supported and strengthened by ligaments
    - iii. Ligaments
      - 5. Serve as bone to bone connections
    - iii. Tendons
      - 3. Attach skeletal muscle to bones and bend the skeleton at moveable joints
  - d. Point of attachment
    - ii. muscle to stationary bone is called the "origin"
    - i. Muscle to bone that moves is called the "insertion"
    - ii. Straightening a joint is called "extension"
    - iii. Flexion refers to bending of a joint.

## Muscular System

- II. General
  - d. Muscles consist of bundles of specialized contractile fibers held together by tissues
  - e. Three types: skeletal muscle, smooth muscle, and cardiac muscle

### III. Skeletal Muscle

#### b. Structure

##### iii. Innervated by somatic nervous system

##### i. Fiber cells

##### 2. are **multinucleated**

1. created by fusion of several mononucleated embryonic cell

1. Embedded in fibers are filaments called myofibrils

1. Cytoplasm is called sarcoplasm

1. Cell membrane is called sarcolemma

a. Capable of propagating action potential

I. Connected to system of transverse tubules oriented perpendicularly to the myofibrils

I. Provides channel for ion flow throughout the muscle fiber

I. Able to propagate an action potential

##### i. Myofibrils

3. Further divided into contractile units called sarcomeres

1. Enveloped by modified endoplasmic reticulum that stores calcium

3. Also called sarcoplasmic reticulum

1. Mitochondria are very abundant in muscle cells, distributed throughout myofibrils

##### ii. Has striations of light and dark bands

2. Also referred to as striated muscle

#### d. Function

##### i. Responsible for voluntary movement

### VIII. Sacromere

#### c. Structure

##### iii. Composed of thick and thin filaments

1. Thin filaments are chains of actin molecules

1. Thick filaments are organized bundles of myosin molecules

##### v. Organized as following

##### 2. Z line

a. Define the boundaries of single sarcomere

I. anchor the thin filament

##### 2. M line

b. Runs down the center of the sarcomere

I band

c. Region containing thin filaments only

##### III. H Zone

a. Region containing thick filaments only

##### IV. A band

b. Spans the entire length of thick filaments and overlapping portions of the thin filament

#### b. Contraction

iv. Stimulated by message from somatic nervous system sent via motor neuron

II. Link between nerve terminal and sarcolemma of the muscle fiber is called

##### **neuromuscular junction**

1. Space between the two part is called "synapse"

3. Release of neurotransmitter happen when motor neuron depolarize

2. If enough neurotransmitter binds to the sarcolemma's receptor site, action potential is generated

i. The action potential is passed along the sarcolemma and the T system into the interior of muscle fiber.



1. This causes sarcoplasmic reticulum to release calcium ions into the sarcoplasm.
1. The calcium ion initiate the contraction of the sarcomere.
  - a. Actin and myosin slides past each other as the contraction occur
- b. Stimulus and Muscle Response
  - iii. Individual muscle fibers exhibit all-or-none response
    2. Only with enough calcium ion, above the threshold can elicit contraction
    1. Strength of contraction cannot be increased
  - iii. Strength of the entire muscle can be increased by adding more muscle fibers
  - iv. Simple Twitch
    2. Response of a single muscle fiber to brief stimulus above threshold
    2. Latent Period
      - a. Time between stimulation and onset of a contraction
      - a. Action potential spread along the sarcolemma and calcium ion released
    1. Contraction period
      - a. When the H-Zone and I-band disappears and only A-band exist
    1. Relaxation period
      - a. Muscle is unresponsive to stimulus
      - a. Absolute refractory period is another name for this
  - iv. Summation and Tetanus
    4. Temporal Summation
      - d. When fibers of muscles are constantly stimulated, it cannot fully relax
      - a. Contractions combine and becomes stronger and prolonged
    1. Tetanus
      - b. When contractions become continuous that the muscle cannot relax
      - a. If maintained, muscle will fatigue and contractions will weaken
  - iii. Tonus
    1. State of partial contraction
      - a. Never fully completely relaxed

## II. Smooth Muscle

- b. Responsible for involuntary actions
- c. Innervate by autonomic nervous system
- d. Found in digestive tract, bladder, uterus, blood vessel walls, etc
- c. Posses **one** centrally located nucleus
- c. Lack striation of skeletal muscle
- d. Myogenic - capable of contracting without stimulation from nerve cells

## III. Cardiac Muscle

- b. Tissue of the heart
- b. Possess characteristics of both skeletal and smooth muscle
- a. Actin and myosin are arranged in sarcomeres, giving the striated appearance
- d. Only have **one or two** centrally located nuclei
- e. Myogenic - capable of contracting without stimulation from nerve cells

## Energy Reserves

### II. General

- b. ATP is primary source of energy
- d. Very little ATP stored in muscle

- b. Other form of energy must be stored and rapidly converted to ATP

### III. Creatine Phosphate and Arginine Phosphate

- b. Creatine phosphate - energy temporarily stored in high energy compound
  - i. Found in vertebrates and some invertebrates
- e. Arginine phosphate
  - iii. Similar compound found in invertebrate

### II. Myoglobin

- a. Hemoglobin like protein found in muscle tissue
- c. Has high oxygen affinity and maintains oxygen supply in muscles by binding to oxygen tightly until needed

## CH. 11 : Digestion

### Keywords

#### V. General

- e. Digestion - degradation of larger molecules into smaller molecules that can be absorbed
- f. Extracellular digestion - digestive process outside of cell, within lumen or tract
- f. Heterotrophic - organisms unable to synthesize their own nutrients
- j. Intracellular digestion - occurs in cell in membrane-bound vesicles

#### IV. Digestion in Unicellular Organisms

- e. Cytopharynx - oral groove where food particles are swept into by cilia
- j. Lysosome - principal digestive organelle with digestive enzyme
- m. Phagocytosis - enveloping of food particles via pseudopods

#### IV. Digestion in Invertebrates

- c. Crop - food storage in annelids
- m. Gizzard - grind food down in annelids
- l. Typhlosole - a large dorsal fold to increase surface area for digestion and absorption in annelids

#### IV. Digestion in Humans

- d. Aminopeptidase - polypeptide digestion
- r. Amylase - digests carbohydrate, produced in pancrea and mouth
- q. Bile - produced in liver, emulsifies fat
- p. Bolus - soft mass of chewed food within mouth
- u. Chyme - partially digested food in stomach that's semi-fluid and acidic
- u. Disaccharidases - digestion of maltose, lactose, sucrose
- u. Emulsify - to break down large globules into small droplets
- w. Gall Bladder - stores bile
- c. Lactase - breaks down lactose (milk sugar)
- f. Lacteals - vessels of lymphatic system, in the villi to absorb fatty acids and glycerol
- f. Large Intestine - 1.5 meter long that absorbs salt and water
- g. Lipases - digests fat, enzyme produced in pancreas
- h. Liver - produces the bile that's stored in gall bladder, location of initial food processing
- j. Mastication - chewing and biting of teeth
- k. Pancreas - produces digestive enzymes and also secretes bicarbonate juice to neutralize the incoming acidic chyme
- k. Pancretic amylase - break down starch to maltose
- l. Pepsin - protein hydrolyzing enzyme in the stomach
- d. Peristalsis - the muscular contractions of esophagus that moves food down
- c. Pyloric sphincter - chyme passes through here to the small intestine
- g. Rectum - temporary storage for feces
- e. Salivary amylase - enzyme in saliva that breaks down starch to maltose
- c. Small Intestine - break down into the duodenum, jejunum, and ileum
- c. Trypsin - protein digestion enzyme produced in pancreas
- b. Villi - finger-like extensions in small intestine that contain capillaries and lacteals for nutrient absorption

#### V. Digestion in Plants and Fungi

- f. Saprophyte - lives on dead organic material
- b. Starch - storage form of plant, polymer of glucose. Found in stem, root, seed

### Digestion in Unicellular Organisms

#### IV. General

- i. Amoeba
  - iii. By utilizing phagocytosis
    - 2. Pseudopods surround and engulf food, enclosing it in vacuole
    - 1. Lysosomes fuse with the food vacuole and digestive enzyme released
      - I. Simpler molecule diffuse into cytoplasm and utilized
      - a. Unusable stuff eliminated
- c. Paramecium
  - ii. By utilizing cilia, food is swepted into a mouth-like opening
    - 2. Oral groove and cytopharynx
      - II. Food vacuole is formed around the inner part of cytopharynx
        - a. Vacuole breaks off and goes off into cytoplasm
        - a. Enzymes secreted into vacuole (lysosome?), and products diffuse into cytoplasm
        - a. Solid wastes expelled at anal pore

#### Digestion in Invertebrates

##### II. General

- c. Two phases, physical breakdown and chemical breakdown
  - ii. Physical breakdown - chewing, cutting, grinding food into smaller pieces
    - 2. Done in digestive tract, and mouth
      - 1. To increase the surface area that the digestive enzyme can act upon
  - vi. Chemical breakdown - enzyme hydrolysis
    - 1. Breaks down the food particle down further into useful molecules
  - vii. Digested nutrients passes through semi-permeable plasma membrane of the gut cells to be transported.

##### V. Cnidarians

- e. Utilizes both intracellular and extracellular digestion
- d. Tentacles bring food to mouth, and it's chewed up slightly here
- b. Food particles are then released into a cup-like sac and digestive enzymes in this gastrovascular cavity and food is broken up further
- d. Once food is sufficiently broken up, the gastrodermal cells engulfs the nutrients
  - i. The digestion now continues intracellularly
- c. Wastes are ejected through the mouth

##### V. Annelids

- c. Functions similar to higher life forms
  - vi. One way digestive tract with both mouth and anus
- d. Food pathway
  - iv. Mouth > Pharynx > Esophagus > crop > gizzard > intestine > anus
  - i. Soluble food passes by diffusion through the walls of small intestine

##### III. Arthropods

- b. Digestive pathway similar to annelids
- d. Also have a jaw for chewing and salivary gland for improved food digestion

#### Digestion in Humans

##### General

- c. Digestion pathway

II. Oral cavity > pharynx > esophagus > stomach > small intestine > large intestine > anus

b. Accessory organs that play a role

I. Salivary glands, pancreas, liver, gall bladder

### III. The Oral Cavity

c. Where the mechanical and chemical digestion begins

d. Mechanical digestion

ii. Also called mastication

e. Chemical breakdown

ii. Salivary gland's saliva

1. Contains enzyme salivary amylase (ptyalin)

a. Hydrolyzes starch to maltose

1. Lubricates food to facilitate swallowing

2. Solvent for food particles

3. Secreted in response to nervous reflect triggered by food in oral cavity

c. The lubricated soft mass of chewed food is called bolus

### VI. The Esophagus

c. Muscular tube leading from mouth to stomach

b. Food moved down via involuntary muscular contractions called peristalsis

### III. The Stomach

b. Large muscular organ in the upper abdomen

iv. Stores and partially digests food

b. Lined by thick gastric mucosa

v. Secretes mucus that protects stomach lining from acidic juices in stomach

iii. Secretes pepsin

3. Protein hydrolyzing enzyme

iv. Secretes hydrochloric acid

2. Kills bacteria

1. Dissolves intercellular "glue" that holds food tissues together

1. Activates certain proteins

d. The churning of stomach produces an acidic, semi-fluid mixture of partially digested food called chyme

f. Chyme goes into first part small intestine called duodenum through the pyloric sphincter

### III. Small Intestine

b. Chemical digestion completed here

c. Divided into three parts: duodenum, jejunum, and ileum

e. Highly adapted to absorption

b. Extremely long, 6 meters long, highly coiled

e. Numerous finger-like projection called villi extend out of the intestinal wall

ii. Contains capillaries and lacteals

iii. Amino acids and monosaccharides are picked up here through capillary system

iv. Fatty acid and glycerol goes into lacteals and re-converted into fats

d. Some nutrients are actively absorbed (requires energy)

vi. Amino acids and glucose

g. Some nutrients are passively absorbed

a. Duodenum

v. Most digestion occurs here

iii. Secretions of intestinal glands, pancreas, liver, and gall bladder mix together with the chyme for further digestion

iii. Intestinal mucosa secretes

2. Lipases - fat digestion

2. Aminopeptidases - polypeptide digestion

1. Disaccharidases - digestion of maltose, lactose, and sucrose
  - a. Lactase - breaks down lactose (milk sugar)
    - I. Present in infants
    - I. Adults lack it, thus lactose intolerant. Bacteria uses it and causes internal discomfort

## II. The Liver

- d. Produces bile that's stored in gall bladder
- b. Bile
  - i. Contains no enzyme
  - iii. Emulsifies fat from large globules into small droplets
    1. Allows pancreatic lipase to act on it better
  - iv. Without bile, fat cannot be digested
- f. Nutrients from intestines are transported here first for initial processing

## V. The Pancreas

- e. Produces enzymes
  - i. Amylase - carbohydrate digestion
  - iv. Trypsin - protein digestion
  - iv. Lipase - fat digestion
- d. Also secretes bicarbonate rich juice that neutralizes the acidic chyme
  - i. The enzymes need to work in higher pH unlike pepsin

## IV. The Large Intestine

- e. Approximately 1.5 meter long
- f. Functions in the absorption of salts and water not already absorbed in small intestine
- c. Rectum is a transient storage of feces prior to elimination through anus

## Digestion in Plants and Fungi

### IV. Intracellular Digestion

- c. Plants store insoluble polymers, starches, lipids, and proteins in the cells
- c. Principal storage form is starch (glucose polysaccharide)
- d. When nutrients are required, starch is broken down by enzyme hydrolysis

### III. Extracellular digestion

- b. Fungi excretes enzymes into the environment, and absorbs the simpler molecules
  - i. Rhizoid
    1. Type of bread mold, typical saprophyte
    1. Secretes enzyme onto the environment (bread)
    1. Digestion produces simple soluble end-product which are absorbed via diffusion
- b. Venus Flytrap
  - i. When fly arrives, certain tissue triggered would spring the trap and enclose the insect
  - vi. Enzymes secreted to digest the fly and absorb the soluble end product
  - ii. Still autotroph because it photosynthesizes to produce glucose
    1. Requires the insect as nitrate source so it can thrive on nitrogen poor soil



## CH. 12 : Excretion

### IV. General

- d. Elimination - removable of indigestible material
- d. Excretion - removal of metabolic wastes, especially nitrogenous wastes produced by deamination of amino acids, like urea and ammonia

### III. Excretion in Invertebrates

- f. Malpighian tubules - minearl salts and uric acid accumulated here and transported to intestine for disposal
- g. Nephridia - in annelids, two pairs in each segment that rid body of wastes
- k. Spiracle - air openings in arthropod for gas exchange
- g. Uric Acid - nitrogenous waste crystals formed by arthropods

### V. Excretion in Human

- c. Bowman's capsule - bulb within nephron for filtration
- n. Collecting duct - section of tubule within nephron
- j. Countercurrent-multiplier system - loop of Henle arranged so 99% of filtrate reabsorbed
- n. Distal convoluted tubule - tubule within nephron for water reabsorption
- m. Filtrate - fluid and small solutes entering nephron
- m. Glomerulus - special capillary bed in the nephron
- s. Hyperosmolar - medium in medulla of kidney is hyperosmolar with respect to filtrate
- r. Kidney - consists of three regions, outer cortex, inner medulla, and renal pelvis
- q. Loop of Henle - a section of tubule within nephron responsible for water reabsorption
- v. Nephron - consists of Bowman's capsule, glomerulus. Reabsorbs nutrients and water
- v. Peritubular capillary - surrounds nephron to facilitate reabsorption of nutrients
- v. Proximal convoluted tubule - tubule within nephron responsible for nutrient reabsorption
- x. Renal pelvis - funnel-like region that opens into the ureter
- d. Ureter - from each kidney empty into urinary bladder
- g. Urethra - path of piss excretion
- g. Urinary bladder - urine collects here until expelled via urethra

## Excretion in Invertebrate

### II. Excretion in Protozoans and Cnidarians

- d. All cells in contact with external aqueous environment, thus wastes are simply diffused out of cell membrane
  - v. Passive excretion of ridding itself ammonia and carbon dioxide
- h. Freshwater Protozoan
  - iv. Paramecium
    - 1. Must use specialized contractile vacuole for getting rid of excess water
      - a. Water constantly diffuses into cell due to hypotonic environment
    - I. To maintain the volume and pressure inside cell

### IV. Excretion in Annelids

- b. Carbon Dioxide excretion occurs directly through moist skin
- I. Nephridia
  - iv. Two pairs in each body segment
  - I. Excrete water, minearl salts, and nitrogenous wastes in form of urea

### V. Excretion in Arthropods

- e. Carbon dioxide released from tissues into tube-like tracheae
  - ii. Converges into air openings called spiracles
- e. Uric acid
  - iii. Nitrogenous wastes are excreted in form of solid crystals



- I. Mineral salts and uric acid accumulated in the Malpighian tubules and then expelled via intestine with rest of the solid wastes of digestion

## Excretion in Humans

### III. General

- c. Principal organs involved
  - iv. Lungs, liver, skin, kidney
- h. Lung
  - v. Carbon dioxide and water vapor from lung constantly exhaled
- f. Skin
  - i. Sweat gland constantly excrete water and dissolved salt
  - i. Small quantity of urea also excreted
  - ii. Regulates body temperature when water evaporates
- c. Liver
  - i. Processes
    1. nitrogenous wastes
    1. Blood pigment wastes
    1. Other chemicals for excretion
  - ii. Produces urea here, but diffuse into blood for excretion in kidneys
  - ii. Bile salts, and red blood pigments are excreted as bile and passes out with feces

### VI. The Kidney

- e. Function
  - iv. Regulate the concentration of salt and water in blood via formation and excretion of urine
  - iii. Maintain the osmolarity of blood
  - iv. Excrete numerous wastes products and toxic chemicals
  - v. Conserve glucose, salt, and water
  - vi. Located behind stomach and liver
  - vii. Composed of one million nephron units
- c. Structure
  - v. Divided into three regions
    1. Outer cortex
    1. Inner medulla
    2. Renal pelvis
  - i. Nephron
    1. Consists of a bulb called Bowman's capsule
      - I. Embraces a special capillary bed called glomerulus
      - a. Leads into long coiled tubule that's divided into units
        - I. Proximal convoluted tubule
          - I. Have  $\text{Na}^+/\text{K}^+$  pump
        - I. Loop of Henle
        - I. Distal convoluted tubule
        - I. Collecting duct
    2. Positioned in a special way
      - I. loop of Henle runs through the medulla
      - b. Convoluted tubules and Bowman's capsule in the cortex
    1. Surrounded by complex peritubular capillary network to facilitate reabsorption of amino acids, glucose, salts, and water
- iv. Urine pathway
  2. Concentrated urine flows into the pelvis of the kidney

- I. Flow s into the ureter
  - 2. Ureters from each kidney empty into the urinary bladder
    - I. Urine collects until expelled through urethra
- e. Urine formation
  - iii. Filtration
    - 1. Blood pressure would force 20% of blood plasma into the Bowman's capsule via the glomerulus
      - I. Fluid and small solutes entering the nephron are called filtrate
        - I. Filtrate is isotonic to blood plasma
      - b. Particles too large to filter remain in circulation
    - 2. Passive process driven by the hydrostatic pressure of the blood
  - ii. Secretion
    - 1. Nephron secretes acids, bases, ions from interstitial fluids into the filtrate
      - I. Done by passive and active transport
  - ii. Reabsorption
    - 1. Essential substances like glucose, salts and amino acids are reabsorbed from filtrate and returned to blood
    - 4. Occurs primarily in the proximal convoluted tubules
      - I. Active process
    - 1. Result is the formation of concentrated urine
      - I. Hypertonic to blood
- c. Nephron Function
  - i. Via selective permeability of its walls and maintenance of an osmolarity gradient, nephron reabsorbs nutrients, salts, and water from filtrate
  - i. Osmolarity Gradient
    - 1. The selective permeability establishes an osmolarity gradient in the surrounding interstitial fluid
    - 1. Tissue osmolarity increases from cortex to inner medulla
      - I. Solutes like urea and salt contribute to maintaining this gradient
    - 1. Countercurrent-multiplier system
      - II. Anatomic arrangement of Loop of Henle within the kidney creates a situation where 99% of the filtrate are reabsorbed.
  - v. Concentration of Urine
    - 1. In medulla of kidney, the concentration of medium is hyperosmolar with respect to the filtrate
      - I. Thus water flows out to the collecting tubules by osmosis
      - a. The reabsorption of water in this zone is regulated by ADH (vasopressin)
        - I. ADH increases the permeability of the collecting duct, thus more concentrated urine
        - I. ADH produced in hypothalamus and stored in posterior pituitary

## Excretion in Plants

### III. General

- d. No specific excretory system in plants
- e. Anything excess would be expelled by the plant through the stomates and lenticels



## CH. 13 : Animal Behavior

### Keywords

#### II. Patterns of Animal Behavior

- b. Circadian rhythm - daily cycle of behavior like eating, sleeping, etc
- d. Complex reflexes - a response that involves the brainstem or cerebrum
- h. Environmental rhythms - patterns of behavior in response to environmental stimuli
- l. Fixed-action patterns - innate behavior in response to certain stimuli
- h. Releaser - stimulus that elicits innate behavior
- h. Reticular activating system - a complex reflex response with interactions of many neuron, pathway to respond to danger, name calling, etc
- o. Simple Reflex - 2 neuron pathway of afferent neuron to efferent neuron

#### V. Learning

- c. Conditioned reflex - response following a previously neutral stimulus
- o. Conditioned stimulus - previously neutral stimulus now connected to a conditioned reflex
- n. Discrimination - ability to discriminate similar stimuli
- n. Extinction - graduation elimination of conditioned responses
- t. Generalization - responding to stimuli that are similar
- s. Habit Family Hierarchy - a set of responses with a stimulus, hierarchy of behavior
- r. Habituation - suppression of normal responses to overexposure of stimuli
- w. Negative Reinforcement - removing unpleasant stimulus after behavior
- w. Operant Conditioning - conditioning response with reinforcements
- w. Pavlovian Conditioning - linking a neutral stimulus to an unconditional reflex by association
- y. Positive Reinforcement - reward when behavior is performed
- e. Pseudoconditioning - the stimulus wasn't neutral to begin with, thus not a true Pavlovian classical conditioning
- h. Punishment - associating pain and hurt after a behavior
- h. Unconditioned reflex - salivation in response to food
- i. Unconditioned stimulus - food to a dog will stimulate salivation
- i. Spontaneous recovery - if stimulus no longer applied, response will return to normal

#### V. Limits of Behavior Change

- f. Critical Period - specific time period when proper environment pattern must be presented for development to be complete
- m. Imprinting - during critical period of development, an object becomes accepted permanently as an element in their behavioral pattern. Konrad Lorenz discovered.

#### IV. Intraspecific Interactions

- e. Behavior Displays - innate behavior used as signal for communication for same species
- i. Olfactory sense - using smell or chemical detection as mean of communication
- f. Pecking Order - minimizes violent intraspecific aggressions by establishing an order
- d. Primer Pheromones - long term behavioral and physiological alteration in recipient
- i. Releaser Pheromones - trigger reversible behavior change in the recipient
- g. Territoriality - member of species defending limited area against intrusion by other

### Patterns of Animal Behavior

#### V. Simple reflexes

- g. Simple, automatic response to simple stimuli
- d. Controlled at the spinal cord by 2 neuron pathway

- ii. Receptor (afferent neuron) to the motor (efferent neuron)
- d. Important for lower animals for quick response, not so for higher animals
- V. Complex reflexes
  - d. Neural integration at higher level
    - iv. Might include brainstem or even cerebrum
  - b. High animal being "Startled"
    - v. Triggers a whole series of flight or fight response pattern
    - ii. System termed "reticular activating system"
- IV. Fixed-Action Patterns
  - c. Complex, coordinated, innate behavioral responses to stimulation in environment
  - f. Stimulus is referred to as "releaser"
    - a. Can't be modified by learning since it's innate
    - d. Stimuli for trigger the response can be modified
    - c. ie. Retrieval and maintenance of female birds to egg
- IV. Behavior Cycles
  - d. Circadian rhythms
    - iv. Daily cycles of behavior
    - vii. They lose their exact 24 hour periodicity if they are isolated from light and dark
      - 2. Will continue approximately
    - viii. Daily cycle of eating is a good example
      - 1. By clock, we know when to eat
      - 1. By the grumbling of stomach, we know to eat
- VI. Environmental Rhythms
  - d. Behavior and maintained by environment stimuli
  - e. Human example would be responding to traffic light

## Learning

- VI. General
  - f. Learning is to become adaptive to the environment
  - c. Complex phenomenon that happens to some extent in all animals
    - ii. Lower animals have more instincts and learning play is relatively minor
    - iii. Higher animals, majority of behaviors are learned
  - d. Capacity for learning adaptive responses correlate with the degree of neurological development
- VI. Habituation
  - d. Suppression of startle response to stimuli
    - iv. By repeating the same stimulation will decrease responsiveness to that particular stimuli
    - iv. Spontaneous recovery - if the stimulus is not regularly applied, the response will recover
- IV. Classical Conditioning
  - g. General
    - ii. Pavlovian conditioning associates normal autonomic response with environmental stimulus
    - ii. Also called conditioned reflex
      - 1. The innate stimulus for the reflex is replaced by one chosen by experimenter
  - e. Pavlov's Experiments
    - iv. Studied salivation reflex in dogs

3. If dog is presented with a bell (conditioned stimulus) then food (unconditional stimulus)

- III. The dog will salivate (unconditioned response) eventually until the bell (conditioned stimulus) will elicits (unconditioned response) by itself

- v. Neutral stimulus - stimulus that will not by itself elicit the response prior to conditioning

- ii. The product of the conditioning experience is termed the conditioned reflex

- i. Conditioning - establishment of a new reflex by addition of a new previously neutral stimulus to the set of stimuli that triggers the response

- f. Pseudoconditioning

- iii. The neutral stimulus isn't neutral at all, but rather elicit the response even before conditioning

### III. Operant or Instrumental Conditioning

- d. General

- ii. Conditioning response to stimuli with reinforcements

- iii. When animal exhibit good behavior patterns, reward is given

- iii. Operant conditioning been successfully applied to visceral responses like heartbeat changing

- d. Experiments of B.F. Skinner

- i. The original experiment is called "Skinner Box"

1. Cage with lever and a food dispenser

2. Food pellet delivered when animal presses the lever

- ii. Positive reinforcement

1. Providing food, light, or electrical stimulation to pleasure centers when desired behavior is performed

1. Following reinforcement, animal more likely to repeat the desired behavior response

- ii. Negative Reinforcement

3. Removing unpleasant stimulus following the desired behavior

- iv. Punishment

2. Painful result when undesirable behavior is performed

1. Animal develops negative connection between stimulus and response

- v. Habit Family Hierarchy

1. Stimulus associated with several possible responses

- I. These responses are in a hierarchy

2. A chicken may respond to light in many ways, but if one response is rewarded, it'd occur with higher probability in the future

1. Reward will raise its order in the hierarchy

1. Punishment will lower the order in the hierarchy

### V. Modifications of Conditioned Behavior

- d. Extinction

- vii. Gradual elimination of conditioned responses in the absence of reinforcement

- iii. In operant conditioning, response is diminished and eventually eliminated. But it is not unlearned since it will rapidly reappear soon as reinforcement appears

- i. In classical conditioning, conditioned stimulus must be paired with unconditioned stimulus else it'd eventually extinct.

1. However, at times, conditioned stimulus may elicit the conditioned reflex in what's called "spontaneous recovery"

- d. Generalization and Discrimination

- ii. Stimulus generalization is where conditioned organism will response to similar stimuli but not identical

- i. Stimulus discrimination is where conditioned organism will not respond to similar stimuli

## Limits of Behavioral Change

### Imprinting

- d. Discovered by Konrad Lorenz when he swam in pond with duckling separated from mother
  - III. A critical period early in development where behavior pattern is accepted permanently in their behavior pattern

### II. Critical Period

- c. Specific time period where animal's behavior pattern must have proper environmental cue for pattern to be developed properly

## Intraspecific Interactions

### II. Behavioral Displays

- c. Innate behavior that is a signal for communication
  - iii. Can be a song, call, or change in behavior patterns
- e. Reproductive displays - complex patterns as signals in preparation for mating
- e. Agonistic display
  - ii. display of appeasement, like when dog wags its tail
  - ii. It involves a contest of some kind, both threatening and submissive behaviors
  - iii. Antagonistic behavior - showing signs of pissed off
- c. Other displays might be to convey information about quality and location of food sources

### III. Pecking Order

- b. Dominant member of the species will get the first right over the subordinate
- f. Minimizes violent intraspecific aggressions

### II. Territoriality

- d. Defense of a certain area from intrusions from other members of the specie
- e. Serve to distribute the species so resources not depleted

### IV. Response to Chemicals

- c. Olfactory senses as a mean of communication in animals
- d. Pheromones that affects behavior on other members of same species
  - v. Releaser Pheromones - trigger reversible behavioral change in recipient
  - v. Primer Pheromones - produce long term behavioral and physiological alteration in recipient animal





## CH. 14 : Ecology

### Keywords

#### II. General

- c. Abiotic - physical environment like water, rock, sunlight, climate, temperature
- m. Biotic - living environment like relationship between organisms, tree, other fish, etc
- i. Ecology - study of interactions between organisms and their environment

#### VI. Levels of Biological Organization

- b. Atmosphere - air we breath got stuff in it
- p. Biosphere - all portions of planet that support life, relatively thin zone of life support
- j. Community - populations of different plants and animals species interacting in given environment
- p. Ecosystem - interaction between biotic communities and non-living environment
- o. Hydrosphere - the ocean and etc
- o. Lithosphere - rock and soil surface
- u. Organism - individual unit of an ecological system
- t. Population - a group of organisms of the same species living together in given location
- s. Species - group of similar organisms that can reproduce viable offspring

#### V. The Environment

- b. Aphotic zone - bottom layer where light can't reach
- x. Humus - amount of decaying plant and animal in soil
- x. Loams - a type of soil with high percentage of each type of soil
- z. Photic zone - top layer where light can shine through for photosynthesis

#### VI. Interaction within the Ecosystem

- b. Autotrophs - make own food
- i. Carnivore - consumes other animals
- i. Commensalism - one organism benefits, other is not affected
- j. Ectoparasite - parasite that lives outside of host
- j. Endoparasite - parasites that live within the host
- f. Habitat - physical place where an organism lives
- n. Herbivore - consume only plants or plant food
- h. Heterotrophs - must consume autotrophs or other heterotrophs for food
- j. Homeothermic - warm-blooded animals that maintain constant body temperature
- g. Hyperosmotic environment - creatures living in sea water
- e. Hypoosmotic environment - creatures living in fresh water
- j. Interspecific interaction - species competing against one another for resource
- h. Intraspecific interaction - specie working together or competing for resource
- e. Mutualism - symbiotic relationship where both organisms derive benefit
- e. Niche - functional role of an organism in its ecosystem
- a. Obligatory symbiosis - one or both organisms cannot survive without the other
- c. Omnivore - eat both plant and animals
- c. Parasitism - parasite benefit at expense of host
- c. Poikilothermic - cold blooded animal that depends on external temperature for activity
- g. Predation - free-living organisms that feed on other living organism
- b. Saprophytism - protists and fungi that decomposes dead organic matter
- e. Scavenger - consumes dead animal

#### V. Relationship within the Ecosystem

- b. Decay Bacteria - releases nitrogen locked in tissue by reducing dead organisms into ammonia
- a. Denitrifying bacteria - reduces nitrogen into elemental nitrogen from ammonia

- c. Food Chain - Sun > Producer > primary consumer > secondary consumer > tertiary consumer > Decomposers
- d. Food pyramid - as the pyramid ascends, energy, mass, and number becomes lower
- d. Food Web - the more intricate the web, the more stable the ecosystem
- b. Nitrifying Bacteria - oxidizes nitrogen until it becomes usable nitrate
- f. Nitrogen Cycle - goes from inorganic to organic and is used by everything
- d. Nitrogen fixing bacteria - turns free N<sub>2</sub> in atmosphere into usable nitrates

#### IV. Stability in the Ecosystem

- b. Climax community - stable, living part of ecosystem where population exists in balance with each other and environment. Will keep going until major change occurs.
- e. Pioneer organism - first living organism in a habitat
- a. Sere - community stage that will succeed one another until climax community reached

#### IV. World Biomes

- c. Aphotic layer - no sunlight layer of the open sea
- a. Benthos - crawling and sessil organisms of the sea
- b. Biome - distinct community characterized by vegetation type
- f. Desert biome - less than 10" of rain, very few plants and animal types
- c. Diatom - algae responsible for most of the autotrophic work
- b. Grassland biome - 10-30" of rain, prairies usually
- f. Intertidal zone - region of marine where tide comes in or out
- g. Littoral zone - contains ocean of up to 600 feet and several miles from shore
- a. Nekton - active swimmers of the sea, like fishes and whales
- d. Pelagic zone - typical of open sea and divided into photic and aphotic layer
- d. Photic layer - sunlit layer of open sea, up to 600 feet
- e. Plankton - passively drifting mass of organisms
- b. Polar region - nothing growing here
- d. Taiga Biome - less rainfall with long cold winters.
- c. Temperate deciduous forest biome - cold winters, warm summers, moderate rainfalls with trees that shed its leaves, and various forest animals
- c. Temperate coniferous forest biome - cold, dry, and inhabited by fir, pine, and spruce. Due to year-round dry and cold, needle like tree
- e. Tropical Rain forest biome - jungles with dense vegetation, numerous kind of animals
- b. Tundra biome - treeless frozen plain with very short summer

### Levels of Biological Organization

#### II. Organism

- b. Individual unit of an ecological system.
  - ii. Composed of organs
    - 2. Composed of tissues
      - c. Composed of cells
        - I. Composed of molecules
        - I. Composed of atoms

#### V. Population

- c. Group of organisms of the same species living together in given location
- b. Species - group of similar organism capable of reproducing viable offspring

#### III. Communities

- c. Population of different plants and animals interacting in a given environment
- g. Biotic community is only the population and not the physical environment
- a. Contains population from all five kingdoms
- e. Examples could be

- i. Lawn - grass, flower, earthworms, insects, bacteria
  - ii. Pond - dragonflies, algae, minnows, fishes
  - ii. Forest - moss, pine, bacteria, lichen, fern, deer, spider
  - ii. Sea - fish, whale, plankton, etc
- III. Ecosystem
  - c. The interaction between living biotic communities and non-living environment
- II. Biosphere
  - c. The strata where the planet support life
    - ii. Atmosphere (where we are)
    - iv. Lithosphere - rock and soil surface
    - iii. Hydrosphere - the ocean

## The Environment

- II. Physical Environment
  - b. Water
    - i. Major component of life
    - iv. If water not readily available, the organism must adapt with storage and conservation of water
  - d. Temperature
    - iii. Must be maintained at optimal level
    - ii. Animals adapt to the environment (but not sharp changes)
  - g. Sunlight
    - iii. Ultimate source of energy for life forms
    - i. Photic zone - top layer of water where light can penetrate
      - 1. Where all photosynthesis take place
    - i. Aphotic zone
      - 1. Animal life and other heterotrophic life exist
  - d. Oxygen Supply
    - ii. Air contains 20% oxygen, animals uses it
    - i. Aquatic plants and animals uses the small amount of oxygen dissolved in water
      - 1. Pollution affects the oxygen content in water
  - d. Substratum
    - ii. Soil is affected by number of things
      - 1. Acidity - acid rain may make soil pH too low for most plant growth
      - 1. Texture and Clay Content - determine water holding capacity for the soil
        - I. Plants grow well in loam (contains high percentage of each type of soil)
      - 1. Minerals - nitrates and phosphate content determines type of vegetation that can be supported
        - I. Beach sand is generally leached of all minerals and unable to support plant life
      - 1. Humus - amount of decaying plant and animal life in the soil
- II. Biotic Factors in the Environment
  - b. Organisms influence each other, whether same species or different.

## Interactions Within the Ecosystem

- II. The Niche
  - b. Defines the functional role of an organism in its ecosystem

- ii. What the organism eat
    - iii. What climate it can tolerate
    - iv. Nature of its prey and predator
    - v. Where and how it reproduces
  - h. Different from habitat which is just the physical place the organism lives
  - d. The niche definition is so specific that no two species can ever occupy the same niche
    - ii. Only the same organisms can compete for the same EVERYTHING
    - ii. Species can be identified from the niche definition
  - e. Competition occurs when similar niche requirement exist for two or more species
    - ii. One species may be superior and drive other to extinction
    - vi. One may be superior in one region, while inferior in other, resulting in differential elimination
    - i. Rapid divergent evolution to stop competing against one another for food
- III. Nutritional Interactions Within the Ecosystem
- b. Autotrophs
    - i. Manufactures own food.
    - v. Chemosynthetic bacteria obtain energy from oxidation of inorganic minerals
  - b. Heterotrophs
    - i. cannot synthesize their own food and must depend on autotrophs or other heterotrophs for nutrition
  - c. Herbivores
    - i. Consumes only plants or plant foods
      - 1. Developed special structure for crushing and grinding tough cellulose food
      - 1. Have symbiotic bacteria that help digest cellulose
    - iii. Adept in defense because they're often prey
  - g. Carnivores
    - ii. Consume only eat other animals
      - 1. Possess pointed teeth and fang-like canine teeth for tearing flesh
    - iii. Shorter digestive tract due to easy digestibility of animal food
  - e. Omnivore
    - ii. Eats both plants and animals
- II. Interspecific Interactions
- a. Community is an integrated system of species dependent on each other for survival
  - h. Major types of interspecific interactions are symbiosis, predation, saprophytism, and scavenging
  - f. Symbiosis
    - i. Both participants living together in permanent association with each other
    - ii. Some are obligatory where one or both organisms cannot survive without the other
    - v. Commensalism
      - 1. One organism benefited by the association while the other is not affected
        - a. Remora and Shark
        - I. Barnacle and Whale
    - ii. Mutualism
      - 1. Both organism derive some benefit
        - a. Tick bird and rhinoceros - bird removes ticks
        - I. Lichen - fungus and algae association
          - i. Algae produces food for itself and fungus
          - I. Fungal thread provides support and conserve rain water. Also provide nitrogenous waste and carbon dioxide.
        - I. Nitrogen0fixing bacteria and legumes
        - I. Protozoa and termite - protozoan digests the cellulose from termite

- I. Intestinal bacteria and humans - bacteria helps digestion
- iii. Parasitism
  - 1. Parasite benefits at expense of host
    - a. Bacteria, fungi, leeches, ticks, sea lampreys
  - 4. Ectoparasites - latches onto the external surface like skin and sucks out what they need
  - 3. Endoparasites - lives within the host
- f. Predation
  - i. Free living organism that feed on other living organism
  - ii. Predator controls the number of prey
  - ii. Usually, the community evolve toward a balance where prey's existence is not threaten by the predator
- b. Saprophytism
  - i. Protists and fungi that decomposes dead organic matter externally
- c. Scavenger
  - i. Animals consume dead animals
    - 1. Bacteria of decay may be considered scavenger
    - 1. Vulture and hyena

#### Intraspecific Interactions

- a. Competition within species and cooperation as well

#### II. Interactions Between Organisms and Their Environment

- a. Osmoregulation
  - i. Adaptation to converse internal osmolarity and conservation of water
- IV. Hyperosmotic environment
  - 1. constantly in danger of dehydration
  - I. must constantly excrete salt to survive
- I. Hypoosmotic environment
  - 1. constantly in danger of excess water and excessive salt loss.
  - 1. Seldom drinking, absorbing salt through gill, and excreting dilute urine
- iv. Insect - Excrete solid uric acid crystal to conserve water
- iii. Desert Camels - Got a lot of water storage and fat for tolerating temperature changes
- i. Horned toad - thick scaly skin to prevent water loss
- i. Plants - thick cuticles to prevent water loss.
- i. Desert Plant - fleshy stems to store water, spiny leaves to limit water loss
- c. Thermoregulation
  - i. Roughly 60% of energy is given off as heat
  - vi. Poikilothermic - cold blooded animals/plants where body temperature similar to environment
  - ii. Homeothermic - warm blooded animals with physical mechanisms that allow them to maintain constant body temperature

#### Relationships within the Ecosystem

- I. Energy Flow
  - a. Food chain
    - i. Energy enters from the sun through photosynthetic organisms
  - iii. Producers
    - 1. autotrophic green plants and chemosynthetic bacteria
    - 1. Utilizes sun or chemical raw material to manufacture organic goods
  - iii. Primary Consumer

1. Animals which consumes green plants
  - vii. Secondary Consumer
    1. Animals that consume the primary consumers
      - a. Tigers, frogs, lions, ants eating a primary consumer
  - vi. Tertiary Consumer
    1. Animals caught in the act of consuming secondary consumers
  - iii. Decomposer
    1. saprophytic organisms that decomposes organic wastes
  - b. Food Web
    - i. Intricate web of who eats who and etc
    - ii. The more intricate the web, the more stable the community
  - e. Food pyramid
    - i. As food is transferred from one level to the next, transfer of energy occurs
      1. Every energy transfer causes significant loss in energy
    - ii. Pyramid of energy
      1. Producer at the bottom contains the greatest amount of energy
      2. Smallest amount of available energy is at the top of the pyramid
    - i. Pyramid of Mass
      1. Each level supports successively smaller biomass
    - ii. Pyramid of Number
      1. Each level contains less and less organisms
    - ii. In general, as pyramid ascend, there are less energy content, less mass, and fewer number of organism
- II. Material Cycles
- a. Material passes from inorganic to organic in an endless cycle
    - i. Accomplished largely through the actions of scavenger and decomposers
  - a. Nitrogen Cycle
    - i. Starting from elemental nitrogen ( $N_2$ )
      1. Cannot be used by anything and is chemically inert
      1. Through lightning and nitrogen-fixing bacteria, it is turned into usable soluble nitrates
    - i. Nitrates ( $NO_3^-$ )
      1. Absorbed by plants to make nucleic acid and plant proteins
      1. Animals consume the plant protein and make their own from these protein
      2. Both animal and plant would excrete ammonia or when dead, the nitrogen are locked up in tissue
      1. Bacteria would then decompose the tissue down and turn nitrogen locked into ammonia
    - ii. Ammonia ( $NH_3$ )
      1. It can be turned into nitrites by nitrifying bacteria via chemosynthesis
      1. It can be turned into free elemental nitrogen in the atmosphere by denitrifying bacteria
        - a. Goes back to #1
    - i. Nitrites ( $NO_2$ )
      1. Turns into nitrates via nitrifying bacteria
  - a. Carbon Cycle
    - i. Starts from carbon dioxide ( $CO_2$ )
    - i. Plant takes the carbon dioxide and fix it into glucose
    - iii. Animals take the glucose and through respiration, burns the glucose back into  $CO_2$ .
    - i. When dead, animals and plants are decomposed by bacteria into  $CO_2$
    - i. Cycle starts over

- a. Other Cycles
  - i. Many other cycles exist, but it's all the same

## Stability in the Ecosystem

- I. Conditions for stability in an ecosystem
  - a. Self-sustaining ecosystem require a stable physical environment (abiotic) and a relatively stable biotic community
  - b. Requires a constant energy source (sun)
  - f. Requires material recycling pathway
- II. The Climax community
  - a. A stable living (biotic) part of the ecosystem where populations exist in balance with each other and with the environment
  - c. Will persist until a dramatic change that disturbs the abiotic environment so much that biotic community must change (and die)
    - i. Or the biotic community changes (diseases?)
- III. Ecological Succession
  - a. Orderly process by which one biotic community replaces another until climax community is established
  - c. Each community stage is called **sere**
    - i. Each stage has its dominant species
      - 1. Each dominant species would change the environment so much that eventually, the environment will be more suitable for the successor dominant specie
    - iii. Eventually, a population will alter the environment that the original condition that give rise to THIS population, are recreated.
      - 1. Indefinite cycle is produced
  - b. The start of everything is a pioneer organism, first living thing in the ecosystem

## World Biomes (Major communities)

- I. Terrestrial Biomes
  - a. General
    - i. Everything trace back to sea, so adaptations must happen
      - 1. Relative lack of water
      - 1. Relative lack of food and supporting medium
      - 1. Varying temperature extremes
      - 1. Varying composition of the soil with different salinity
    - ii. Each geographic region is a distinct community called biome
    - ii. Land biomes are characterized and named after the climax vegetation of the region
      - 1. Becomes dominant and stable after years of evolution
      - 2. Since plants are the producer, they determine the nature of the animal population and everything else
      - 2. Thus, climax vegetation determines the climax animal population
  - b. Desert Biome
    - i. Less than 10" of rain each year.
    - vi. Small plants and animals inhabit the desert
      - i. Plant life includes: Cactus, sagebrush, mesquite
      - ii. Animal life includes: insects and lizards

- c. Grassland Biome
  - i. Low rainfall (10-30" per year)
  - ii. No shelter for herbivorous mammals from carnivorous predators
  - i. Animals inhabit here developed long legs and hoofs
- c. Tropical Rain Forest biome
  - i. Jungles characterized by high temperature and torrential rains
  - ii. Dense vegetation which does not shed leaves
    - 1. Vines
    - 2. Epiphytes - plants growing on other plants
  - i. Numerous animals
  - iv. Floor inhabited by saprophytes
- c. Temperate Deciduous Forest biome
  - i. Cold winters, warm summers, and moderate rainfall
  - iii. Trees like beech, maple, oaks, and willows
    - 1. Leaves during warm time
    - 1. Shed leaves during cold time
  - iv. Various animals
- b. Temperate Coniferous Forest Biome
  - i. Cold, dry, and usually no warm time
  - ii. Inhabited by fir, pine, and spruce
    - 1. Adapted for water conservation with needle-shaped leaves
- b. Taiga Biome
  - i. Less rainfall than temperate forests with long cold winters
  - iii. Inhabit only by spruce
  - ii. floors having moss and lichens
  - ii. Chief animals is the moose, with black bear, wolf, and some birds
- b. Tundra Biome
  - i. Treeless, frozen plain with very short growing summer
  - ii. Lichen, moss, polar bear, musk oxen, and arctic hen found here
- b. Polar region
  - i. Frozen with no vegetation and animals
  - ii. Penguins live near water!

## II. Terrestrial Biome and Altitude

- a. From the equator to the polar region, the same can be found with from base of mountain to the top

## II. Aquatic Biomes

- a. General
  - i. 70% of Earth surface is covered by water
  - ii. Most of Earth's life is found in water
  - iii. 90% of Earth's food and oxygen production takes place in water
  - iii. Nothing changes drastically in water, so really only two major aquatic biomes, marine and fresh water
- b. Marine Biome
  - i. Relative constant amount of nutrient and dissolved salts
  - iv. Not a great deal of temperature change
  - ii. Intertidal zone
    - 1. region exposed during low tide
    - 4. Algae, sponges, clams, snails, sea urchins, starfish, and crabs
  - iii. Littoral Zone
    - 1. On continental shelf with depths up to 600 feet
    - 1. Algae, crabs, crustaceans, many different kinds of fish
  - i. Pelagic Zone



1. Typical open sea, divided into two parts
  1. Photic zone
    - a. Sunlit layer extending up to 600 feet
    - a. Chief autotroph is diatom, type of algae
    - a. Contains plankton
      - i. Drifting masses of microscopic photosynthetic and heterotrophic organisms
    - b. Contains nekton
      - i. Active swimmers such as sharks, fish, or whales
  3. Aphotic zone
    - a. No sunlight here
      - i. No photosynthesis plant here
    - a. Deep-sea organisms have adaptation enabling them to survive in very cold water, high pressures, and complete darkness
      - i. Nekton - fishes, eels, etc
      - I. Benthos - crawling and sessil organisms
    - a. Most living things here are scavengers or predators, competition is fierce
- d. Freshwater biome
  - i. Rivers, lakes, ponds, marshes, in between ocean and land
  - iv. Temperature, transparency, depth of water, CO<sub>2</sub> availability, and oxygen are important factors
  - iv. Salt concentration can also be a big factor (closer to ocean)
  - ii. Fresh water organisms must always be removing excess water
    1. Contractile vacuoles of protozoa
    2. Excretory system of fish
    3. Plants with rigid cell wall
  - ii. Strong currents, fishes must have strong muscles to swim against, and plants must have root-like holdfast to stay in place
  - ii. Temperature of fresh water bodies may freeze up, dry up, and muddy
    1. So... the fish must adopt to frozen lake!



## CH. 15 : Classification

### Keywords

#### II. Taxonomic Classification

- b. Order of classification - kingdom, phylum, order, class, family, genus, species
- h. Taxonomy - science of classification and nomenclature used

#### IV. Classification into Kingdoms

- b. Animalis - heterotrophic, motile generally, differentiation of tissues
- k. Fungi - non-photosynthetic that's either saprophytic or parasitic. Cell wall made of chitin. Non-motile, differentiated and multicellular
- q. Monera - simple prokaryotes without nucleus nor any membrane bound organelles
- p. Plantae - photosynthetic, multicellular, non-motile, differentiation of tissues
- p. Protista - simple primitive eukaryotic organisms, a catchall kingdom

#### IV. Virus

- b. Bacteriophage - virus that specifically invade bacteria only
- u. Lysogenic - invades, then lay dormant
- t. Lytic - blows whatever they invade up, fast division
- q. Virus - not placed in any of the kingdoms because it's not considered alive

#### IV. Kingdom Monera

- c. Bacteria - single cell, with cell wall, single double stranded circular DNA
- y. Cyanobacteria - one of the very first photosynthetic organisms

#### V. Kingdom Protista

- b. Algae - photosynthetic organisms like euglena
- a. Ciliophors - type of protozoan in kingdom prista. Have cilia
- j. Coenocytic - many nuclei in a mass of protoplasm
- j. Protozoa - heterotrophic little animals
- k. Rhizopod - a type of protozoan in kingdom Protista. Like amoeba

#### IV. Kingdom Fungi

- d. Sproulation - forming spores and with wind or animals, this is spread and new fungi is formed

#### VI. Kingdom Plantae

- d. Angiosperms - flowering plants with covered seeds
- o. Dicotyledons - net veined leaves with two cotyledons within seed.
- i. Gymnosperms - plants with naked-seeds
- k. Monocotyledons - leaves with parallel veins, seed with single cotyledons

#### VII. Kingdom Animalia

- b. Alimentation - intake of food and the process of digestion
- f. Annelida - segmented worm like earthworm, leeches
- k. Arthropods - can be insects, archnids, crustaceans
- i. Bony fish - notochord replaced by bony skeleton. Most fishes
- f. Calcareous - calcium carbonate secretion from mollusca for exoskeleton
- f. Cartilaginous fish - jaws and teeth with reduced notochord
- b. Chordates - characterized by presence of notochord
- d. Coelom - body cavity
- d. Cnidarians - jellyfish, hydra, sea anemone, coral
- d. Echinoderms - spiny, radially symmetrical. Starfish or sea urchin
- h. Jawless fish - eel-like with cartilaginous internal skeleton, retain notochord
- c. Mollusca - soft bodied possessing mantle and secrete calcium carbonate exoskeleton like squid, snails, clams
- f. Monetremes - type of mammal that lay leather egg with horny bill and milk glands
- a. Nematoda - round worm like hookworm, trichina

- b. Notochord - stiff dorsal rod found in chordates
- d. Platyhelminthes - flat worms like planarian
- e. Porifera - sponges
- e. Vertebrates - most advanced subphylum of chordates. The vertebrate replaces notochord of the embryo

## Taxonomic Classification

### II. Taxonomy

- d. Modern classification seeks to group organisms based on evolutionary relationships
- c. Takes into account anatomical, structural, excretory, movement, digestion, genetic, biochemical, etc
- g. Organization from broadest to smallest/specific

### V. Classification and Subdivisions

- c. 5 Kingdoms
  - i. Monera, Protista, Plantae, Fungi, Animalia
  - ii. Further subdivided into phyla
- f. Phyla/Division
  - i. Major groupings of animal
  - i. Division is used for grouping in other kingdoms
- a. Subphyla/subdivision
- b. Classes
- c. Orders
- g. Families
- d. Genera
- c. Species

### V. Assignment of scientific names

- c. All organisms are assigned Genus and species name

## Classification into Kingdoms (modern approach)

### II. Monera

- b. Prokaryotes
- h. Lack nucleus or any membrane bound organelles
- b. Usually bacteria

### III. Protista

- c. Primitive eukaryotic organisms with both plant and animal like characteristics
- e. Single cell or colonies of single cells
- f. Each protist able to carry out all the life processes
- c. Contains all the simple eukaryotes that cannot be assigned as plants or animals
  - ii. A catchall group

### III. Fungi

- c. Non-photosynthetic plants
  - ii. Resemble plants in that they are
    - 1. Multicellular
    - 1. Differentiated
    - 1. Non-motile
- f. Either saprophytic or parasitic
- c. Modes of reproduction are unique and varied
- a. Cell walls composed of chitin, not cellulose

### III. Plantae

- b. Multicellular organisms that exhibit
  - ii. differentiation in tissues
  - v. Photosynthetic
  - i. Non-motile
- b. Most has alternation of generation and distinct embryonic phase

### III. Animalia

- c. Multicellular, generally motile, heterotrophic organisms with differentiated tissues and organs

## Viruses

### II. General

- a. Not considered as living organism, so not placed in any of the five kingdoms
- g. Highly advanced parasites
- e. Have lytic or lysogenic life cycles
- d. Contains either RNA or DNA
- a. Bacteriophages - invade bacteria exclusively

## Kingdom Monera

### II. General

- b. Also called bacteria
- a. Prokaryotic
- f. Exists as single cells, or as aggregates of cells that stick together after division

### III. Cyanobacteria

- b. Also called blue-green algae
- b. Lives primarily in fresh water, but can also be in marine
- e. Possess
  - iii. Cell wall
  - iii. Photosynthetic pigments
  - iii. No flagella, no true nucleus, no chloroplasts, no mitochondria
- c. Can withstand extreme temperatures
- f. Believe to be descended from the first organism which are photosynthetic

### V. Other Bacteria

- c. Single celled prokaryotes with single doubled stranded circular loop of DNA not enclosed in membrane
- e. All have cell wall
- e. Active role in biogeochemical cycles (ie nitrogen/carbon cycle)
- b. Classified by their shape
  - ii. Cocci - round
  - ii. Bacilli - rod like
  - ii. Spirilla - spiral
  - ii. Diplococci - duplexes
  - iv. Staphylococci - clusters
  - v. Streptococci - chains

## Kindom Protista

## II. General

- c. Most are unicellular, but some forms colonies
- b. Eukaryotes and possess membrane bound nucleus and organelle
- i. Two major category of protozoa and algae

## III. Protozoa

- c. Single celled organisms that are heterotrophic
  - iii. Like little animals
- e. Rhizopods - types of amoeba
- f. Ciliophors - types of protozoan with cilia

## IV. Algae

- b. Primarily photosynthetic organisms
  - iii. Includes phytoplankton that many marine organisms live off of
- d. Euglena - a type of algal protista because it photosynthesizes
  - i. Can act as heterotrophs and move about with its flagellum

## IV. Protists Resembling Fungi

- b. Slime molds are often placed in kingdom Fungi
- c. Arranged in coenocytic mass of protoplasm
  - ii. Has animal-like and plant-like stages
- c. Reproduce asexually via sporulation

## Kingdom Fungi

### II. General

- b. Eukaryotes, primarily multicellular
- d. All are heterotrophs
- e. May be saprophytic or parasitic, either way, fungi absorb nutrients from environment
- b. Produces via asexual sporulation or complex sexual process

## Kingdom Plantae

### II. General

- b. Multicellular, non-motile, photosynthetic autotrophs

### II. Differentiation of Tissues

- b. Complex and differentiated
- f. Photosynthetic layer of tissue that contains chloroplast for manufacturing of carbohydrates
- f. Supportive tissues to hold the plant upright and transport nutrients
- a. Specialized rhizoids and complex root that project into the soil
- i. Waxy cuticles to prevent water loss and permits light to go through
- g. Cells that open up in day and close at night

### II. Reproduction

- b. Specialized sex organs in gametophytes that can produce egg and sperm
- b. Undergoes alternation of generation
  - ii. Sexual gametophyte (haploid stage)
  - ii. Followed by asexual sporophyte stage (diploid stage)

### II. Division Bryophyta

- b. General
  - ii. Bryophytes are simple plants with few specialized organs and tissues
  - iv. Lack water-conducting woody material (xylem)
  - iii. Must live in moist environments

iii. Reproduction

- 2. Undergo alternation of generations
- 2. Gametophyte is dominant generation
- 2. Sporophyte is short-lived and attached to gametophyte
  - a. Grows from the archegonium

b. Mosses

- i. Primitive bryophytes
- v. Sporophyte and gametophyte grows together

e. Liverworts

- ii. Flat horizontal leaf-like plants with differentiated dorsal and ventral surfaces

III. Division Tracheophyta

b. General

- ii. Tracheophyte
- iii. Complex vascular plants with great degree of cell differentiation
- iii. Contain vascular tissue of xylem (water), and phloem (food)
- iii. Have radial symmetry and anchored by deep roots
- i. Can grow to great height
- iii. Sporophyte generation is dominant

Division Psilophyta

- ii. Most primitive of the tracheophytes and contain rhizoids instead of roots
- I. Has one vascular bundle in the leaves
- V. psilotum

d. Division Lycophyta

- i. Lycophytes belong to ancient subdivision
- II. Have roots, non woody, and contain microphyll
- ii. Club mosses

c. Division Sphenophyta

- i. Sphenophytes possess roots, microphyll leaves, and hollow jointed stem
- iv. Whorls of leaves occur on each joint, thus called horsetail

c. Division Pterophyta

- ii. Largest division and includes the fern
- ii. Evolved from early psilopsids
- ii. Contain large leaves which possess many vascular bundles
- i. Grows lengthwise
- vii. Contain xylem as tracheids, not vessels
- iii. Do not produce seed, and sperm are flagellated and require water for fertilization
- iv. Grow from an underground stem called rhizome

III. Division Coniferophyta

b. Conifers

c. Largest grouping of gymnosperms

- ii. Naked seeded plants
- viii. Include cycads, pines, spruce, fir

b. Have cones

- ii. spiral clustered of modified leaves
- iv. Two types of cones
  - 2. Large female cones that produce megaspore
  - 1. Small male cones that produce microspores

c. Specialized cambium tissue allows for secondary growth in width and in length

f. Woody and usually evergreens

III. Division Anthrophyta

b. General

- ii. Flowering plants known as angiosperms

- ii. Have flowers, not cones
  - 1. Anther of the male stamen produces microspores (pollen)
  - 1. Ovary of the female pistil produces megaspores
  - 1. Successful pollination results in germination of pollen tubes and develops into a seed within an ovary
- iii. Subclasses of angiosperms
  - 1. Dicotyledons
    - a. Net veined leaves
    - a. Vascular bundles about a ring within central cylinder
    - a. Have two cotyledons within the seed
    - a. Have cambium and can be woody
    - a. Flower parts in 4 or 5
  - 2. Monocotyledons
    - a. Parallel veins
    - a. Scattered vascular bundle
    - a. Seeds with single cotyledons
    - a. Do not possess cambium and therefore nonwoody
    - a. Flower parts in 3

## Kingdom Animalia

### II. General Characteristics of All Animals

- b. Differentiation of tissues, organs, and organ systems
  - i. Simple animals have minimal differentiation
  - ii. In more advanced, functions are divided into organs
- b. Alimentation
  - ii. Ingest foods in bulk, digest them, and eliminate the remains
- d. Locomotion
  - ii. All animals have some form of locomotion to acquire nutrients
    - 2. Also for protection, mate selection, and reproduction
  - iv. Some are sessile but can create currents to trap food
- b. Bilateral symmetry
  - ii. Left and right side mirror images
    - 2. Echinoderms and cnidarians are radially symmetrical
  - ii. Head is anteriorly
- b. Nervous System
  - ii. System for receiving stimuli and control their action
  - i. Higher animals have sense organs, brain centers for coordination
- g. Chemical Coordinating System
  - ii. Hormones secretion that work with the nervous system
  - i. Maintain the body in homeostasis

### III. Porifera (Sponges)

- b. 2 layers of cells, pores
- a. Sessile
- d. Have low degree of cellular specialization

### III. Cnidarians

- b. Also called coelenterates
- c. Contain a digestive sac that is sealed at one end (so intake and expelling out through mouth)
- c. Two layers of cell only
  - i. Ectoderm



- ii. Endoderm
  - c. Have specialized cells like tentacles, stinging cells, and nerve net
  - b. Examples: hydra, jellyfish, sea anemone, coral
- II. Platyhelminthes (flatworm)
  - b. Ribbon like that's bilaterally symmetrical
  - b. Three layers of cells including a solid mesoderm
  - b. No circulatory systems
  - c. Nervous system consists of eye, simple brain ganglion, and pair of longitudinal nerve cords
- II. Nematoda (round worm)
  - b. Round worms with long digestive tube and an anus
  - c. Solid mesoderm present
  - b. Lack circulatory system
  - d. Possess nerve cords and anterior nerve ring
  - c. Examples: hookworm, trichina, soil nematods
- III. Annelida (segmented worm)
  - b. Segmented worms with a true coelom (body cavity)
  - d. Well defined system with nervous, circulatory, and excretory system
  - c. Examples: earthworms, leeches
- IV. Mollusca
  - b. Softbodied and possess mantles that secretes calcareous
  - e. Calcareous is calcium carbonate exoskeleton
  - c. Breathe by gills and contain chambered hearts, blood sinuses, and pair of ventral nerve cords
  - d. Examples: clams, snails, and squid
- II. Arthropoda
  - b. Joint appendages, chitinous exoskeletons, and open circulatory system
    - ii. Insects
      - 2. Possess three pairs of legs, spiracles, and tracheal tubes
    - iii. Arachnids
      - 1. Have four pairs of legs, book lungs for breathing
    - v. Crustaceans
      - 1. segmented body with variable number of appendages and posses gills
      - 1. Examples: lobster, crayfish, shrimp
- II. Echinoderms
  - b. Spiny radially symmetrical
  - c. Contains water-vascular system
  - b. Possess capacity for regeneration of parts
  - c. Examples: starfish, sea urchin
- II. Chordates
  - b. General
    - ii. Characterized by stiff dorsal rod called notochord
    - i. Paired gill slits and tail extending beyond the anus at some point in development
    - iii. Some are chordates, but not vertebrates
      - 1. Lancelets and tunicates
    - i. Vertebrates
      - 1. Most advanced subphylum of chordates
      - 1. Includes: amphibians, reptiles, birds, fish, and mammals
      - 1. Also possess bones called vertebrae that form the backbone
      - 1. Bony vertebrae replaces the notochord of the embryo
        - a. Protects the nerve cord
      - 1. Bony case protects the brain

- b. Fish
  - ii. Possess two chambered heart, gills, and have external fertilization
  - iv. Jawless-fish
    - 1. Eel-like
    - 1. Retains notochord throughout life
    - 1. Cartilaginous internal skeleton
    - 1. Sucking mouth
    - 5. Examples: lamprey and hagfish
  - iv. Cartilaginous fish
    - 2. Possess jaws and teeth
    - 2. Reduced notochord
    - 1. Sharks
  - ii. Bony fish
    - 1. Scales
    - 2. Lack notochord
    - 3. Most fishes
- b. Amphibia
  - ii. Have a larval stage in water
    - 1. Like tadpole
      - a. Possess gill, tail, no legs
  - ii. Adult lives on land
    - 1. Has lungs, two pairs of legs, no tail, three chambered heart
    - 4. Eggs laid in water with jelly secretion
  - ii. Examples: frogs, salamander, toad, newt
- d. Reptiles
  - i. Terrestrial animals
  - i. Breathe air by lungs
  - v. Lay leathery eggs and uses internal fertilization
  - v. Cold-blooded (poikilothermic)
  - iii. Have scales, and three chambered heart
- b. Birds
  - i. Four chambered hearts
  - ii. Warmblooded (homeothermic)
  - iii. Eggs surrounded by shell
- b. Mammals
  - ii. Warm blooded animals that feed their offspring with milk from mammary gland
    - 1. Monotremes
      - a. Lay leathery eggs
      - c. Horny bills
      - a. Milk glands with numerous openings, no nipples
      - a. Example: duckbill platypus, spiny anteater
    - 1. Marsupials
      - a. Pouched mammals
      - a. Embryo development in uterus
        - i. Completes development while attached to nipples in abdominal pouch
      - a. Examples: kangaroo, opossum
    - 1. Placental mammals
      - b. Embryos developing fully in the uterus
      - a. Placenta attaches the embryo to the uterine wall and provided exchange for food, wastes, oxygen, etc
      - a. Examples: whale, mouse, bat, man



## CH. 16 : Evolution

### Keywords

#### III. General

- d. Adaptive advantage - a variation in genetic that imparts an advantage
- e. Evolution - change in genetic makeup in a population over time

#### V. Evidence of Evolution

- g. Actual remains - with teeth, bones, etc found in rock, tar pits, ice, amber
- n. Amber - fossilized resin of tree
- j. Analogous Structure - similar structure, different origin. Wing of insect vs wing of bird
- i. Cast - minerals deposited in molds
- i. Homologous structure - similar structure, similar origin
- l. Imprints - impressions left by an organism
- r. Molds - form in hollow spaces of rocks with the organism decayed
- q. Petrification - minerals replace the cells of an organism
- q. Reproductive isolation - interbreeding impossible after enough changes accumulated
- n. Vestigial structures - structures appear to be useless but had ancestral functions

#### V. Theories of Evolution

- a. Natural selection - the fittest survive
- u. Use and disuse - Lamarckian Evolution that's disproved

#### VI. Forces of Evolution

- d. Adaptive Radiation - emergency of number of lineages from single species to adopt to different niches
- r. Allopatric speciation - geographic barrier that leads to speciation
- z. Bottleneck effect - majority of population died, resulting gene pool not representative
- t. Convergent Evolution - unrelated species becoming more similar in feature to adapt to same environment
- b. Deme - small local population that breed with each other only
- k. Divergent Evolution - two or more similar species becoming more dissimilar
- k. Dominant allele - letter p is used to represent this gene locus
- l. Founder Effect - small colonizing population that leads to genetic drift
- e. Gene flow - migration of individuals between different populations
- f. Gene frequency - decimal fraction representing the presence of an allele
- p. Gene pool - sum of all the alleles for any given trait in population
- j. Genetic Drift - changes in composition of gene pool due to change
- l. Hardy-Weinberg Principle - certain equilibrium exist in all genes in gene pool with conditions that must be met
- a. Parallel Evolution - predators and prey coevolve
- g. Phylogeny - study of the evolutionary history
- l. Population - all members of a particular species in a given location
- j. Recessive allele - letter q is used to represent this gene locus
- g. Sympatric Speciation - 1 mutation causing a reproductive barrier

#### IV. Origin and Early Evolution of Life

- f. Primordial soup - early molecules that are miscible with one another and formed simple monomeric molecules after years
- c. Coacervate droplets - colloidal protein molecules that absorbs substances from surrounding

### Evidence of Evolution

## II. Fossil record

### d. General

- ii. Most direct evidence of evolutionary change
- iv. Represent the remains of extinct ancestor
- i. Generally found in sedimentary rocks

### e. Types of fossils

- ii. Actual remains - with teeth, bones, etc found in rock, tar pits, ice, amber
- i. Petrification - minerals replace the cells of an organism
- i. Imprints - impressions left by an organism
- ii. Molds - form in hollow spaces of rocks with the organism decayed
- iii. Cast - minerals deposited in molds

### c. Significant fossil remains found

- ii. Trilobite - primitive crustacean in early Paleozoic era
- v. Dinosaurs - ancient animals similar to birds and reptiles in Mesozoic era
- vi. Eohippus - primitive horse the size of fox
- vii. Woolly mammoth - hairy elephant in Siberian ice
- i. Saber-tooth tigers - found in asphalt tar-pit
- i. Insects - preserved in amber (fossilized tree resin)
- i. Archaeopteryx - missing links between reptiles and birds

## V. Comparative Anatomy

### c. Homologous structures

- ii. Same basic anatomical features and evolutionary origin
- i. Same evolutionary origins

### b. Analogous structures

- ii. Similar functions
- iii. Different evolutionary origins and entirely different patterns of development
- i. Example: wings of fly versus wing of birds

## IV. Comparative Embryology

- e. Stages of development that shows common ancestry
- h. The earlier in stage that the development of embryo diverge, the more dissimilar the adult form will be.
  - iii. Thus, embryo of monkey and human can't be differentiated until much later in development
- e. Examples of Evolution: Avian embryo has teeth, mollusks resemble annelids, human embryo has a tail

## IV. Comparative Biochemistry (physiology)

- b. Organisms with the same basic needs and metabolic processes
- a. The closer the two organisms in comparison, the closer the genetic makeup
- i. Bloods of closely related organisms are very similar
- c. The more different the biochemical characteristics, the earlier the divergence of two species

## IV. Vestigial Structures

- f. Structures that appear useless but had ancestral function
- f. Appendix
  - i. Small and useless in humans
  - i. In herbivores, it assists in digestion of cellulose
- d. Tail - Human, tail is reduced to few useless coccyx
- a. Splints - horse has them as vestigial remains of 2 side toes of Eohippus
- d. Python - has legs which are reduced to useless bones

## IV. Geographic Barriers

- e. Some species migrate after multiplication
- v. Lessens intraspecific competition

- ii. When barrier happens, genetic adaptation on either side of barrier might happen
- d. Each population would evolve specific adaptation to the environment in addition to other neutral changes
- b. If interbreeding doesn't happen (from geographic barrier), eventually, the species won't be able to interbreed even if barrier were removed

## Theories of Evolution

### III. Lamarckian Evolution

- d. Discredited
- a. New organs or changes in existing ones arose because of the need
- b. "use or disuse"
- h. Inheritance of acquired characteristics
  - i. The more muscle mass my daddy has, the more I'd have
  - ii. Disproved - only changes in the DNA of sex cells, can changes be inherited

### IV. Darwin's Theory of Natural Selection

- c. General
  - i. Survival of the fittest
  - i. Many basic agents that'd lead to evolutionary change
- f. Overpopulation
  - ii. More offspring are produced than can survive, thus the fittest of the brood survive
- e. Variations
  - i. Offspring showing different characteristics that parents and might have an advantage for survival
- b. Competition
  - i. Struggle for survival, competing for necessities of life
- b. Natural Selection
  - i. Some organisms have adaptation that allows it to survive
- g. Inheritance of the variations
  - i. The individuals that survive live to reproduce
  - i. When reproduce, the favorable variation is passed on
- c. Evolution of new species
  - i. Favorable changes are perpetuated
  - i. Eventually, enough changes lead to a new specie

## Forces of Evolution

### II. Population Genetics

- b. General
  - i. Population includes all members of a particular species in a given location
  - iv. Gene pool - sum of all the alleles for any given trait in population
  - iv. Gene frequency - decimal fraction representing the presence of an allele
  - i. Dominant allele - letter p is used to represent this gene locus
  - i. Recessive allele - letter q is used to represent this gene locus
  - i. For any gene locus,  $p + q = 1$
- f. Hardy-Weinberg Principle
  - i. When conditions are met, then the Hardy-Weinberg Equation can be used
    - 1. Population is very large
    - 1. No mutations that affect the gene pool
    - 1. Mating between individuals is completely random

- 1. No net migration into or out of the population
- 1. The genes in the population are all equally successful at reproduction
- iii.  $p + q = 1$
- v.  $p^2 + 2pq + q^2 = 1$ 
  - 1.  $p^2$  = frequency of dominant homozygote
  - 1.  $2pq$  = frequency of heterozygote
  - 1.  $q^2$  = frequency of recessive homozygote

## II. Microevolution

- c. Hardy-Weinberg condition does not persist for long in nature
- b. Real populations suffers from unstable gene pool, and migrating populations
  - i. Natural Selection
    - 1. phenotype with favorable variations are selected
  - ii. Mutation
    - 1. Gene mutations change allele frequency in population
    - 1. Gene equilibrium is altered
  - iv. Assortive Mating
    - 1. Mates not randomly chosen
    - 1. Selected via proximity and phenotypes
      - I. Relative genotype ratios will be affected
      - I. Depart from the Hardy-Weinberg equilibrium
    - 1. On the whole, the frequencies in the gene pool is unchanged
  - iii. Genetic Drift
    - 1. Changes in composition of gene pool due to change
    - 1. Bottleneck effect - population drastically reduced
      - I. Some alleles over-represented, some under-represented, some disappeared
    - 1. Founder effect -
      - I. Gene pool doesn't represent the original population
      - I. Few individuals colonize new habitat
    - 1. Gene flow - migration of individuals between populations resulting in loss or gain of genes, thus changing the population's gene pool

## III. Speciation

- a. Evolution of new species that can no longer interbreed
- g. Demes
  - i. Small local population
  - ii. Members of a deme resemble each other more than other demes nearby
  - iii. Mating between same deme occurs more frequently
- j. Development of New Species
  - i. Gene flow impossible between two idifferenet species
  - i. Events that lead to speciation
    - 1. Genetic variation
    - 1. Environmental changes
    - 1. Migration to new environment
    - 1. Adaptation to new environment
    - 1. Natural selection
    - 1. Isolation
  - iv. Allopatric speciation - physical barrier
  - iv. Sympatric speciation - no barrier
- I. Adaptive Radiation
  - i. Emergency of a number of lineages from a single ancestral species
  - iii. Each specie adapts to a distinct niche
  - i. Such speciation minimizes competition

- c. Evolutionary History
  - iv. Phylogeny - study of evolutionary history between species
    - 1. Ancestor at the trunk
    - 1. Modern species at the tip of branches
  - i. Convergent Evolution
    - 2. Groups within the branches develop in similar ways to adapt to similar environments
    - 1. Fishes and dolphin both developed same features but came from different classes of vertebrate
  - iv. Parallel Evolution
    - 1. Groups that faced similar though geographically separate environment with a similar ancestor
    - 1. Example - placental wolf, anteater, mouse and mole
  - ii. Divergent Evolution
    - 1. Two or more related species becoming more dissimilar due to environmental factors
  - iv. Isolation
    - 1. Genetic isolation that results in speciation

## Origin and Early Evolution of Life

### II. The Heterotroph Hypothesis

#### a. General

- ii. First form of life lacked ability to synthesize their own nutrients

Molecules must already exist

#### II. Primitive sea of inorganic and organic compounds

- 1. Energy like lightning might have led to synthesis of simple organic molecules such as sugar, amino acids, purines, and pyrimidines

#### b. Evidence of Organic Synthesis

##### ii. Stanley L Miller in 1953

- 2. Application of UV radiation, heat with methane, hydrogen, ammonia, and water
  - I. Forms complex organic compounds
  - I. After one week, the liquid in the apparatus contained
    - I. Urea, hydrogen cyanide, acetic acid, lactic acid

#### b. Formation of Primitive Cells

##### iii. Coacervate droplets

- 1. Colloidal protein molecules that clump up to form coacervate droplets
  - I. Colloidal molecules surrounded by shell of water
- 1. absorb and incorporate substances from surrounding environment
- 1. developed on early Earth
- 1. Possess properties that associated with living organisms

##### i. Most of these coacervate droplets were unstable

- 2. Few might be stable enough to survive and probably mutated into first primitive cells with nucleic acid polymers that became capable of reproduction

### III. Development of Autotrophs

#### b. The primitive heterotrophs evolved complex biochemical pathways

#### d. Evolved anaerobic respiratory processes

##### iii. Not enough nutrients produced/existed

#### d. Autotrophic nutrition developed



- ii. Pioneer autotrophs developed primitive photosynthetic pathways to synthesize carbohydrates

## II. Development of Aerobic Respiration

- b. Primitive autotrophs fixed CO<sub>2</sub> and released oxygen as waste
- c. Oxygen turned the atmosphere from reducing to oxidizing one
  - ii. Some oxygen converted to ozone to block high energy radiation
  - v. The living organisms at the time destroyed the conditions that made their development possible
- 2. They must evolve to survive, thus aerobic pathways developed

## IV. General Categories of Living Organisms

- c. All living organisms can be divided into four categories
  - iv. Autotrophic anaerobes - chemosynthetic bacteria
  - i. Autotrophic aerobes - green plants and photoplankton
  - ix. Heterotrophic anaerobes - yeasts
  - i. Heterotrophic aerobes - amoebas, earthworms, humans