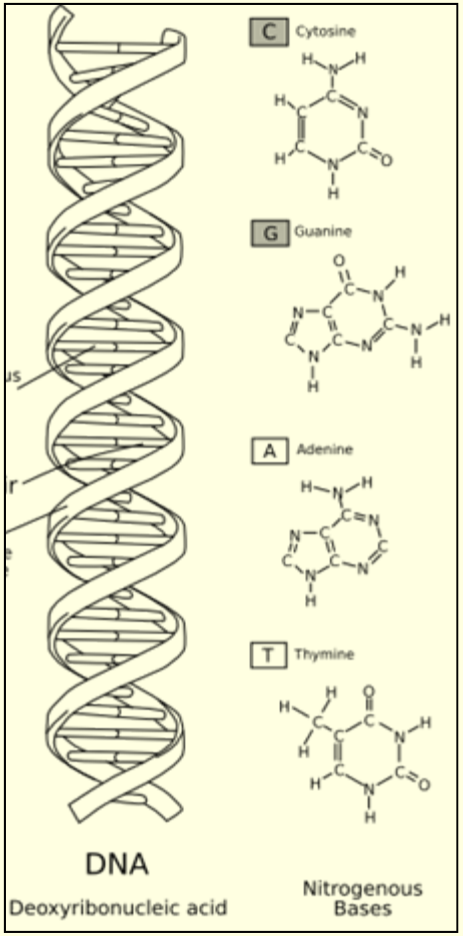
Unit 7: Nucleic Acids and Proteins

Lesson 7.1 DNA Structure

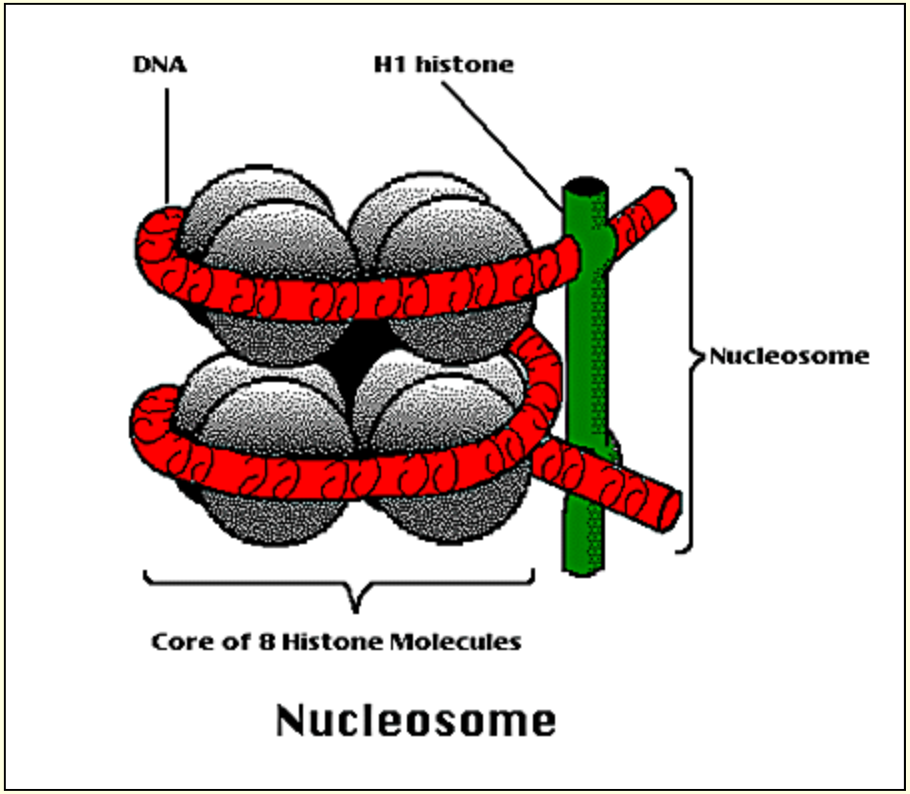
7.1.1 Describe the structure of DNA including antiparallel strands, 3′-5′ linkages, and hydrogen bonding between purines and pyrimadines.

- Antiparallel- each side of the double helix runs in an opposite direction, just like opposing sides of a road.
- 3′-5′ linkages- occur between sugars.
- Purines- adenine and guanine
- Pyrimadines- cytosine and thymine
- Hydrogen bonds- occur between interior bases, a purine across from a pyrimadine.



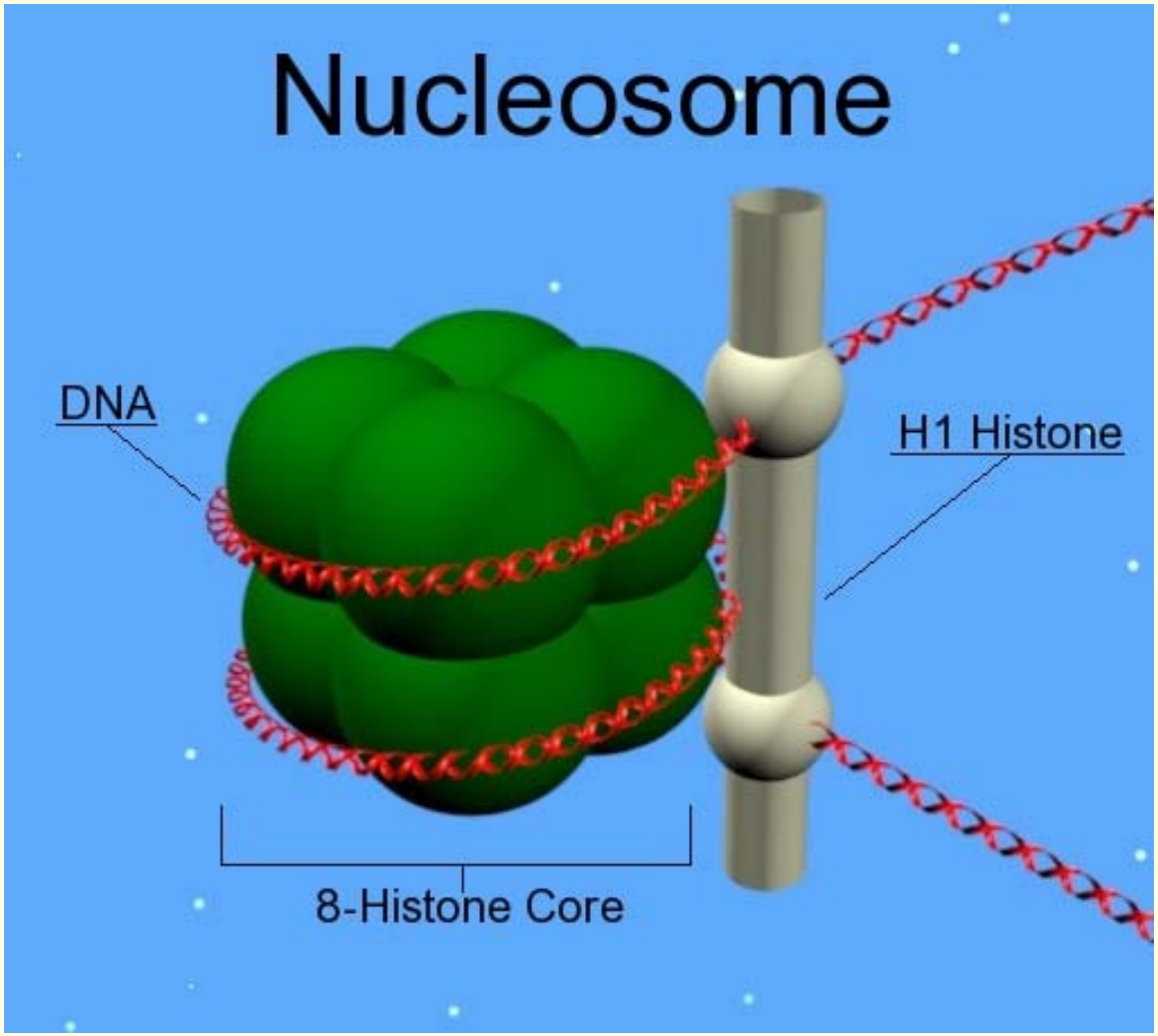
7.1.2 Outline the structure of nucleosomes.

- A nucleosome consists of DNA wrapped around eight histone protein molecules and held together by another histone protein.



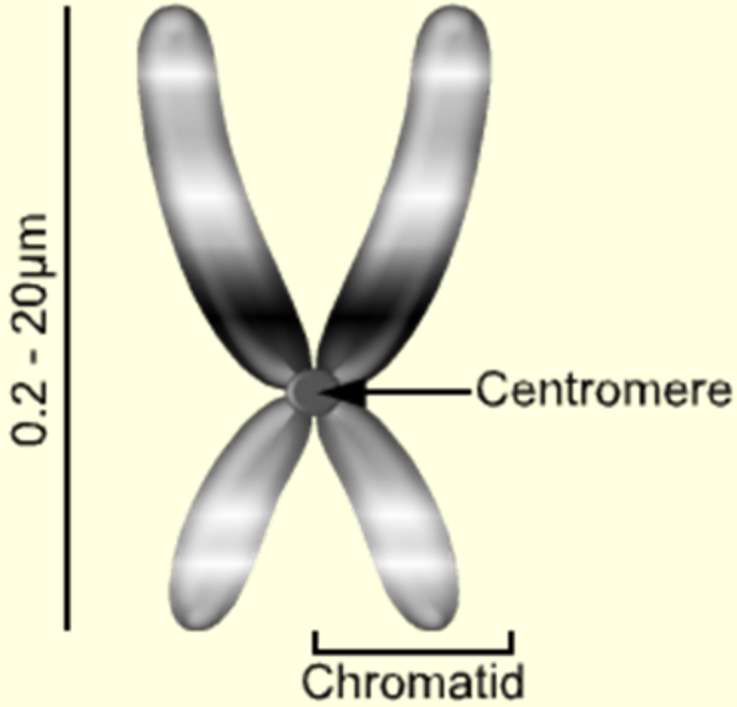
Courtesy of Access Excellence

7.1.3 State that nucleosomes help to supercoil chromosomes and help to regulate transcription.

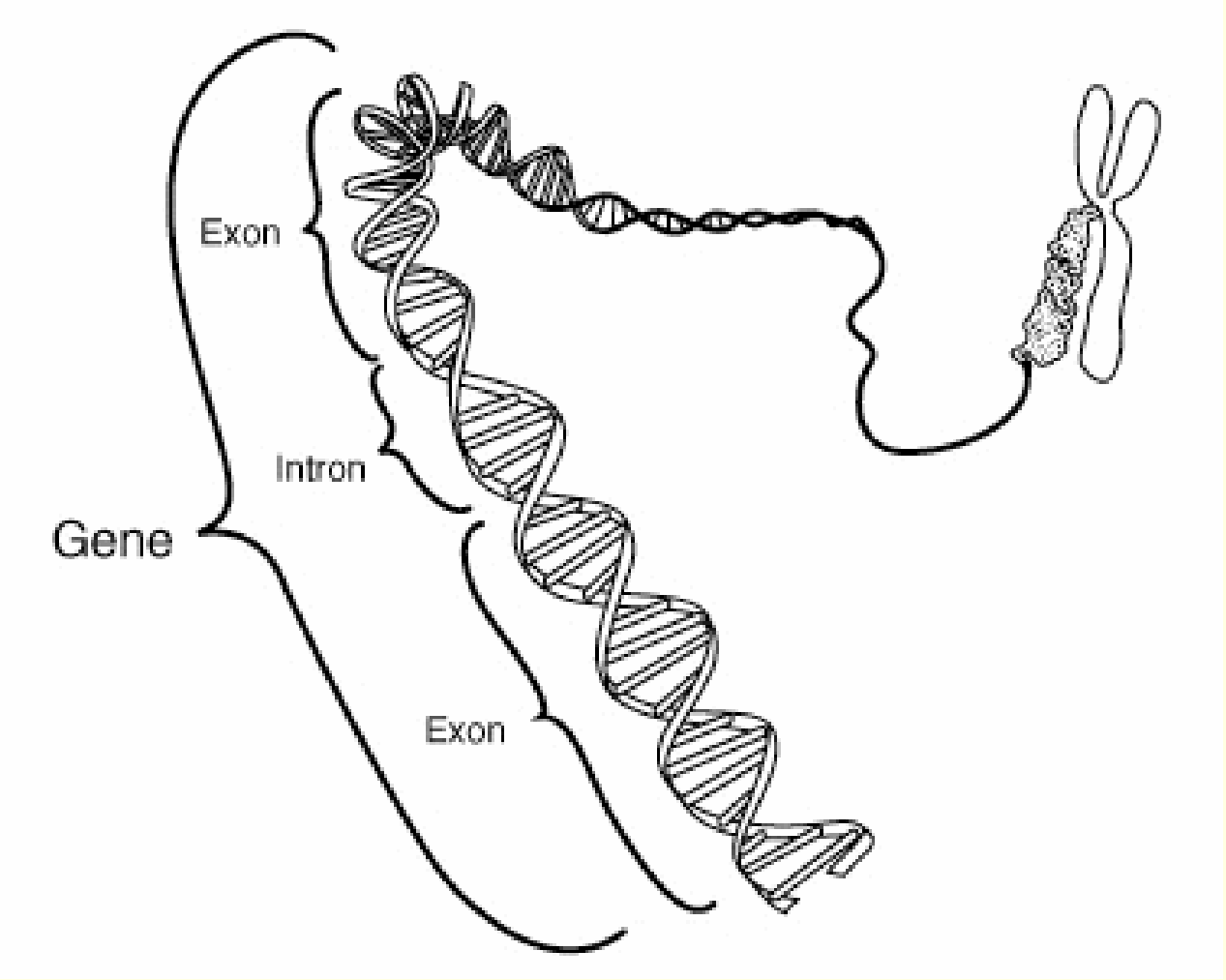


7.1.4 Distinguish between unique or single-copy genes and highly repetitive sequences of nuclear DNA.

- Highly repetitive sequences (satellite DNA) constitutes 5-45% of the genome.
- Sequences are typically between 5 and 300 base pairs per repeat, and may be duplicated as many as 100,000 times per genome.



7.1.5 State that eukaryotic genes can contain exons and introns.

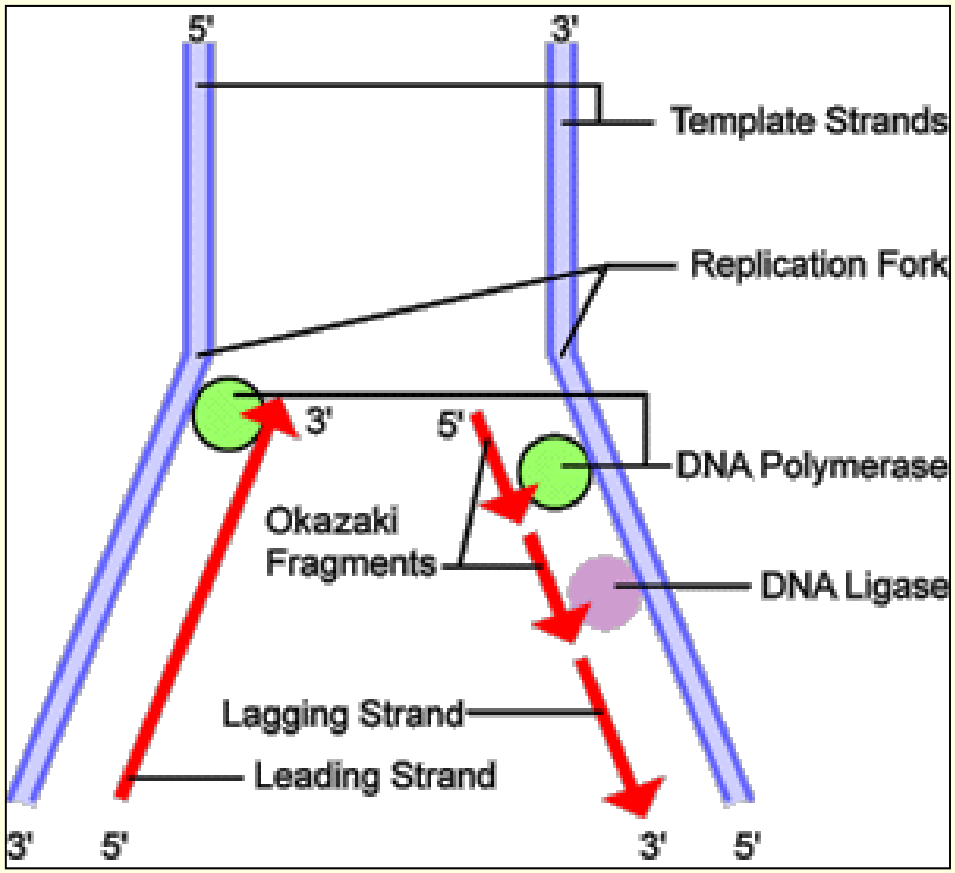


Unit 7: Nucleic Acids and Proteins

Lesson 7.2 DNA Replication

7.2.1 State that DNA replication occurs in a 5′→3′ direction.

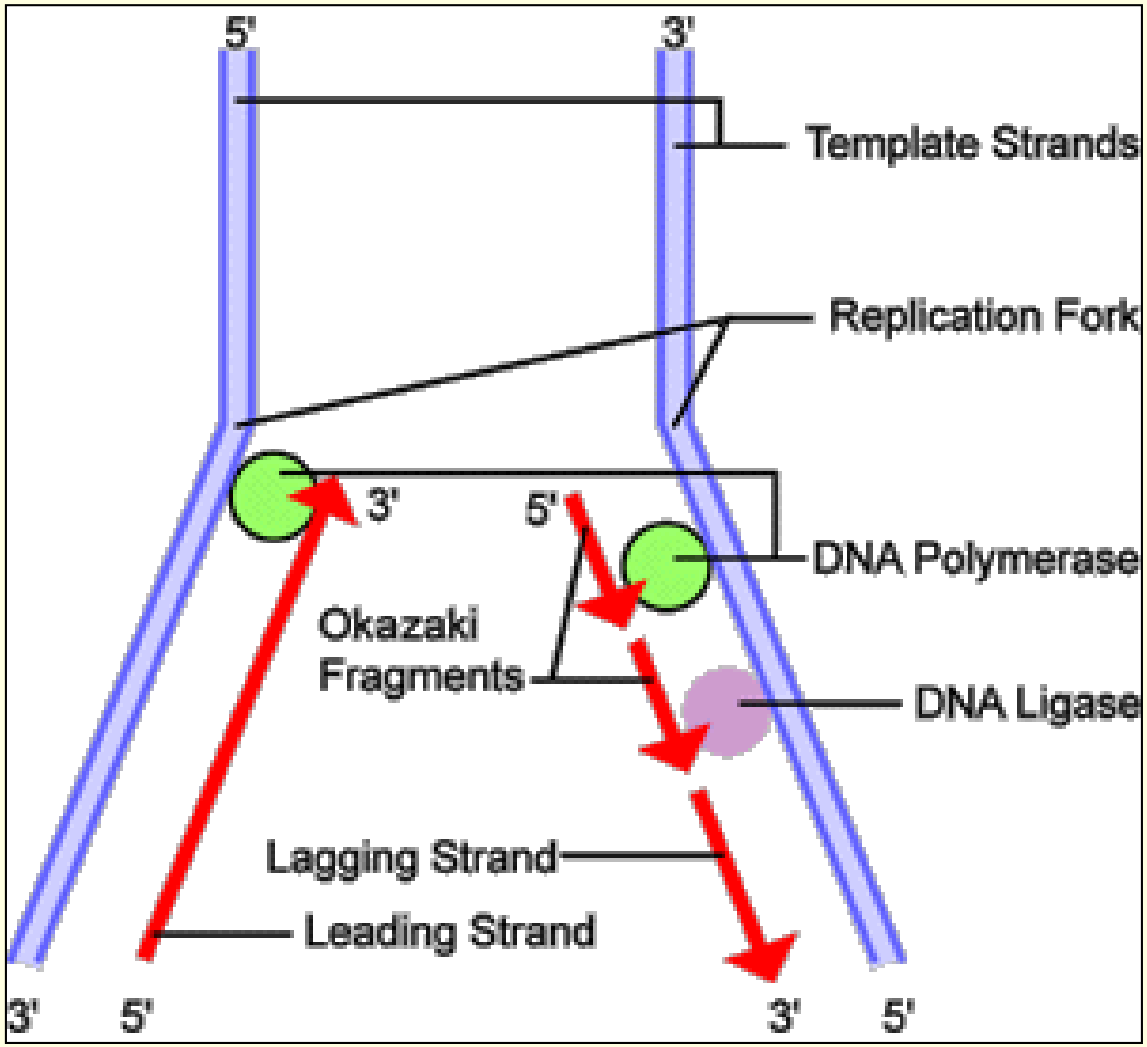
- The 5′ end of the free DNA nucleotide is added to the 3′ end of the chain if nucleotides which is already synthesized.



7.2.2 Explain the process of DNA replication.

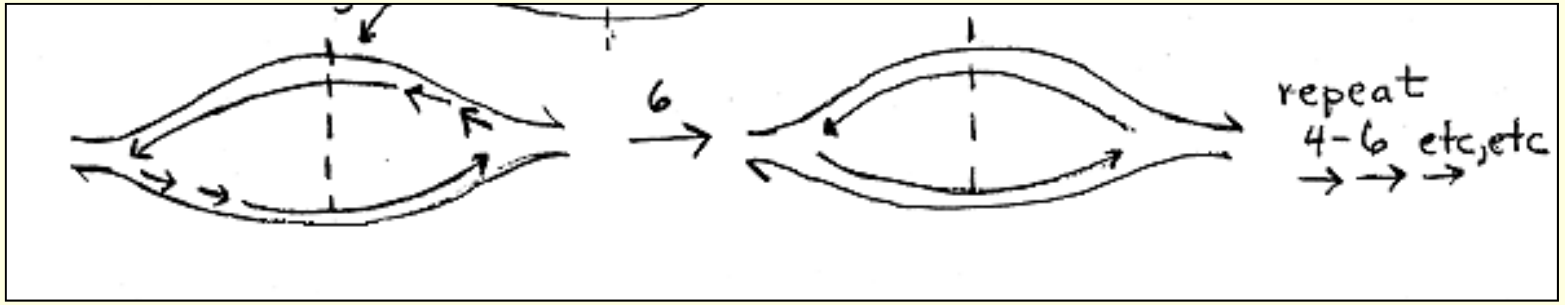
- Helicase- unravels double helix and breaks hydrogen bonds.
- Deoxynucleoside triphosphates- precurser to a nucleotide.
- DNA polymerase III- facilitates the joining of deoxynucleoside trophosphate to the synthesizing strand.
- RNA primase- serves as an anchor for DNA synthesis to begin.
- DNA polymerase I- removes RNA primase and replaces with nucelotides
- DNA ligase- joins together Okasaki fragments.
- Okasaki fragments- segments of synthesized DNA on the lag strand.

7.2.2 Picture


5'
3'
Template Strands
Replication Fork
3'
5'
DNA Polymerase
Okazaki
Fragments
DNA Ligase
Lagging Strand
Leading Strand
3'
5'
3'
5'

7.2.3 State that DNA replication is initiated at many points in eukaryotic chromosomes.

- Unlike a zipper, which initiates and one point only, and works it's way down, DNA replication occurs in many bubbles simultaneously on the same strand. This enables replication to occur more rapidly.



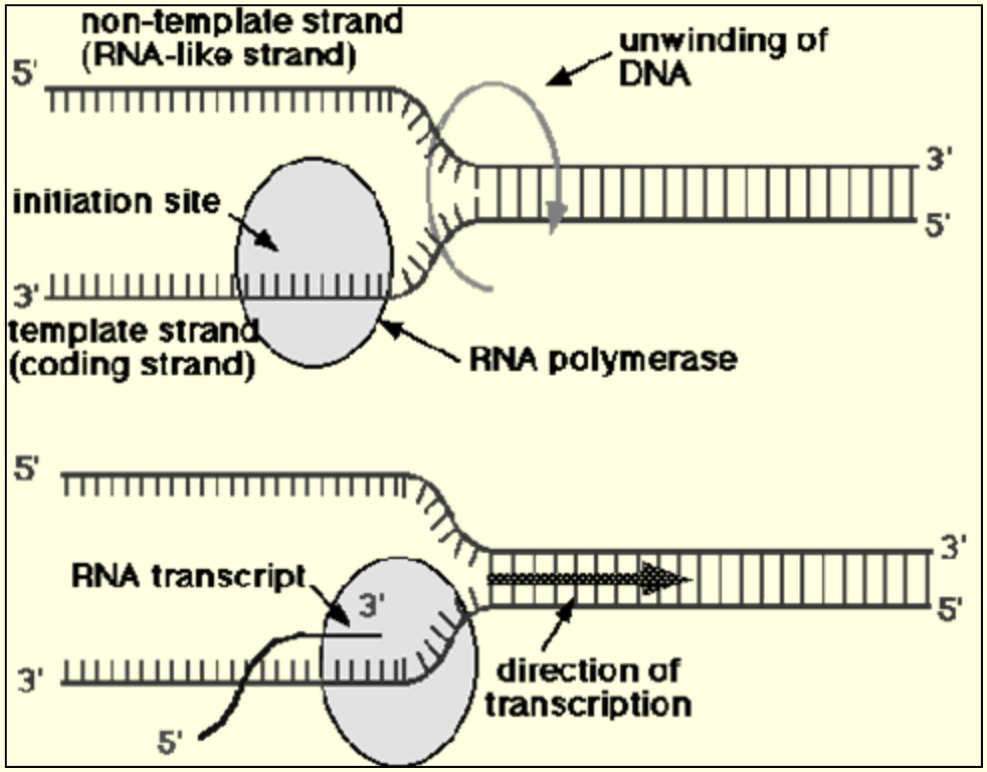
Courtesy of Columbia University

Unit 7: Nucleic Acids and Proteins

Lesson 7.3 Transcription

7.3.1 State that transcription is carried out in a 5′→3′ direction.

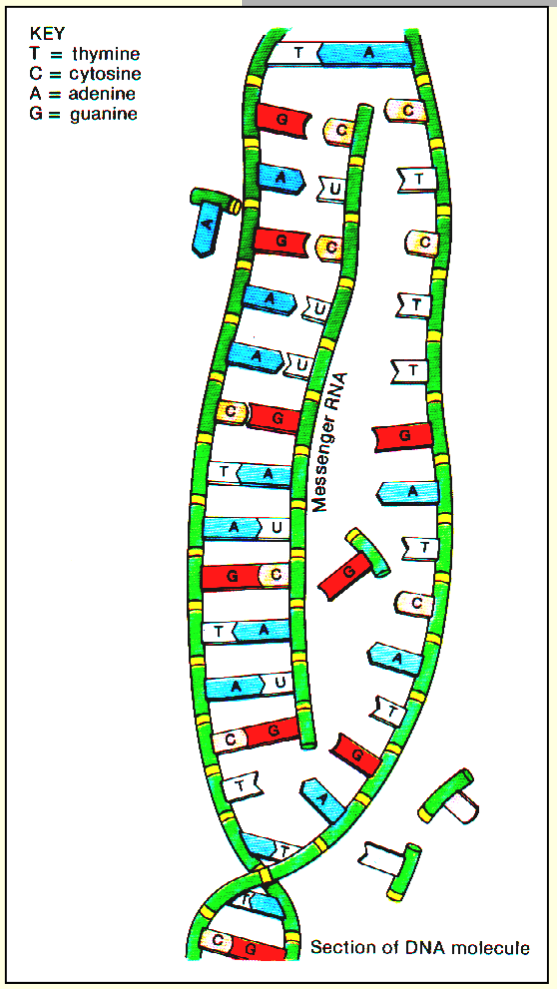
- The 5′ end of the free RNA nucleotide is added to the 3′ end of the RNA molecule which is already synthesized.



7.3.2 Distinguish between the sense and antisense strands of DNA.

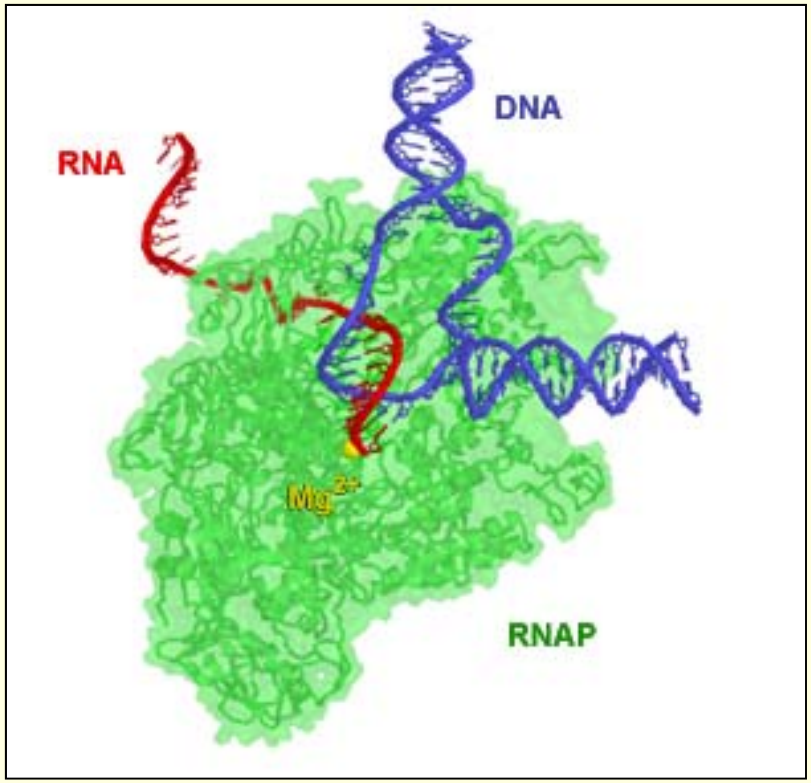
- Antisense strand- the strand transcribed by RNA polymerase by attaching complimentary RNA nucleotides (on the left of picture).

- Sense strand- non coding (on the right of picture).



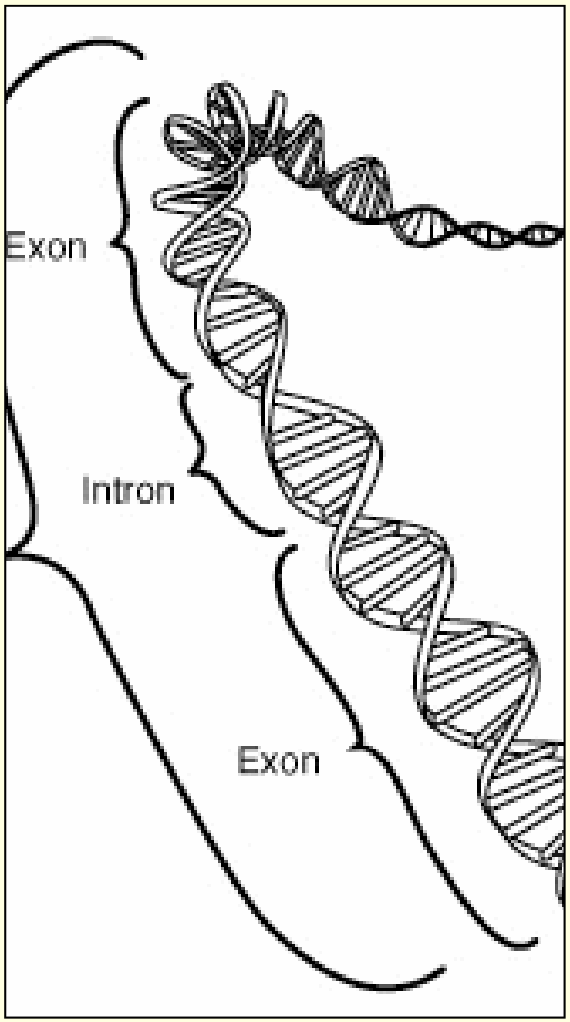
7.3.3 Explain the process of transcription.

- Promoter region- where transcription starts.
- RNA polymerase- enzyme which facilitates transcription.
- Nucleoside triphosphates- precurser to RNA nucleotide.
- Terminator region- where transcription ends.



7.3.4 State that eukaryotic RNA needs the removal of introns to form mature mRNA.

- Introns are removed and exons are spliced together in the process of post-trancriptional mRNA processing.

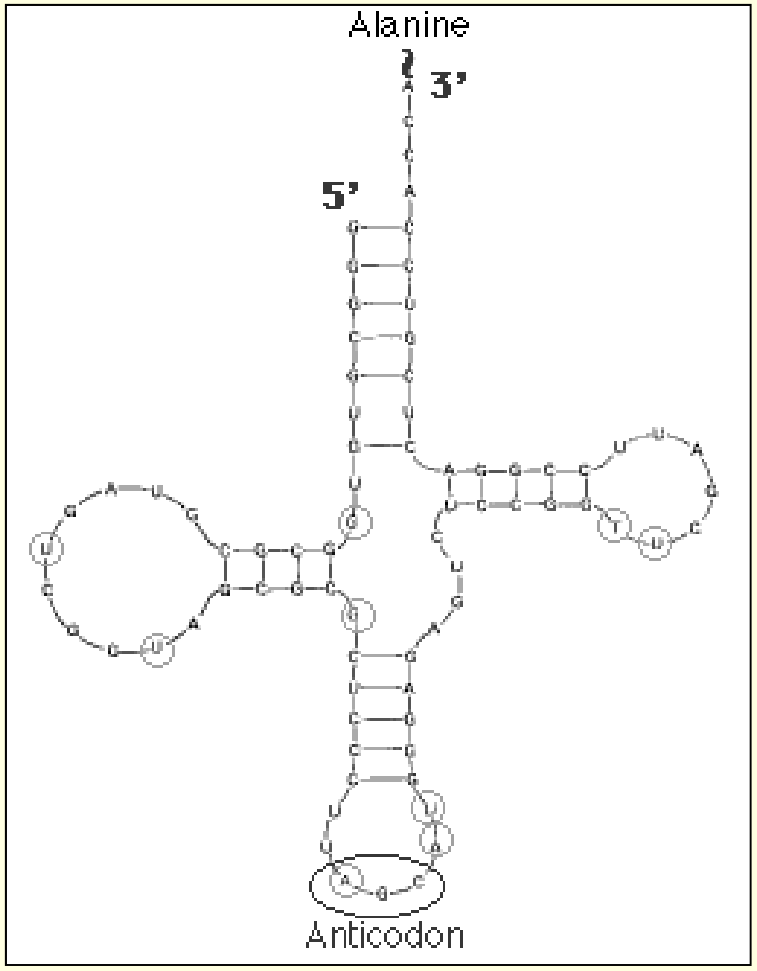


Unit 7: Nucleic Acids and Proteins

Lesson 7.4 Translation

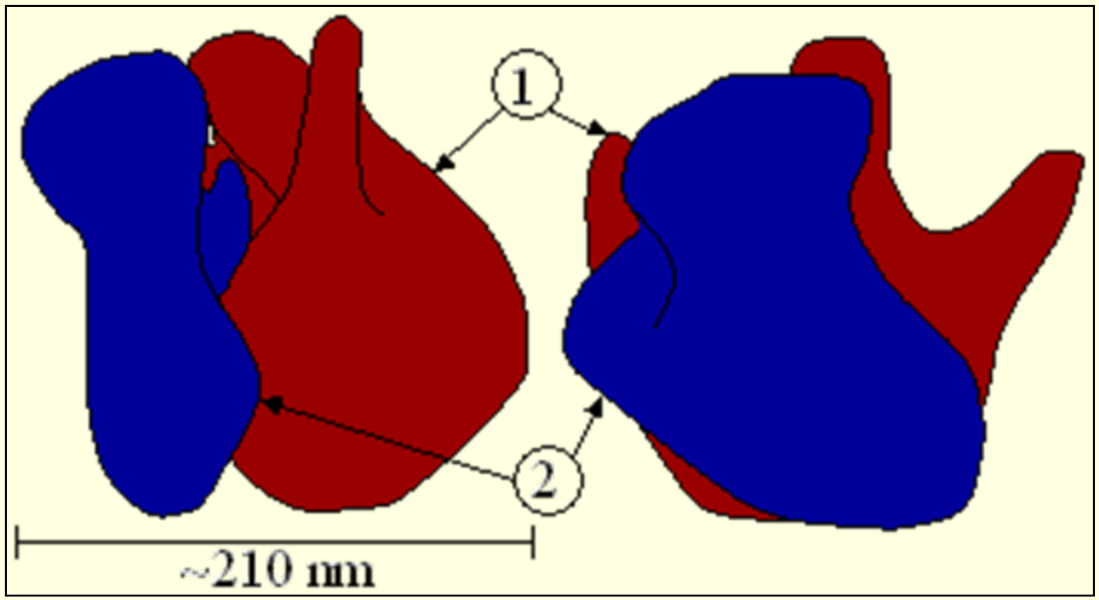
7.4.1 Explain how the structure of tRNA is recognized by a tRNA-activating enzyme that binds a specific amino acid to tRNA, using ATP for energy.

- Each amino acid has a specific tRNA-activating enzyme. The shape of tRNA and CCA at the 3′ end help facilitate the attachment of the amino acid to the tRNA. Degeneracy plays a role here in that some amino acids have more than on tRNA they are associated with.



7.4.2 Outline the structure of ribosomes including protein and RNA composition.

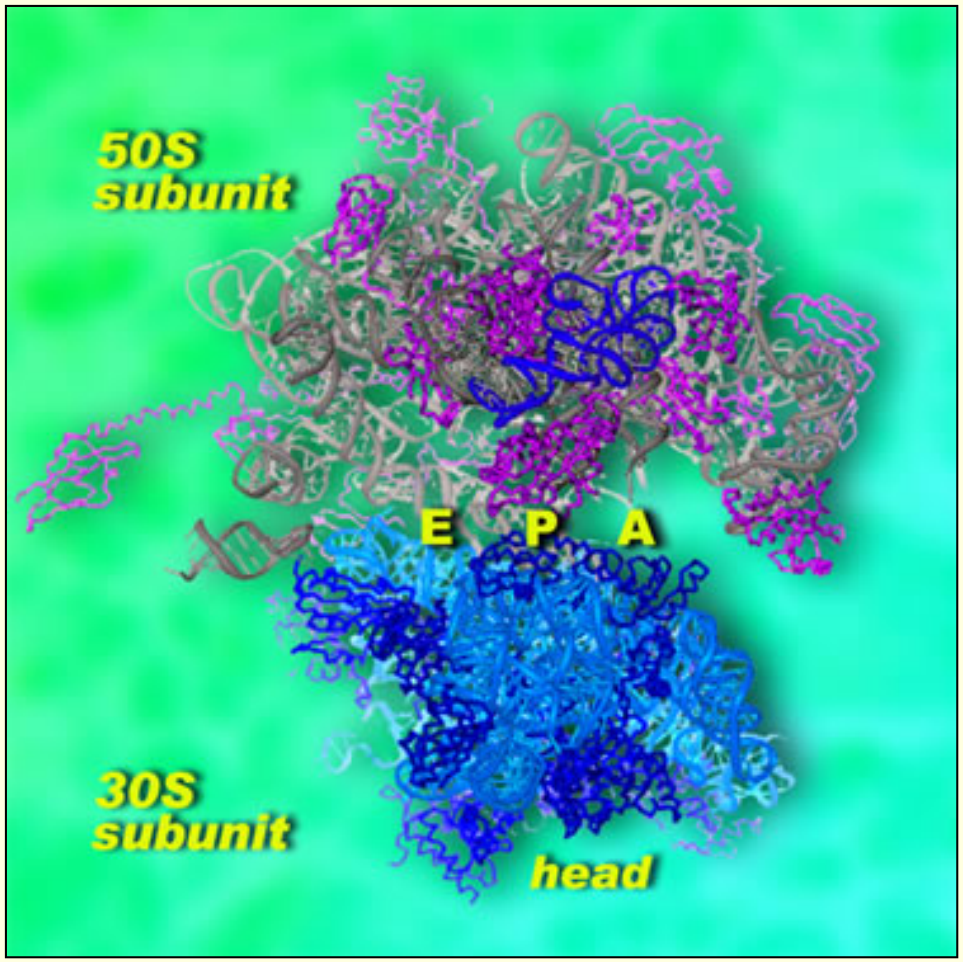
- Large (red) and small (blue) sub units combine to form the ribosomal unit.
- There are two tRNA binding sites, and one mRNA binding site.



Courtesy of Mark Dominus

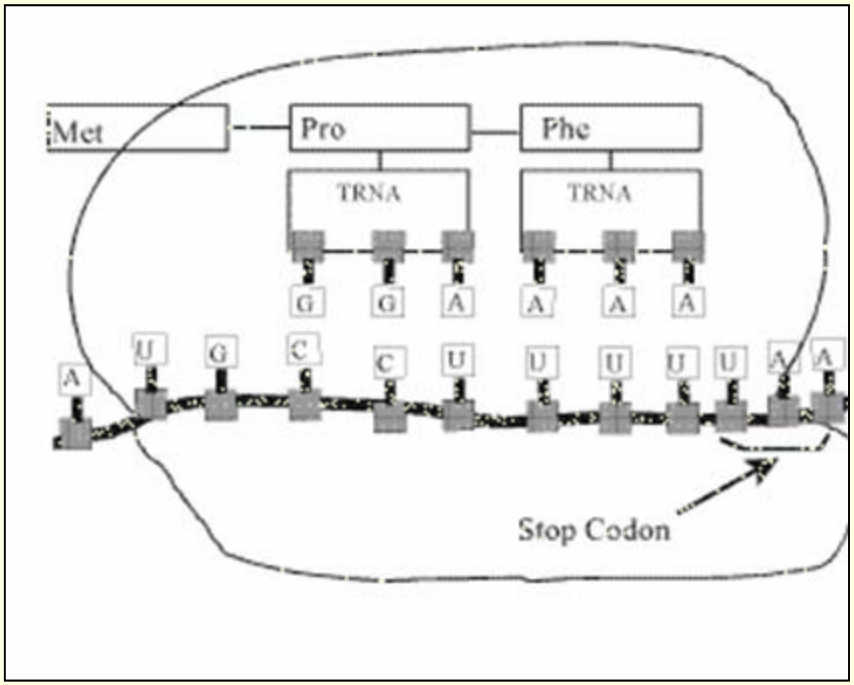
7.4.3 State that translation consists of initiation, elongation, and termination.

- Initiation- polypeptide chain begins.
- Elongation- polypeptide chain is extended.
- Termination- polypeptide chain ends.

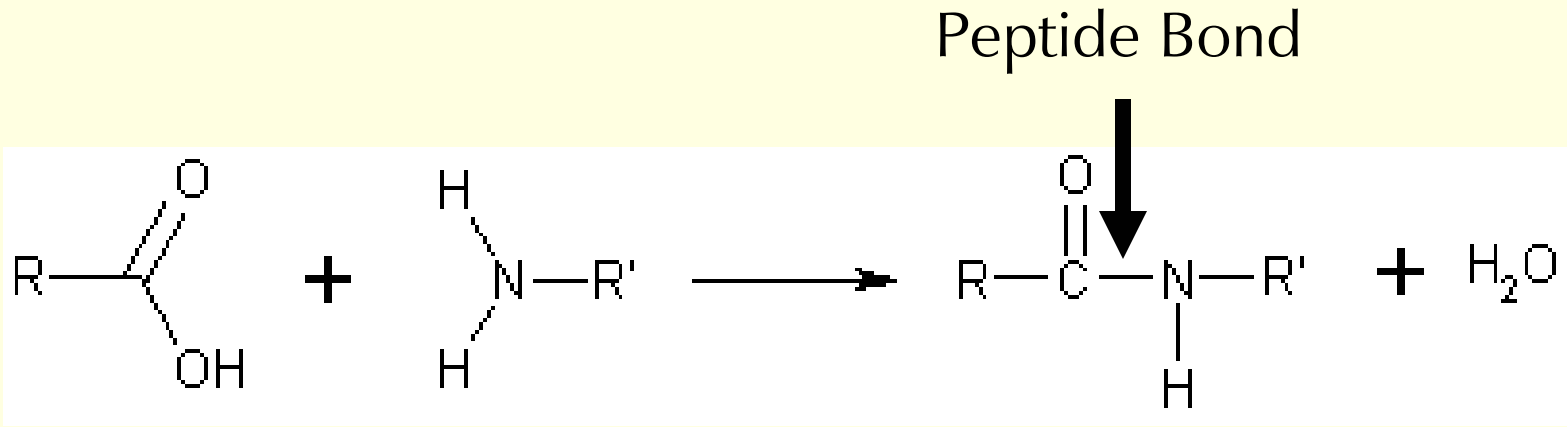


7.4.4 State that translation occurs in a 5′→3′ direction.

- During translation, the ribosome moves along the mRNA towards the 3′ end. The start codon is nearer to the 5′ end than the stop codon.

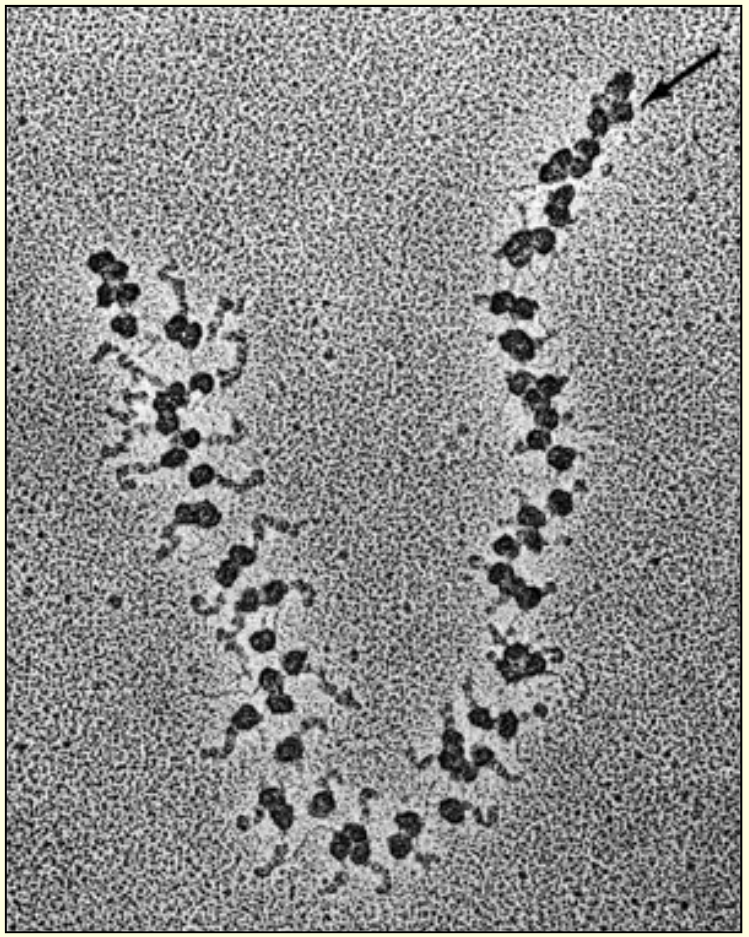


7.4.5 Draw and label a diagram showing the structure of a peptide bond between two amino acids.



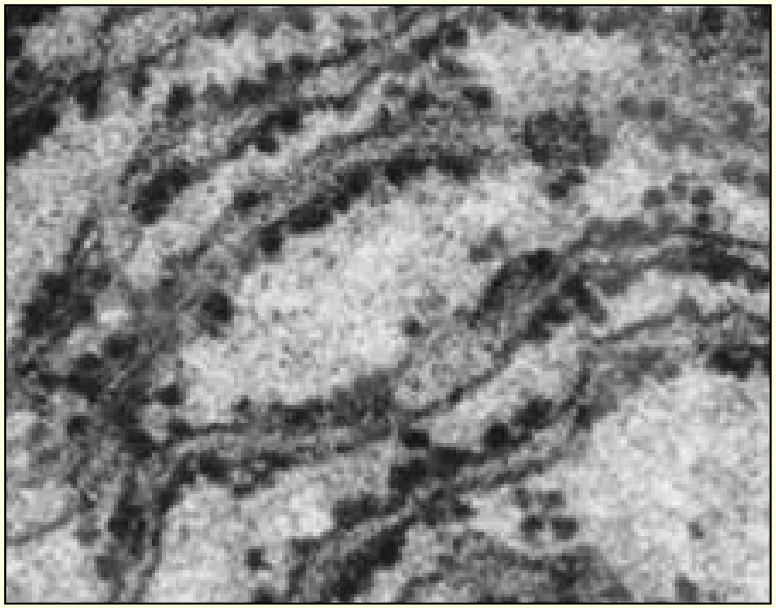
7.4.6 Explain the process of translation including ribosomes, polysomes, and start and stop codons.

- Polysomes- a cluster on ribosomes which synthesize polypeptide chains concurrently from a single mRNA molecule.
- Start codon- sequence that initiates polypeptide formation.
- Stop codon- sequence that stops polypeptide formation.



7.4.7 Differentiate between free ribosomes and bound ribosomes.

- Free ribosomes- synthesize proteins for use primarily within the cell.
- Bound ribosomes- found along the rough endoplasmic reticulum, synthesize proteins primarily for secretion or for lysosomes.



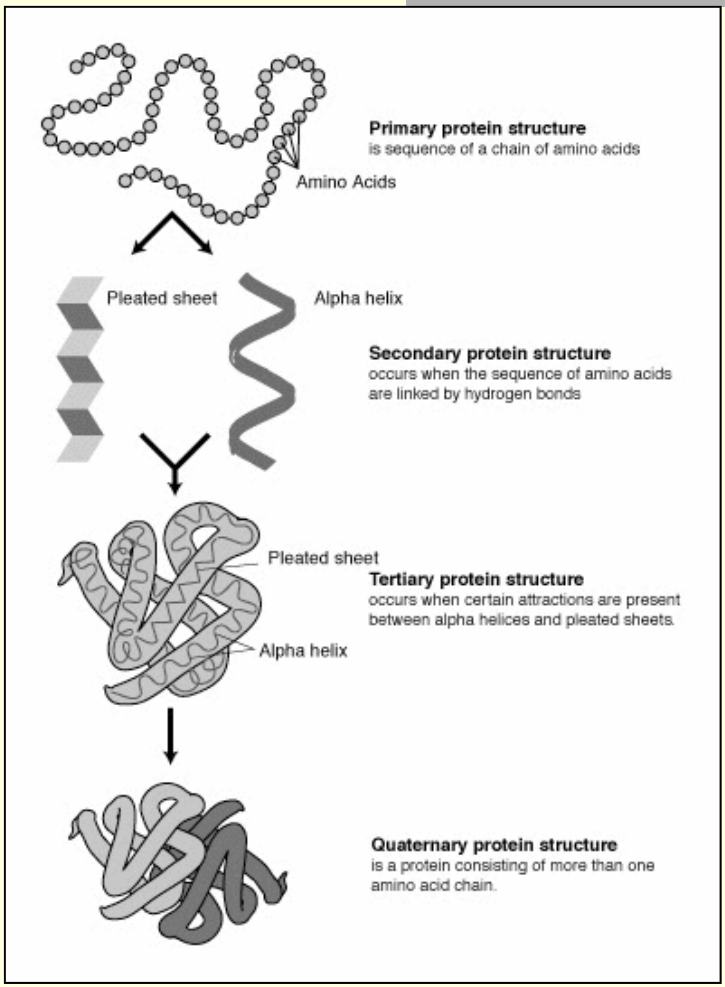
Bound ribosomes

Unit 7: Nucleic Acids and Proteins

Lesson 7.5 Proteins

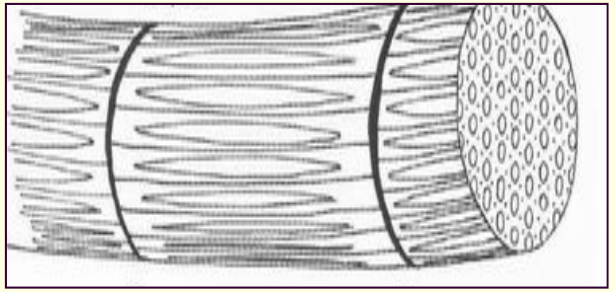
7.5.1 Explain the four levels of protein structure, including each level's significance.

- Primary- order of individual amino acids
- Secondary- helix or pleated sheet, due to hydrogen bonds.
- Tertiary- asymmetrical, cluster-like shape, due to bonding occurrences between R groups.
- Quaternary- combination of two or more individual polypeptide chains.



7.5.2 Outline the difference between fibrous and globular proteins, with reference to two examples of each protein type.

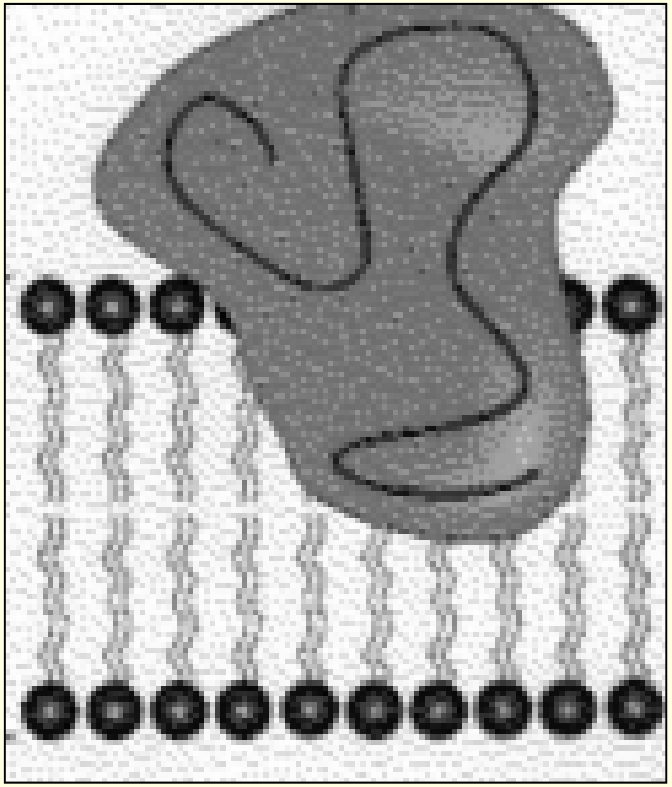
- Fibrous protein- have consistant repeating sequences, which form long pieces of tissue, eg. muscle fiber, collagen.



- Globular protein- asymmetrical, occur as individual units which may contain several polypeptide chains, eg. hormones, enzymes.

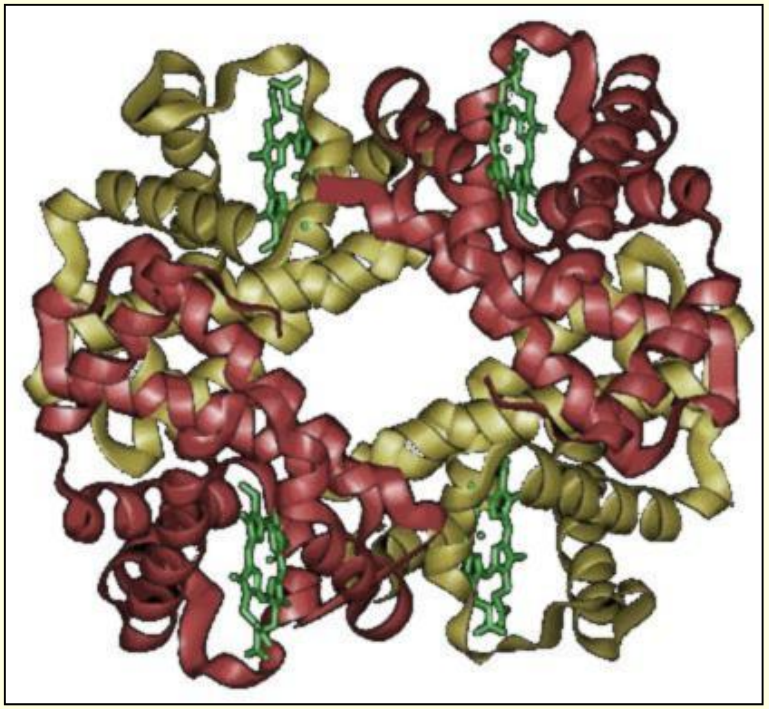
7.5.3 Explain the significance of polar and non-polar amino acids.

- Because the phospholipid bilayer of the plasma membrane has both hydrophilic and hydrophobic components, globular proteins will “line up”, with their hydrophilic and hydrophobic areas matching those of the plasma membrane. This helps position the proteins correctly.



7.5.4 State four functions of proteins, giving a named example of each.

- Enzymes- catalase
- Structural- collagen
- Transport- hemoglobin
- Hormones- insulin



Hemoglobin molecule

Unit 7: Nucleic Acids and Proteins

Lesson 7.6 Enzymes

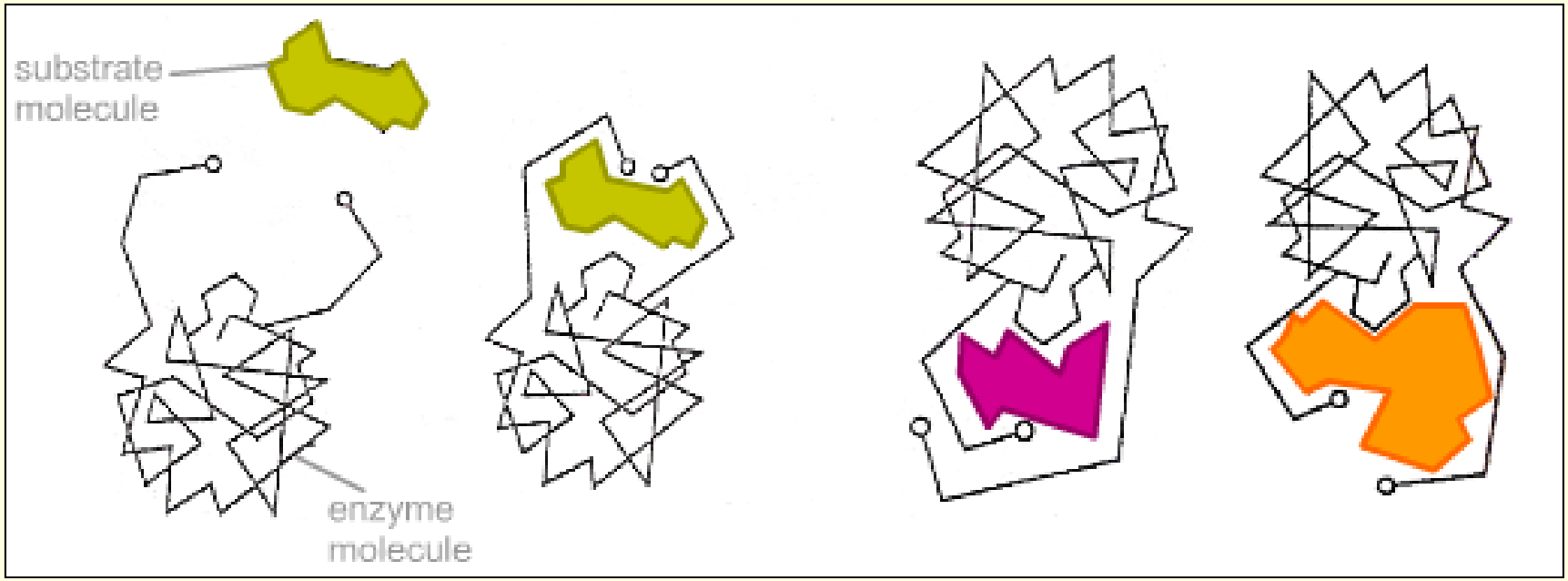
7.6.1 State that metabolic pathways consist of chains and cycles of enzyme catalyzed reactions.

- The products of the first reaction, become the reactants of the second reaction, and so on. Enzymes catalyze each step.

A→B→C→D→E

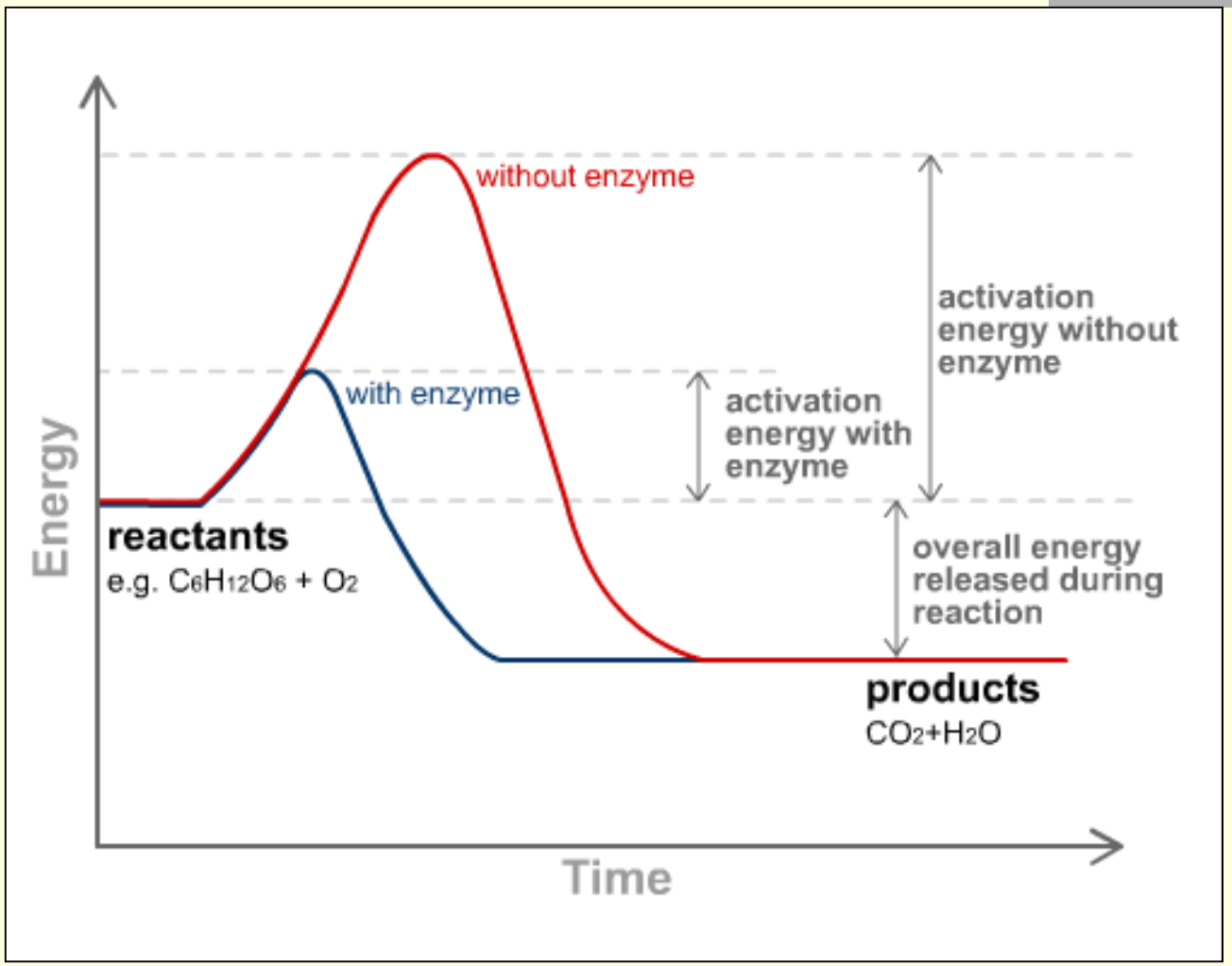
7.6.2 Describe the induced fit model.

- The induced fit model is an extension of the lock and key model. It is important in accounting for the broad specificity of some enzymes.



Courtesy of Jerry Crimson Mann

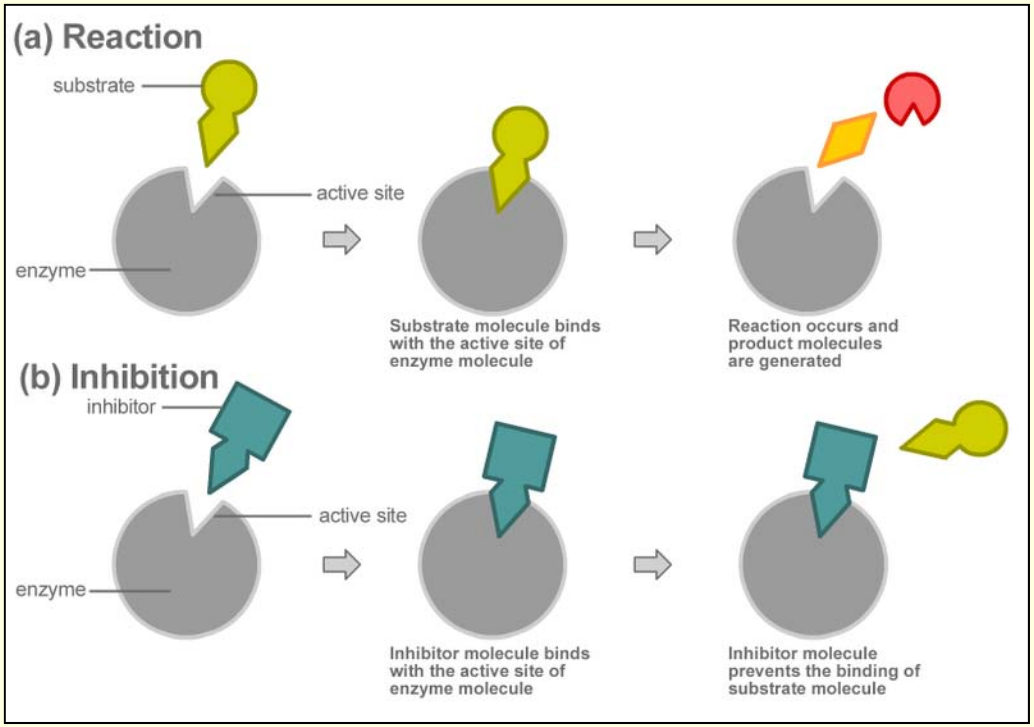
7.6.3 Explain that enzymes lower the activation energy of the chemical reactions that they catalyse.



Courtesy of Jerry Crimson Mann

7.6.4a Explain the difference between competitive and non-competitive inhibition, with reference to one example of each.

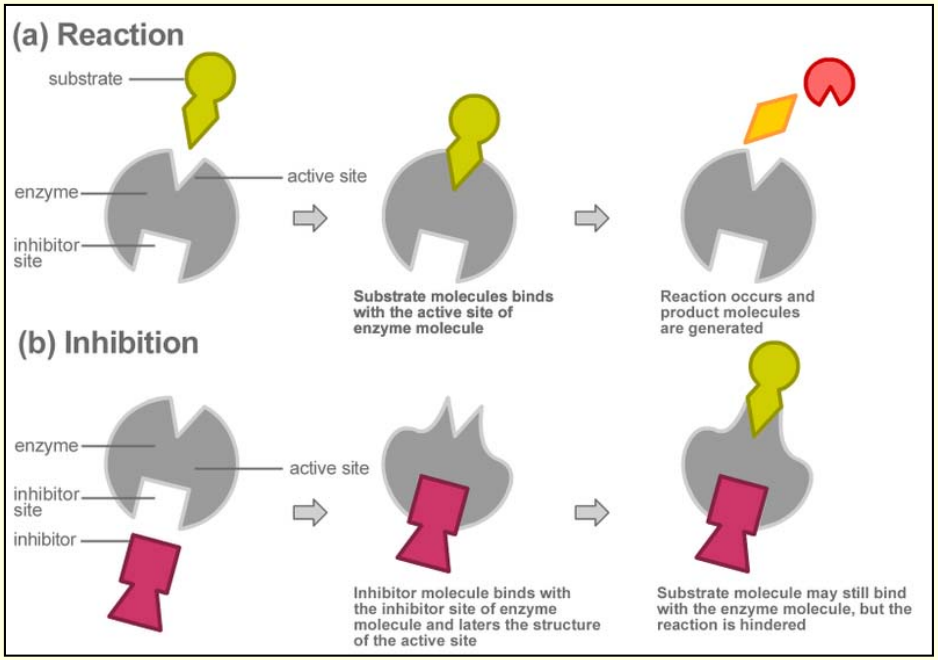
- Competitive inhibition- an inhibiting molecule structurally similar to the substrate molecule binds to the active site, preventing substrate binding. Example- the antibiotic Prontosil in bacteria.



Courtesy of Jerry Crimson Mann

7.6.4b Explain the difference between competitive and non-competitive inhibition, with reference to one example of each.

- Non-competitive inhibition- the inhibiting molecule binds to the enzyme, but not at the active site. This causes a conformational change in the overall enzyme, including its active site, which reduces activity. Example- cyanide binds to proteins in the cytochrome complex, inhibiting cell respiration.



Courtesy of Jerry Crimson Mann

7.6.5 Explain the control of metabolic pathways by end-product inhibition, including the role of allosteric sites.

A→B→C→D→E

- An accumulation of product E goes back and inhibits the conversion of A→, slowing the rate of the whole sequence.

- Allostery is a form of non-competitive inhibition. End products of a metabolic sequence can bind to allosteric sites earlier in the metabolic pathway, regulating the entire chain of events. Example- ATP can inhibit components of glycolysis.

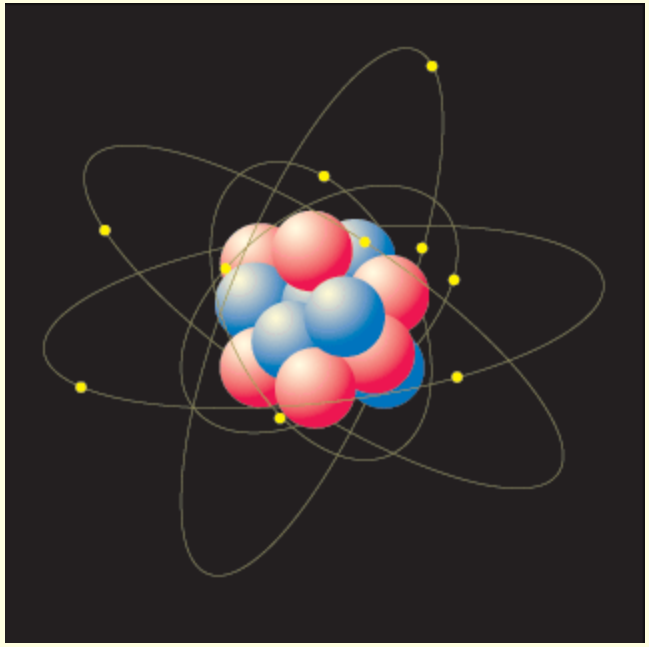
Unit 8: Cell Respiration and Photosynthesis

Lesson 8.1 Cell Respiration

8.1.1 Explain oxidation and reduction.

- Oxidation- involves the loss of electrons from an element. Also frequently involves gaining oxygen or losing hydrogen.

- Reduction- involves a gain in electrons. Also frequently involves losing oxygen or gaining hydrogen.

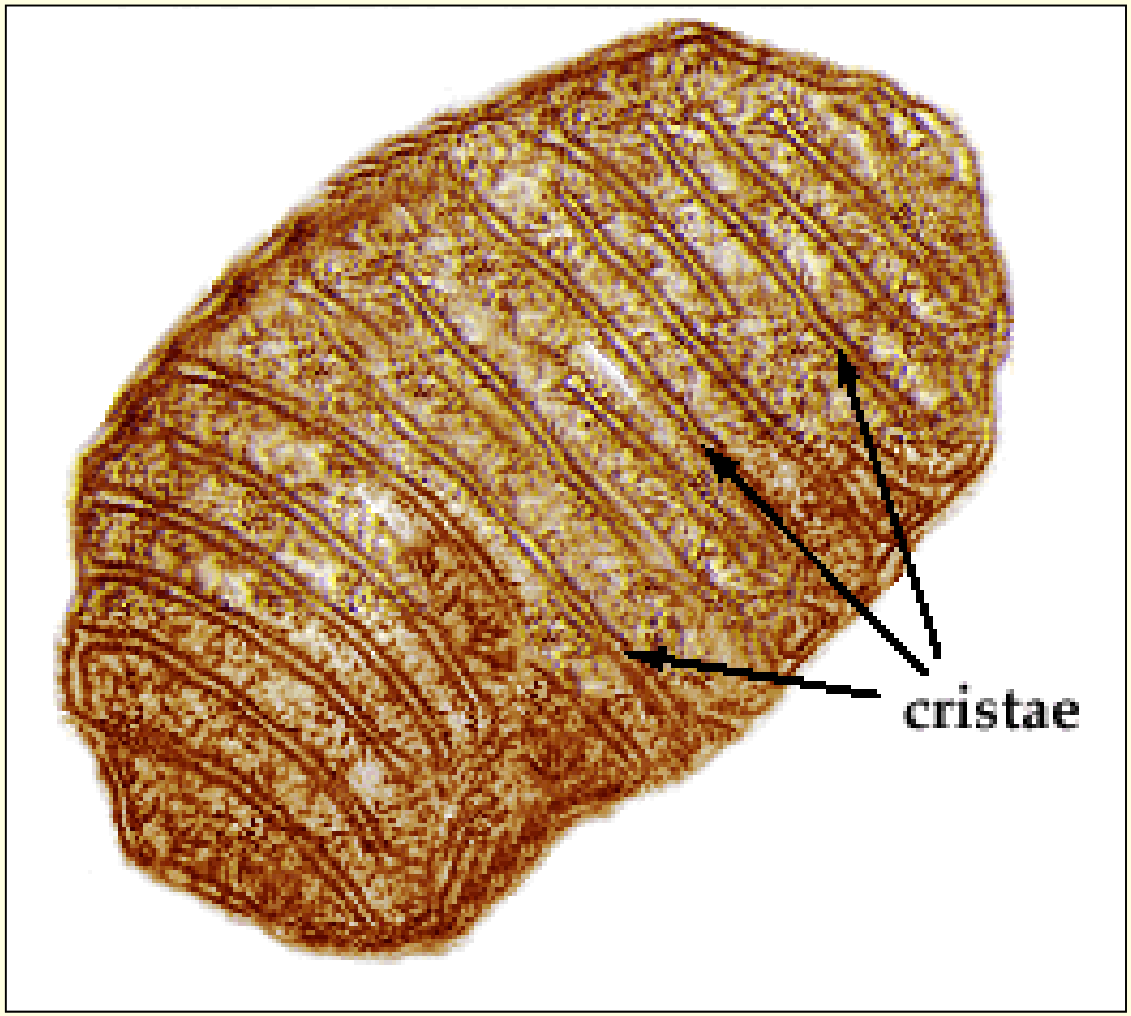


8.1.2 Outline the process of glycolysis including phosphorylation, lysis, oxidation and ATP formation.

- Glycolysis- In the cytoplasm, one hexose sugar is converted (lysis) into two tree-carbon atom compounds (pyruvate) with a net gain of two ATP and two NADH + H^+.
- Phosphorylation- is a process in which ATP is produced from ATP. During glycolysis, this is a substrate leve phosphorylation.

- C_6(molecule) → $2C_3$ (molecules)

8.1.3 Draw and label the structure of a mitochondrion as seen in electron micrographs.



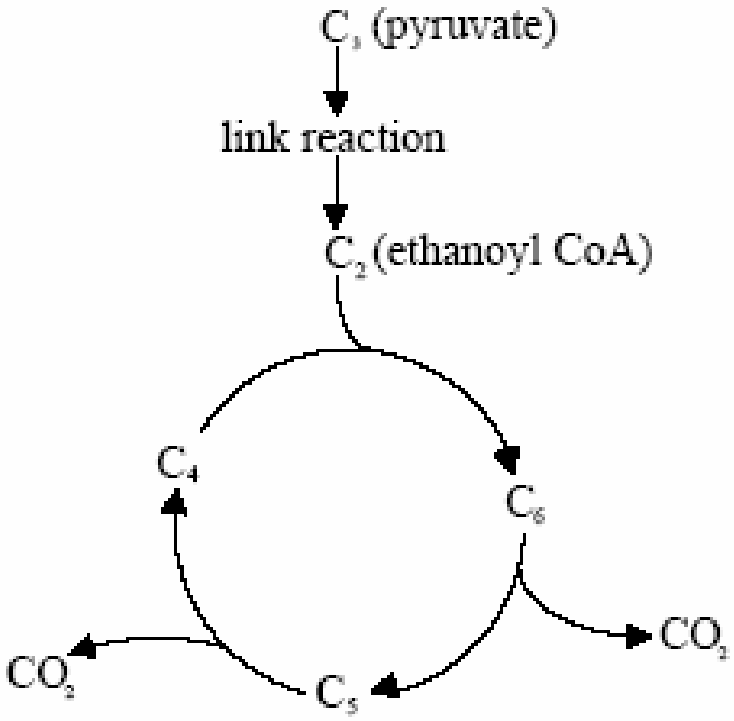
8.1.4a Explain aerobic respiration.

- Oxidative decarboxylation of pyruvate- one carbon is removed from the C_3 molecule (link reaction).
- Krebs Cycle- produces trios phosphate, precurser to glucose.
- NADH + H^+- carrier molecules created during the Krebs cycle.
- Electron Transport Chain- chemiosmotic synthesis of ATP via oxidative phosphorylation
- Role of oxygen- acts as a final electron acceptor for electrons which have gone through the ETC.

8.1.4b Picture of link reaction and Krebs Cycle.

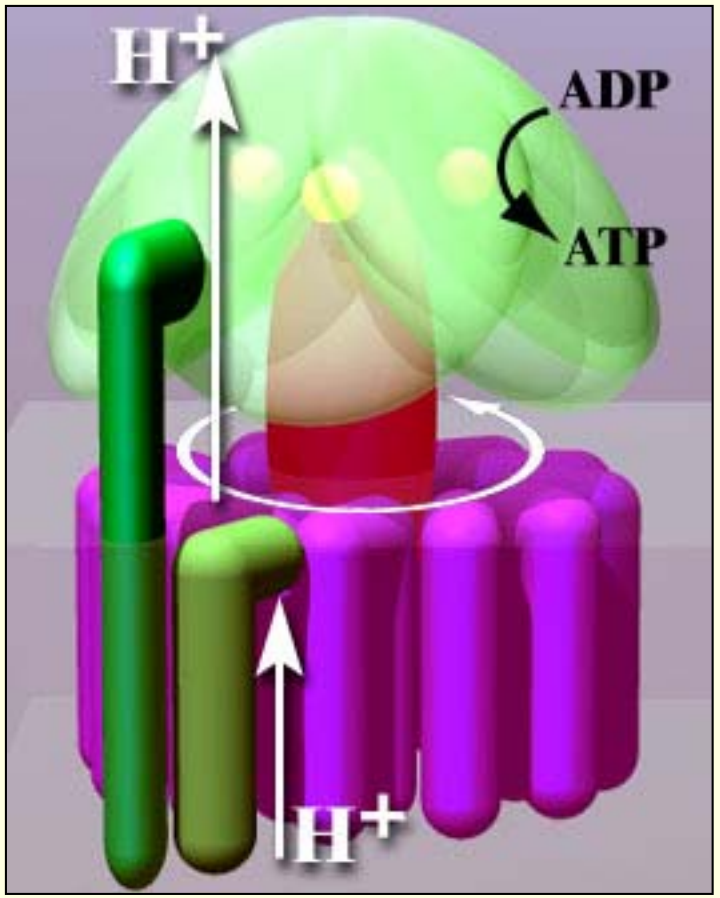
One turn of the Krebs cycle yields:

- 2 CO_2
- 3 x $NADH + H^+$
- 1 x $FADH_2$
- 1 x ATP (by substrate level phosphorylation)



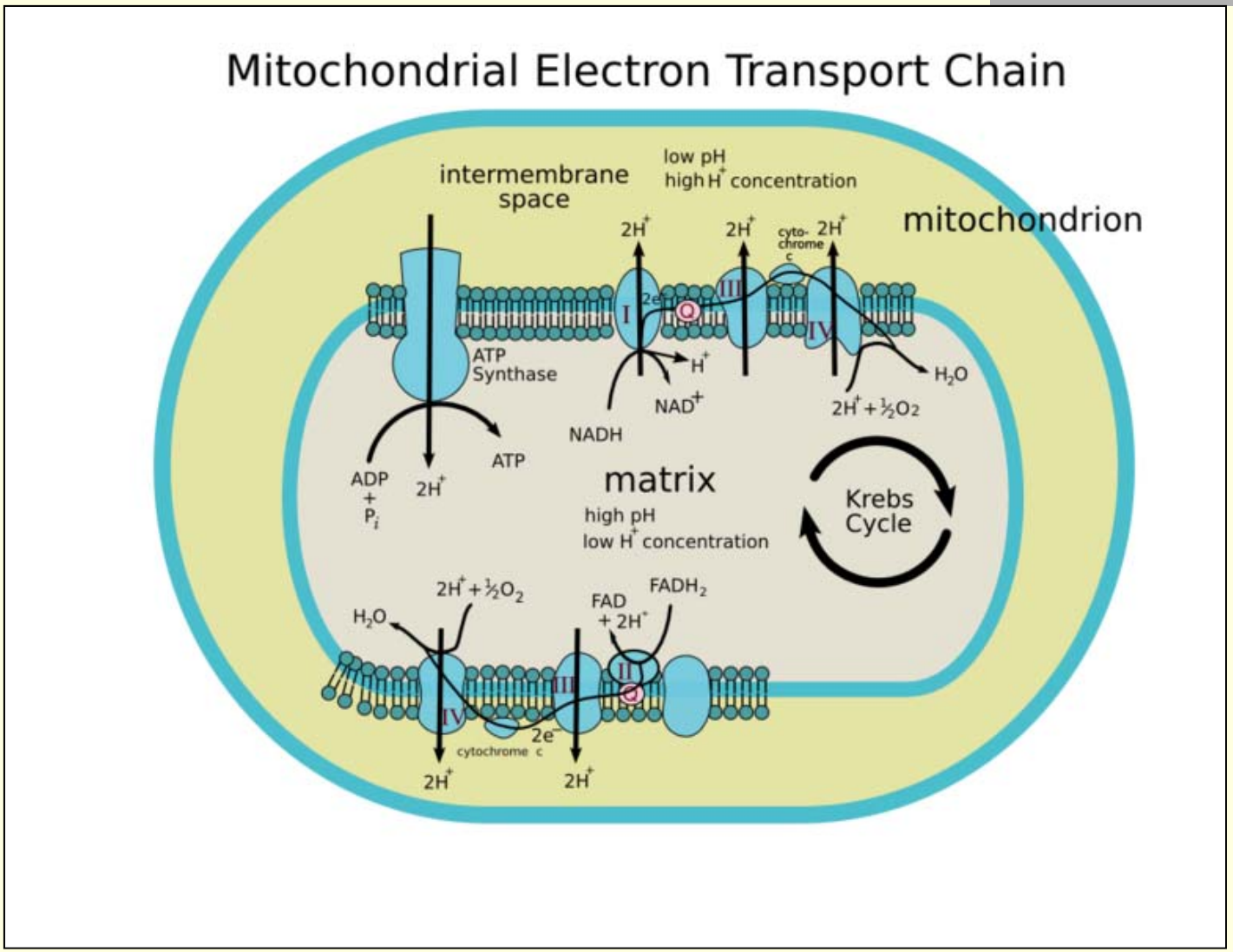
8.1.5a Explain oxidative phosphorylation in terms of chemiosmosis.

- 1) NADH and $FADH_2$ release high energy electrons into the electron transport chain.
- 2) As the electrons move down the cytochrome chain toward oxygen, H^+ ions are propelled against their concentration gradient from the matrix into the intermembrane space.
- 3)H^+ ions flow back to the matrix via gated ATP synthase, which uses energy from the flow to make ATP.



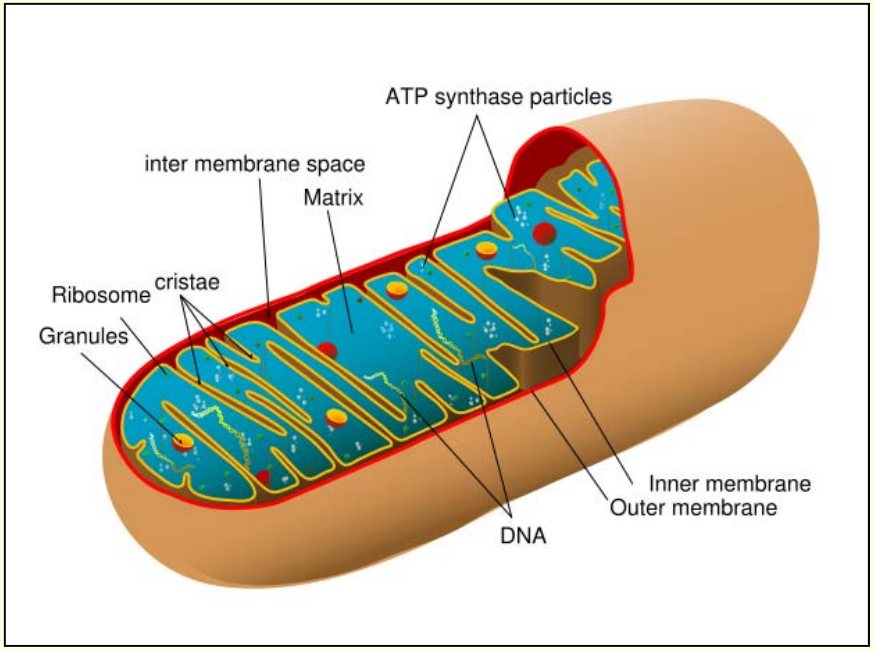
ATP synthase

8.1.5b Picture of electron transport chain.



8.1.6 Explain the relationship between the structure of the mitochondrion and its function.

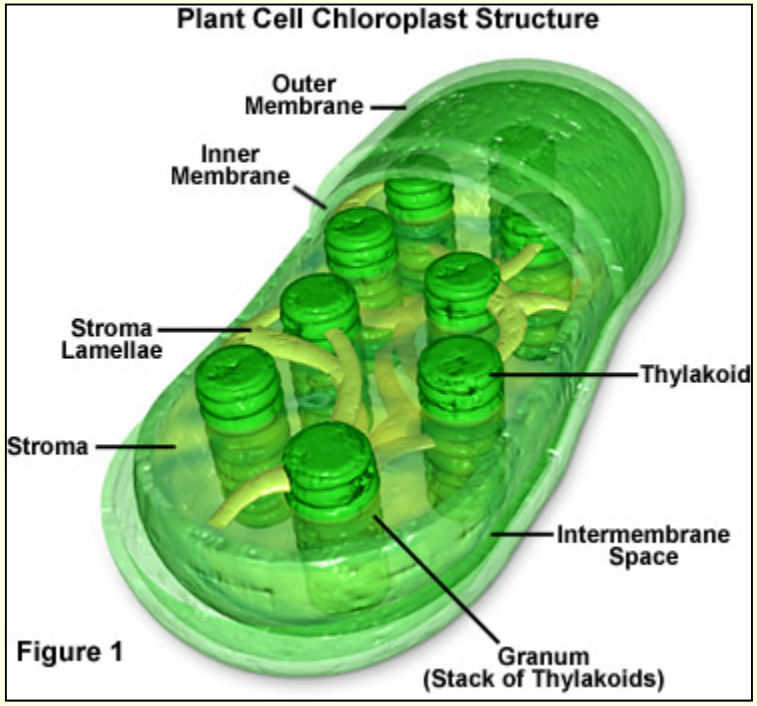
- 1) Cristae form a large surface area fort he electron transport chain.
- 2) The space between the outer and inner membranes is small.
- 3) The fluid contains enzymes of the Krebs cycle.

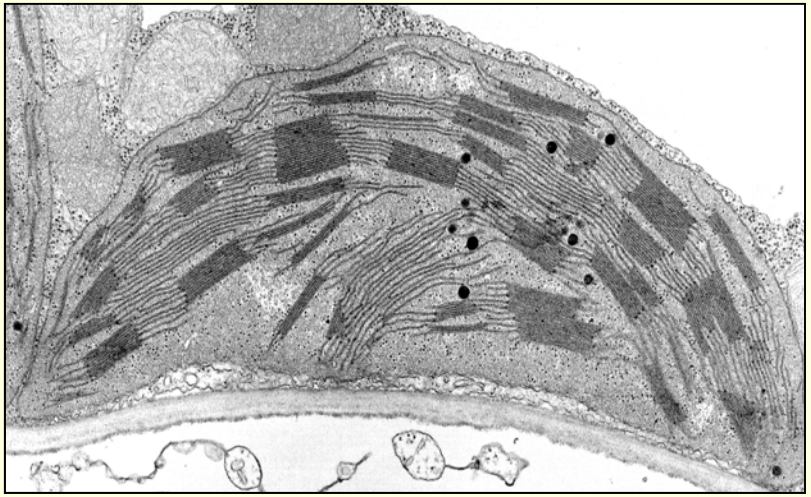


Unit 8: Cell Respiration and Photosynthesis

Lesson 8.2 Photosynthesis

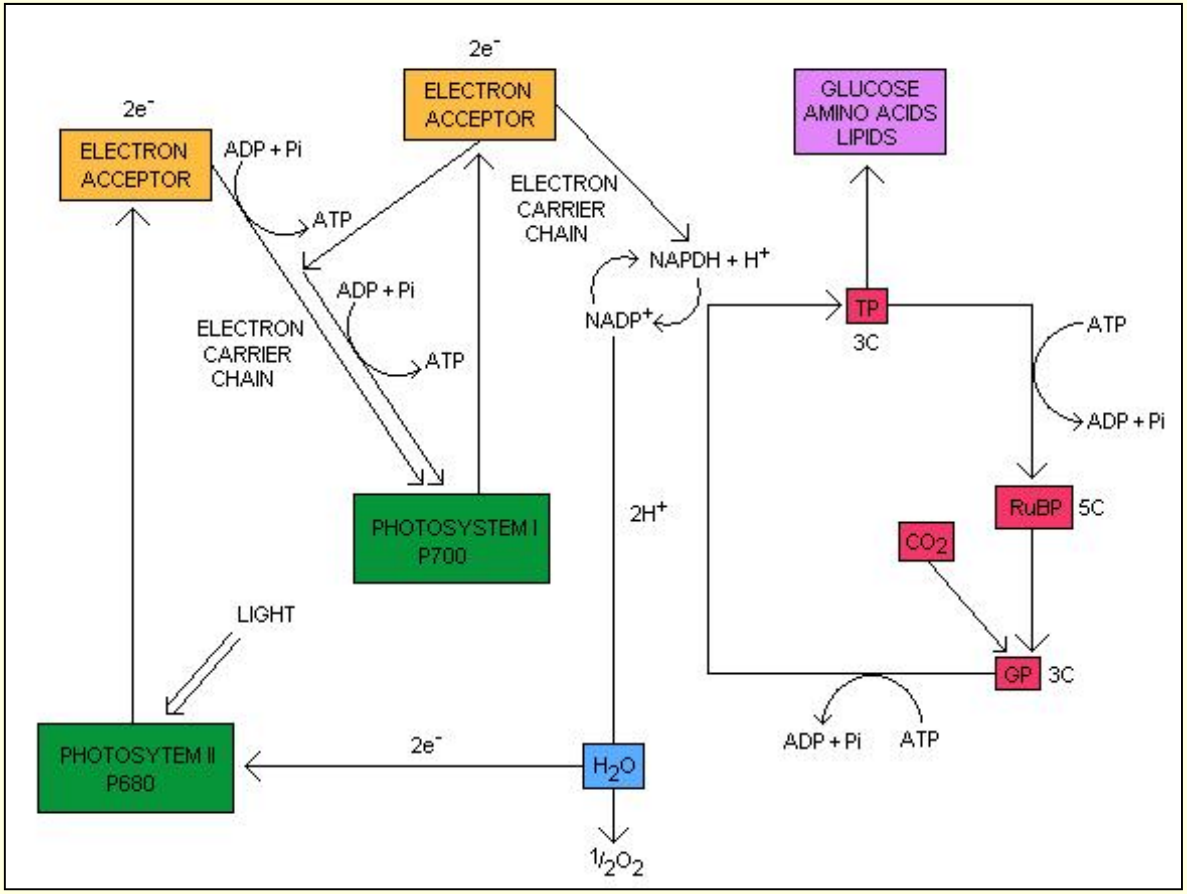
8.2.1 Draw the structure of a chloroplast as seen in electron micrographs.





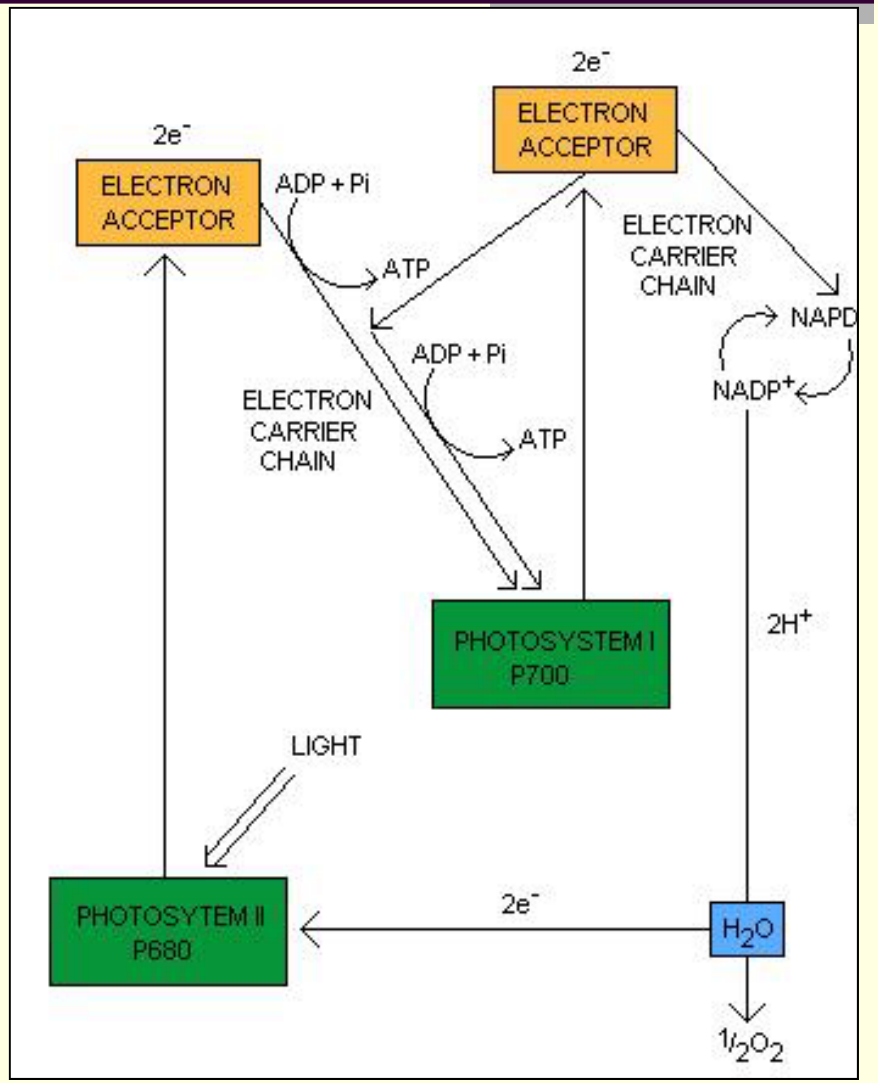
8.2.2 State that photosynthesis consists of light-dependent and light-independent reactions.

- Light dependent reaction (green)
- Light independent reaction (pink)



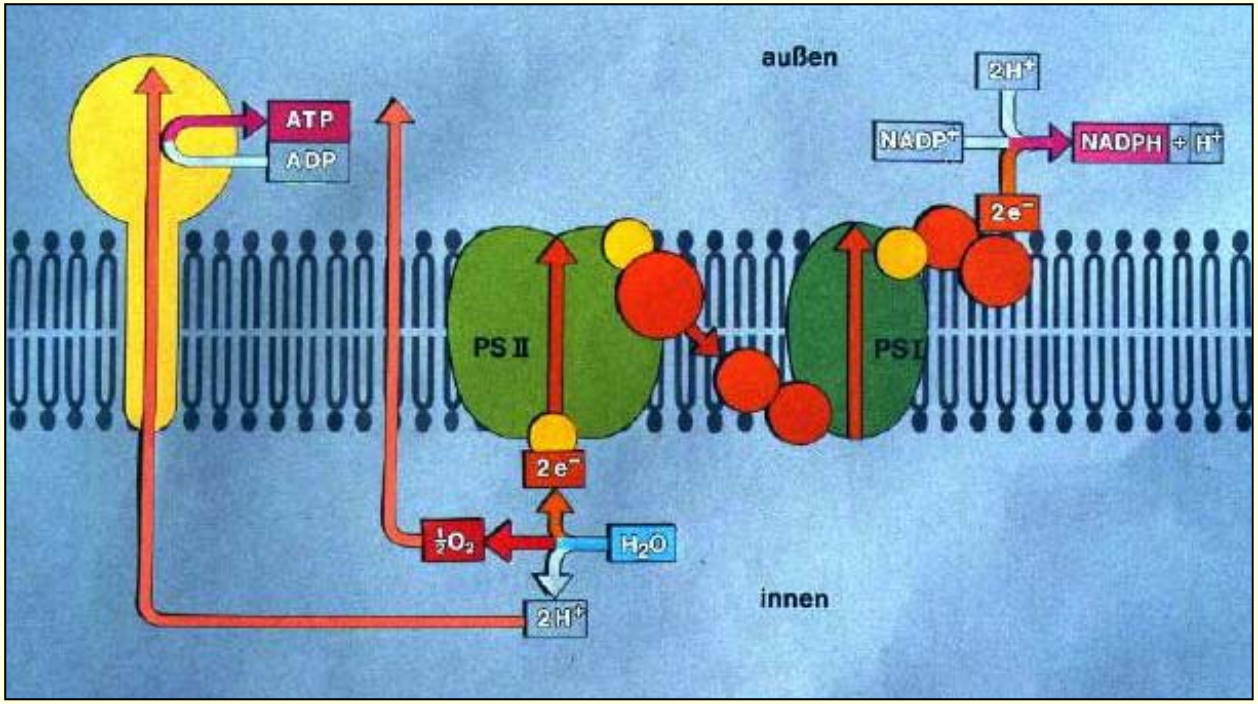
8.2.3 Explain the light-dependent reaction.

- 1) photoactivation of photosystem II
- 2) photolysis of water
- 3) electron transport
- 4) cyclic and non-cyclic phosphoryliation
- 5) photoactivation of photosystem I
- 6) reduction of $NADP^+$



8.2.4 Explain photophosphorylation in terms of chemiosmosis.

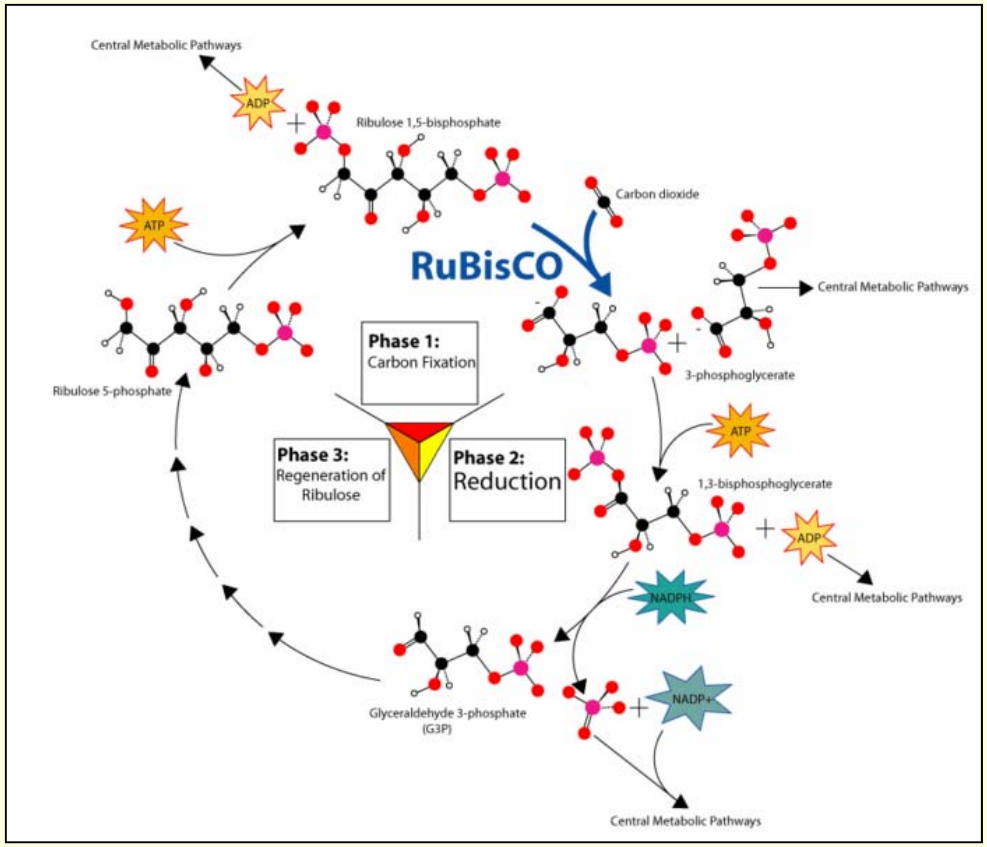
- Electron transport causes the pumping of protons to the inside of the thylakoids. They accumulate (pH drops) and eventually move out to the stroma through ATP synthase. This flow provides energy for ATP synthesis.



Courtesy of The University of Salzburg

8.2.5 Explain the light-independent reactions.

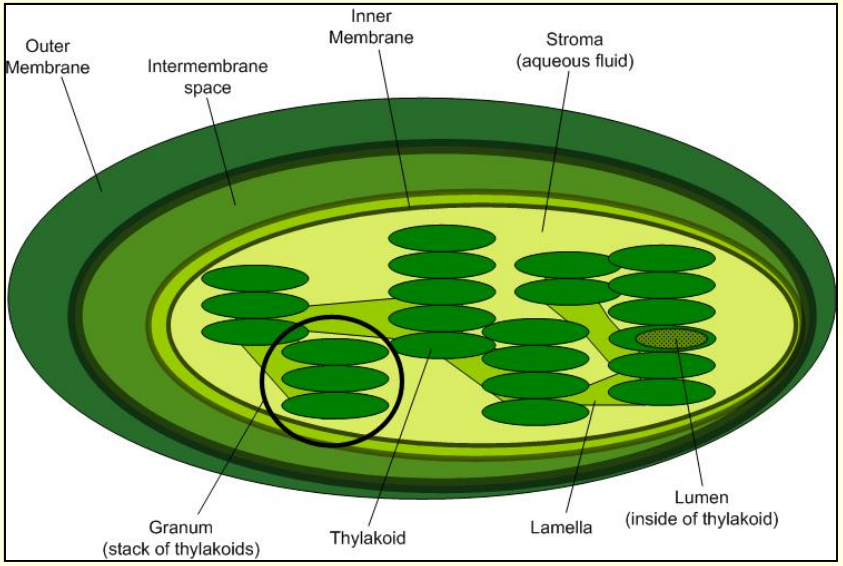
1) Carbon fixation- CO_2 is fixed to RuBP to form glycerate 3- phosphate (GP).
2) Reduction- GP is reduced to trios phosphate (TP).
3) Regeneration- RuBP is regenerated, and able to begin another turn on the cycle (with the help of Rubisco).



Courtesy of Mike Jones

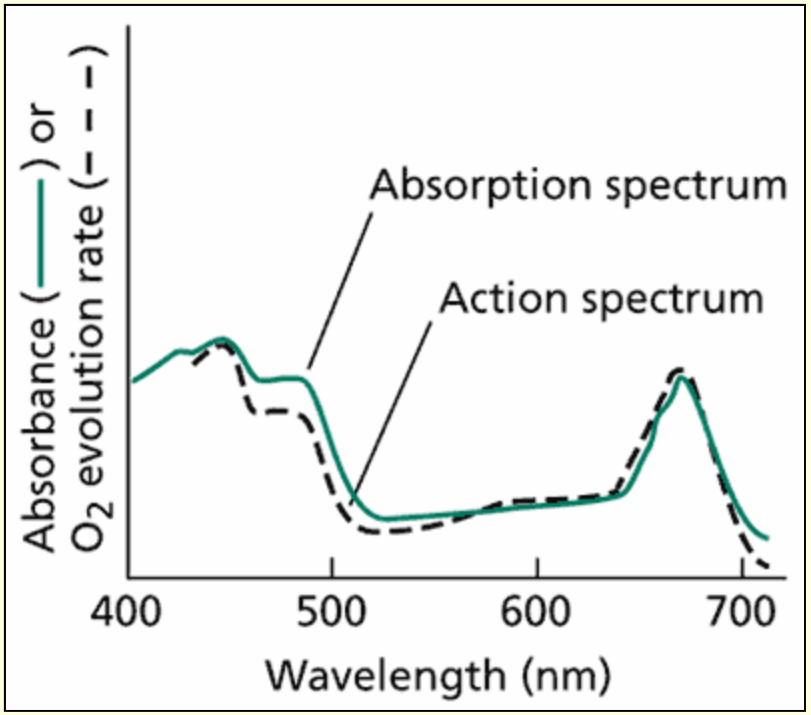
8.2.6 Explain the relationship between the structure of the chloroplast and its function.

- 1) Thylakoids have a large surface area for light absorption.
- 2) The area inside the thylakoid is small, which facilitates the buildup of protons used in chemiosmosis.
- 3) the fluid filled stroma surrounding the thylakoid contains enzymes which facilitate the calvin cycle.



8.2.7 Explain the relationship between the action spectrum and the absorption spectrum of photosynthetic pigments in green plants.

- The absorption spectrum illustrates the efficiency with which certain wavelengths of color are absorbed by pigments.
- The action spectrum is a measure of overall photochemical activity.



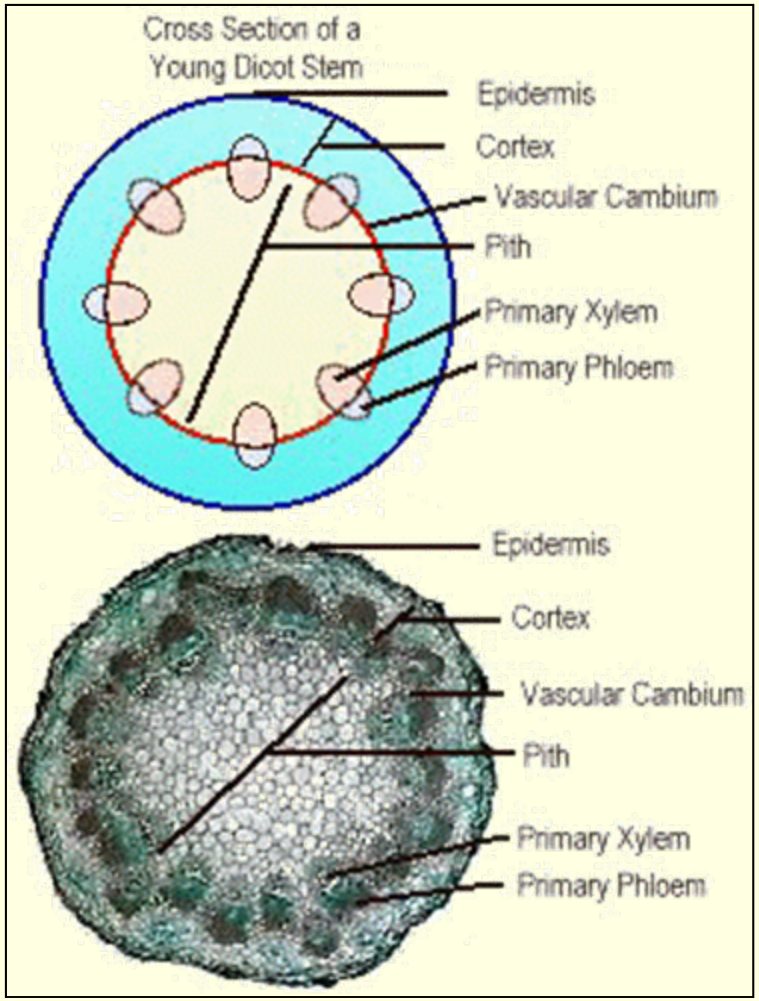
8.2.8 Explain the concept of limiting factors in photosynthesis.

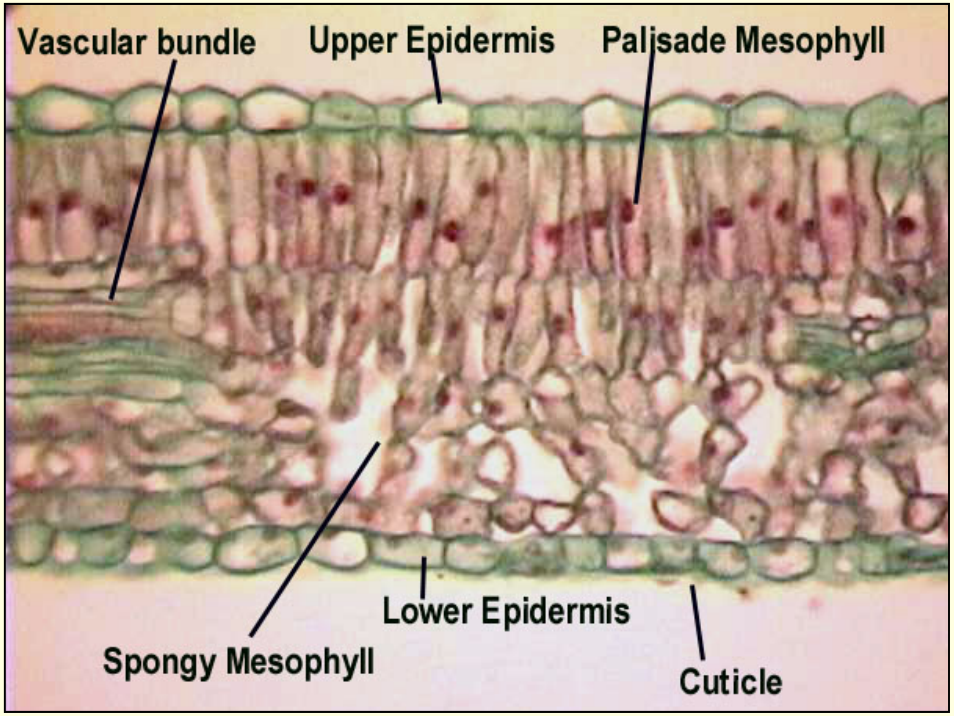
- Light intensity- as light intensity increases, photosynthetic rate increases, until a maximum efficiency is reached.
- Temperature- each plant species has an optimum temperature range at which photosynthesis operates. To deviate in either direction reduces photosynthetic rate.
- Concentration of CO_2- as concentration of CO_2 increases, photosynthetic rate increases, until a maximum efficiency is reached.

Unit 9: Plant Science

Lesson 9.1 Plant Structure and Growth

9.1.1 Draw and label plant diagrams to show the distribution of tissues in the stem and leaf of a dicotyledonous plant.





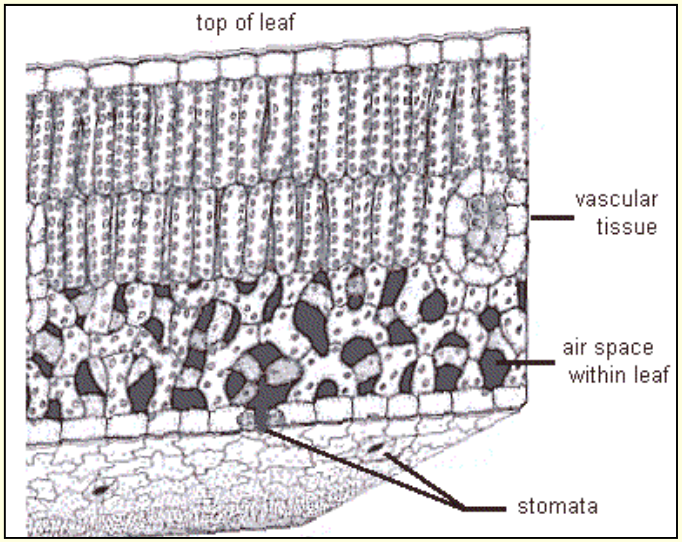
9.1.2 Outline three differences between the structures of dicotyledonous and monocotyledonous plants.

- Dicot
- Flowers in groups of four or five
- Seeds have two cotyledons
- Leaves have reticulate venation

- Monocot
- Flowers in groups of three
- Seeds have one cotyledon
- Leaves have parallel venation

9.1.3 Explain the relationship between the distribution of tissues in the leaf and the functions of these tissues.

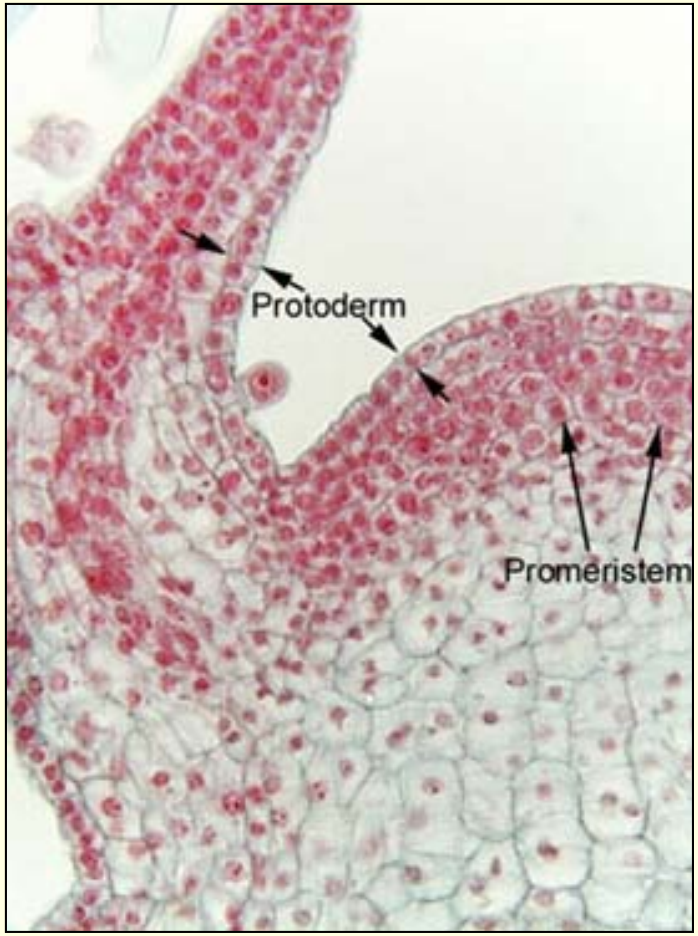
- Absorption of light- palisade mesophyll at top of leaf.
- Gas exchange- spongy mesophyll in lower portion of leaf near stomata.
- Support- dense, structural tissue.
- Water conservation- regulated by stomata.
- Transport of water- through the xylem.
- Products of photosynthesis- transported through the phloem.



9.1.4 Identify modifications of roots, stems and leaves for different functions.

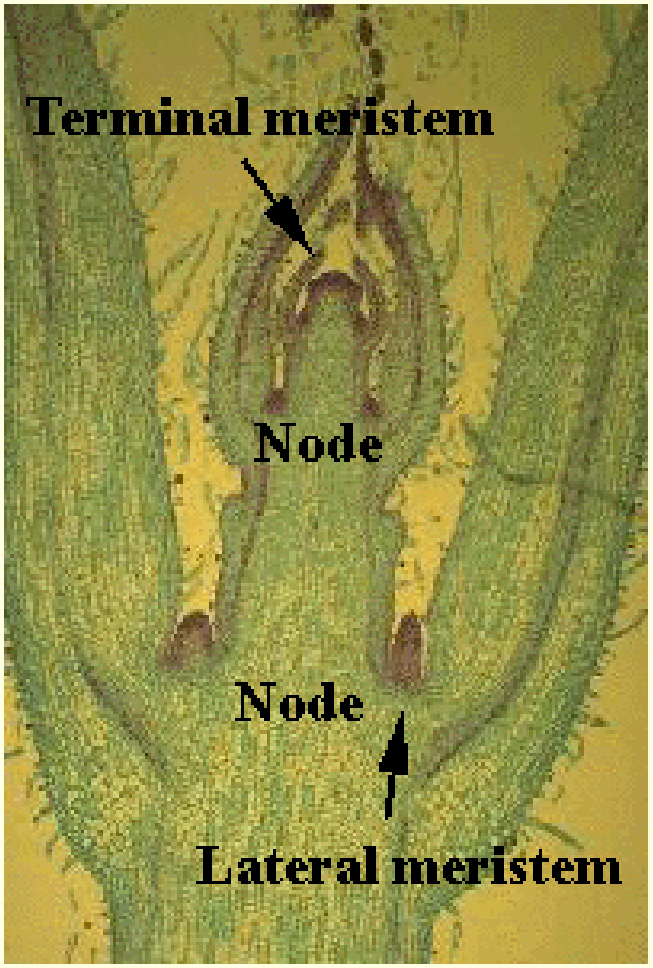
- Bulb- modified leaf used for food storage.
- Stem tuber- thickened rhizome or stolon used to store nutrients.
- Storage root- modified root used for food storage.
- Tendril- modified stem, leaf or petiole used by climbing plants for support and attachment.

9.1.5 State that dicotyledonous plants have apical and lateral meristems.



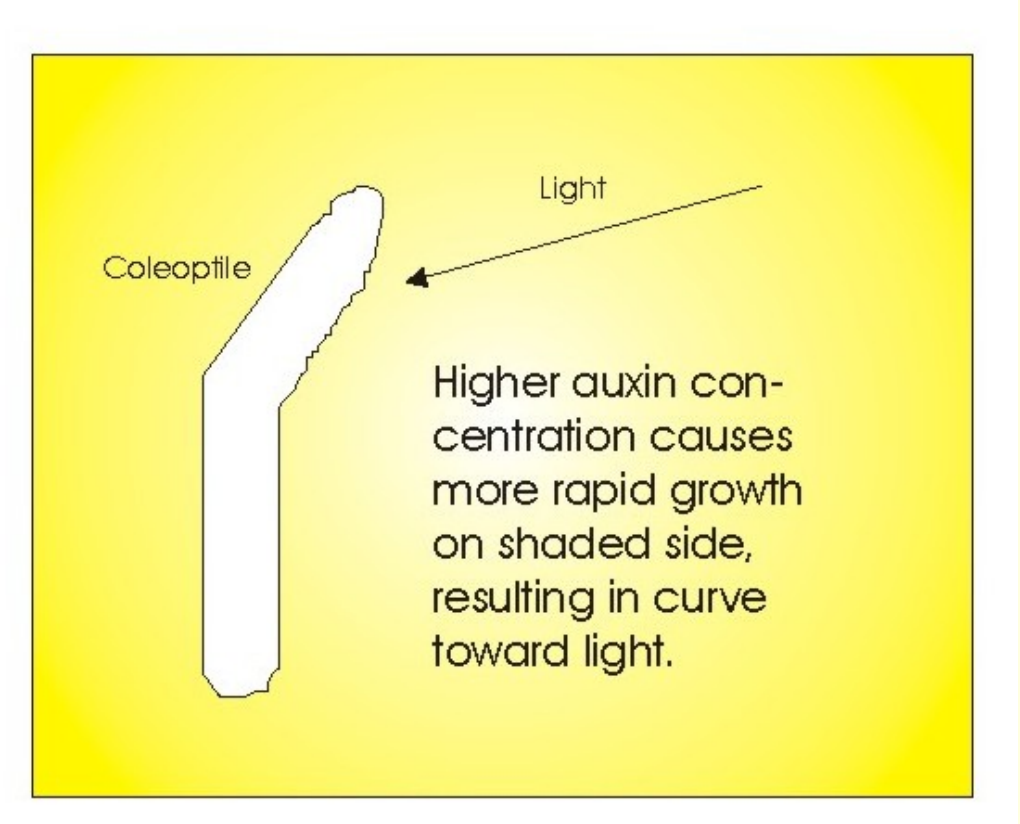
9.1.6 Compare the growth due to apical and lateral meristems in dicotyledonous plants.

- Meristematic tissue generates new cells for growth of the plant.
- Apical (terminal) meristems are found in roots and shoots, and facilitate vertical growth.
- Lateral meristems facilitate horizontal growth,



9.1.7 Explain the role of auxin in phototropism as an example of the control of plant growth.

- Auxin is a plant hormone which elongates cells. When a plant is exposed to a light source, the auxin migrates away from the source. In this way, the side of the plant farther from the light elongates, bending the plant toward the light source.



Unit 9: Plant Science

Lesson 9.2 Transport in Angiospermophytes

9.2.1 Explain how the root system provides a large surface area for mineral ion and water uptake.

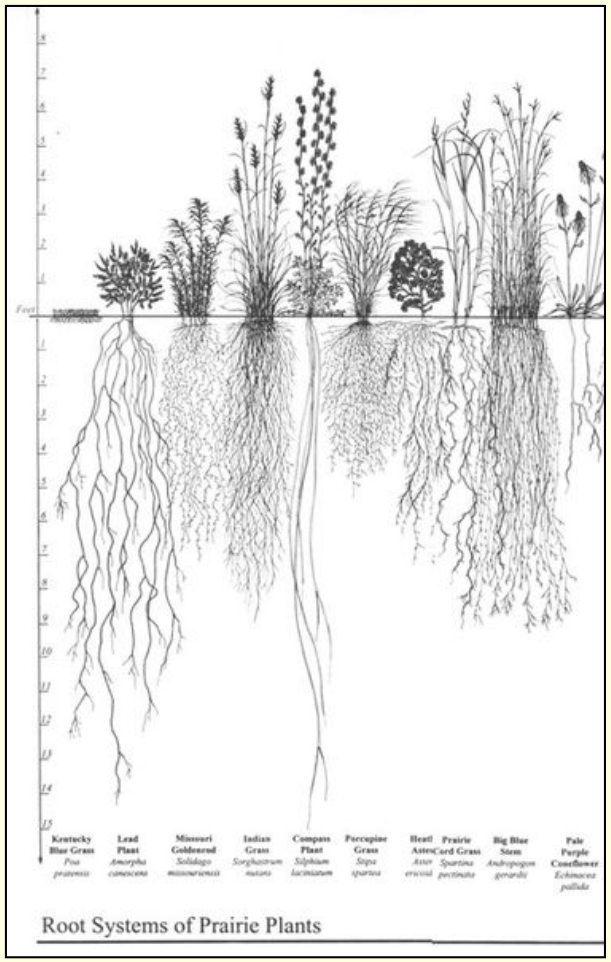
- Branching- increases overall surface area
- Root hairs- increases surface area of individual roots
- Cortex cell walls- facilitates absorption.

Root hairs.

Yucca plant roots.

9.2.2 List ways in which mineral ions in the soil move to the root.

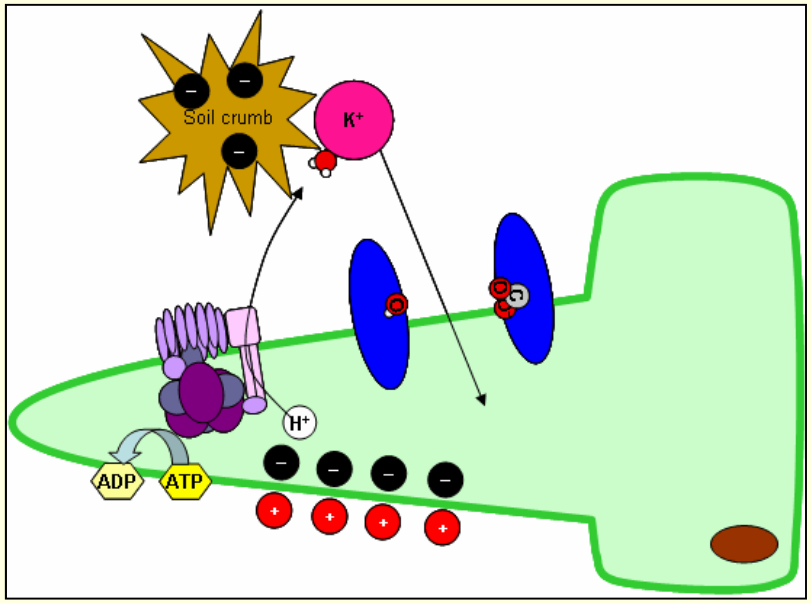
- 1) Diffusion of mineral ions.
- 2) Fungal hyphae (in a mutualistic relationship)
- 3) Mass flow of water in the soil carrying ions.



Root Systems of Prairie Plants

9.2.3 Explain the process of mineral ion absorption from soil into roots by active transport.

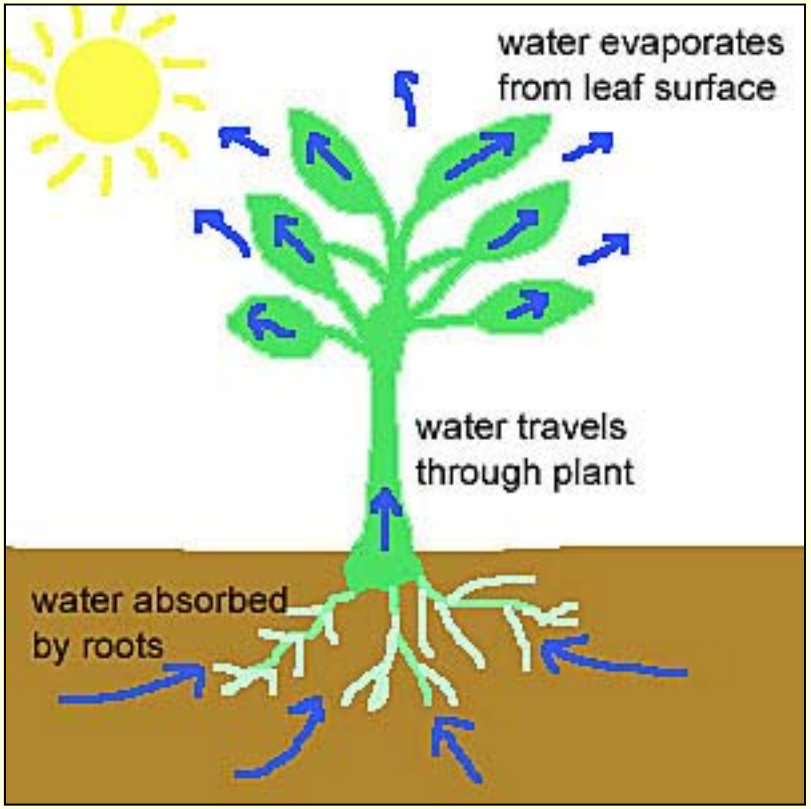
- Integral proteins transport minerals from the soil into roots through active transport. One the minerals have crossed over into the plants, they attract water through a concentration gradient.



9.2.4 State that terrestrial plants support themselves by means of thickened cellulose, cell turgor and xylem.

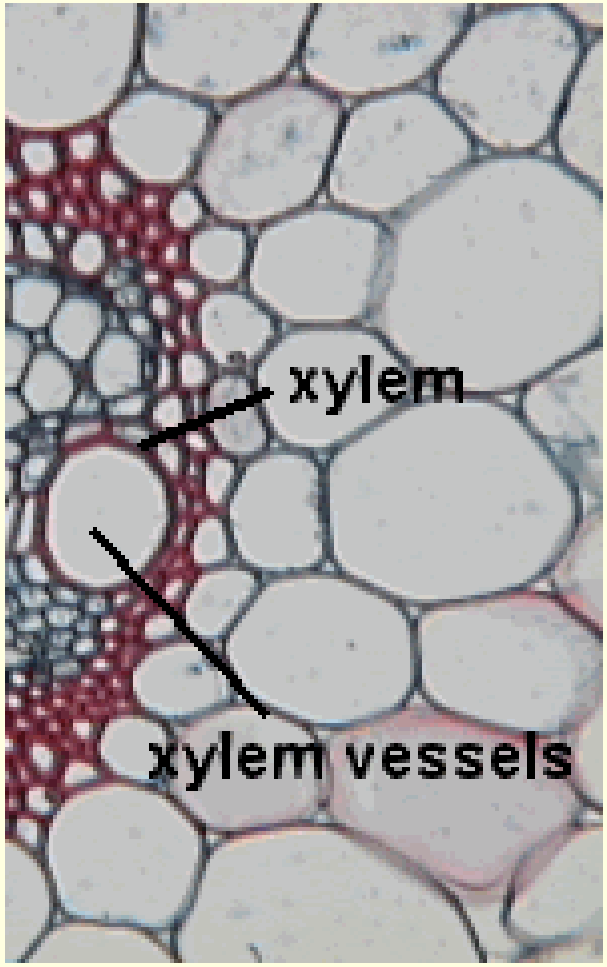
9.2.5 Define *transpiration*.

- Transpiration- the loss of water vapor from leaves and stems of plants.

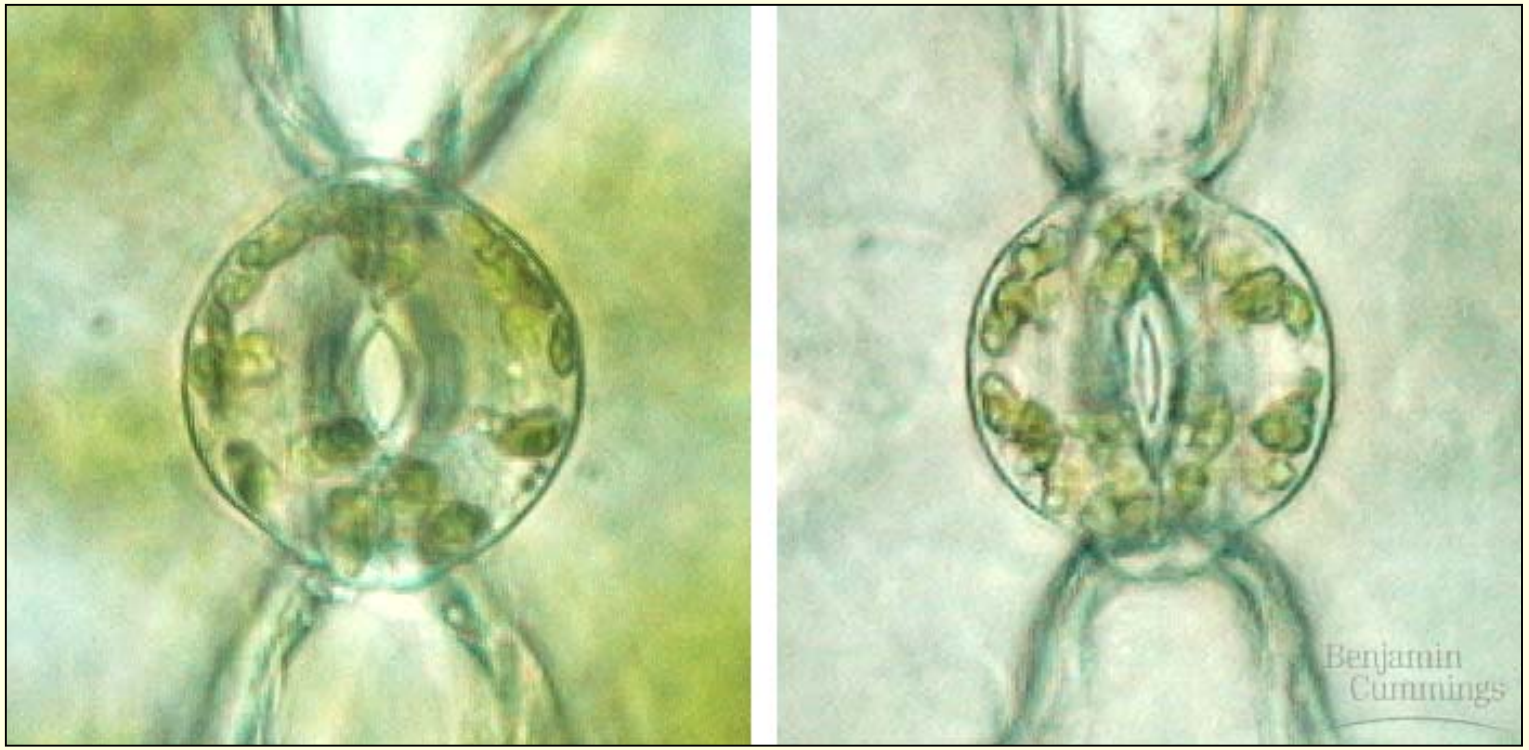


9.2.6 Explain how water is carried by the transpiration stream.

- Xylem vessel structure- dead, empty cells with no cytoplasm.
- Transpiration pull- a vacuum is created by the evaporation of water from the stomata of the leaves. The water column moves up to fill the vacuum.
- Cohesion- the hydrogen bonding in water causes it to 'stick' to itself.
- Evaporation- works with transpiration as described above.



9.2.7 State that guard cells can open and close stomata to regulate transpiration.



9.2.8 State that the plant hormone abscisic acid causes the closing of stomata.

9.2.9 Explain how the abiotic factors, light, temperature wind and humidity affect the rate of transpiration in a typical terrestrial mesophytic plant.

Direct relationship:

↑light = ↑rate

↑temperature = ↑rate

↑wind = ↑rate

Inverse relationship:

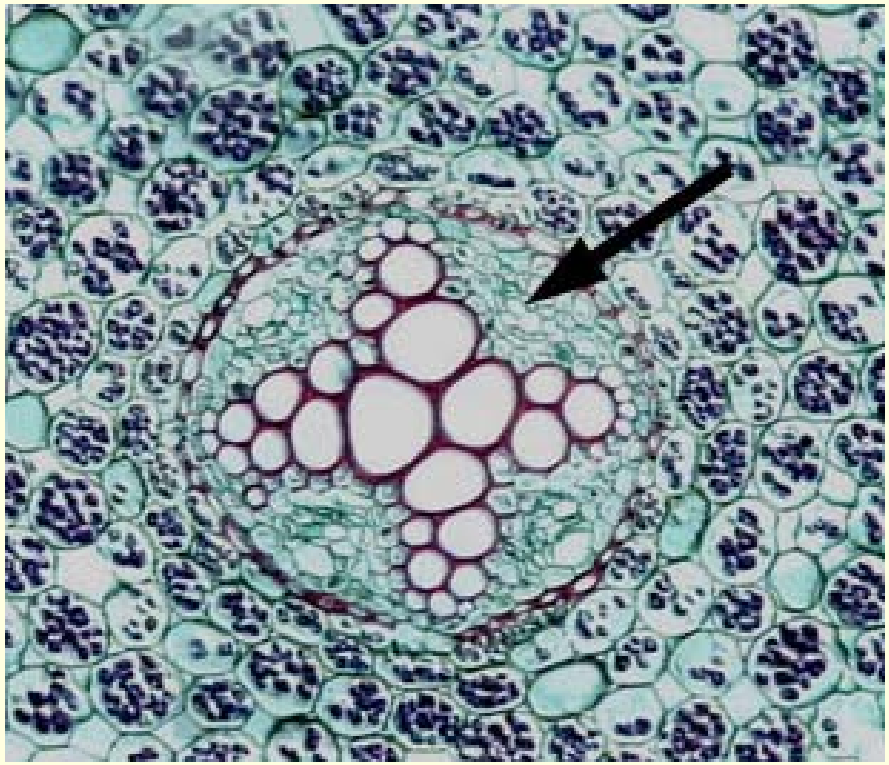
↑humidity = ↓rate

9.2.10 Outline four adaptations of xerophytes that help to reduce transpiration.

- Reduced leaves and spines
- Deep roots
- Thickened, waxy cuticles
- Reduced number of stomata

9.2.11 Outline the role of phloem in active translocation of sugar and amino acids.

- The phloem transports the products of photosynthesis, primarily sugar. Movement is from source (leaves) to sink (fruits, seeds, roots).

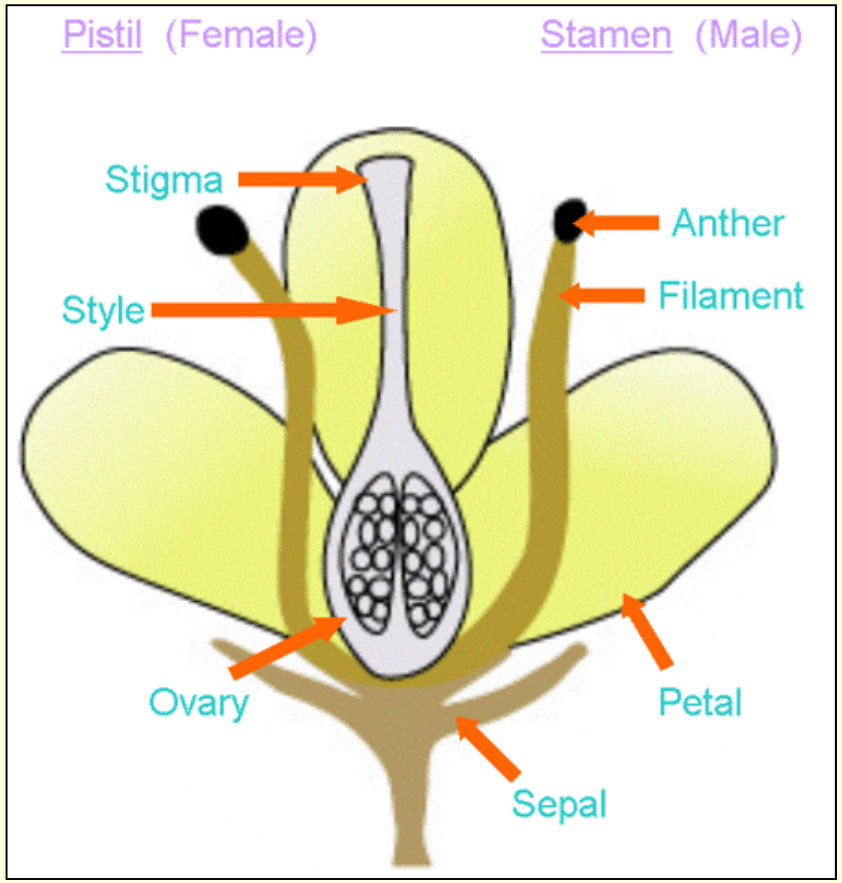


Unit 9: Plant Science

Lesson 9.3 Reproduction in Flowering Plants

9.3.1 Draw and label a structure of a dicotyledonous animal-pollinated flower.

- Identify: sepal, petal, anther, filament, stigma, style, ovary.



9.3.2 Distinguish between *pollination*, *fertilization* and *seed dispersal*.

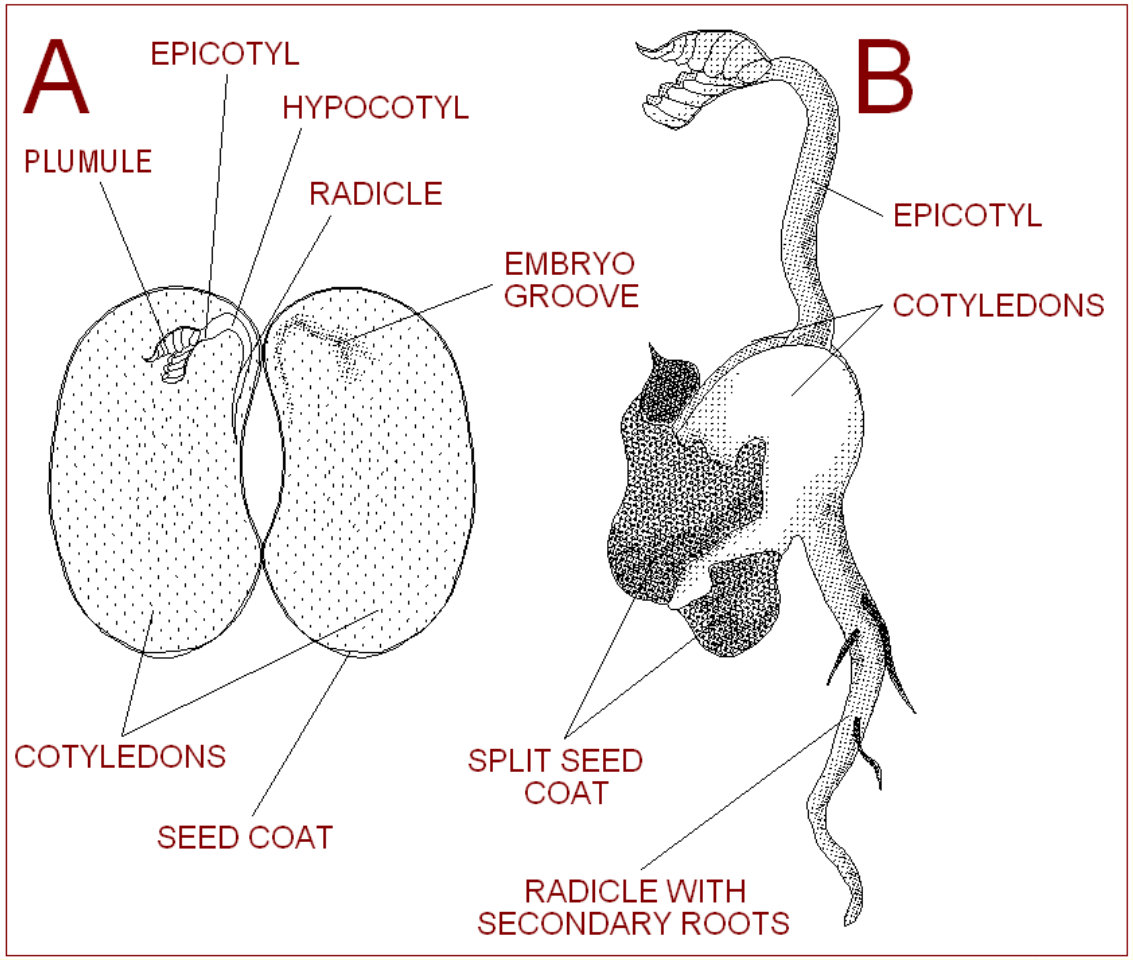
- Pollination- the transfer of male gametes (pollen) from anther to stigma.
- Fertilization- the fusion of pollen with a female gamete. Pollination does not always lead to fertilization.
- Seed Dispersal- once fertilized, the fused ovule develops into a seed. This is then contained in a fruit, which facilitates seed dispersal.

Courtesy of Debivort

9.3.3 Draw and label a diagram showing the external and internal structure of a named dicotyledonous seed (non-endospermatic).

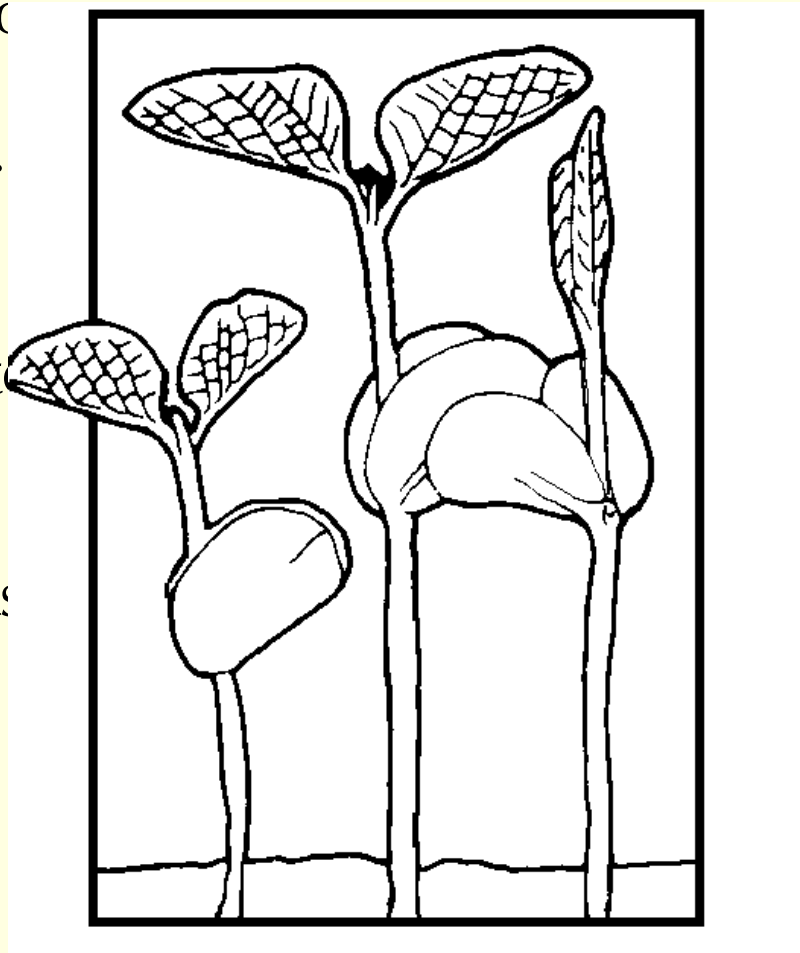
Identify:

- Testa
- Micropyle
- Embryo root
- Embryo shoot
- Cotyledon



9.3.4 Explain the conditions needed for the germination of a typical seed.

- Hydration- seeds need to absorb water to initiate the germination process.
- Temperature/pH- optimum temperature and pH ranges contribute to the probability of germination.
- Note: Light requirements (or the lack of light) vary among seeds, and are difficult to generalize.



9.3.5 Outline the metabolic processes of germination in a typical starchy seed.

- Absorption of water precedes the formation of gibberellin in the cotyledon. This stimulates the production of amylase, which catalyses the breakdown of starch to maltose. This subsequently diffuses to the embryo for energy production and growth.

9.3.6 Explain how flowering is controlled in long-day and short-day plants, including the role of phytochrome.

- Phytochrome- a plant protein which detects the length of daylight, and in turn, can trigger flowering based seasonal changes of light.
- Long Day Plant- will not flower unless daylight hours extend past a certain number of hours.
- Short Day Plant- will not flower unless daylight hours are capped below a certain minium.

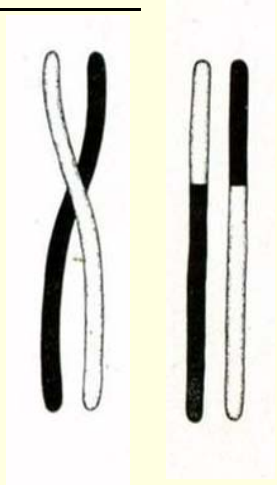
Unit 10: Genetics

Lesson 10.1 Meiosis

10.1.1a Describe the behavior of chromosomes in the phases of meiosis.

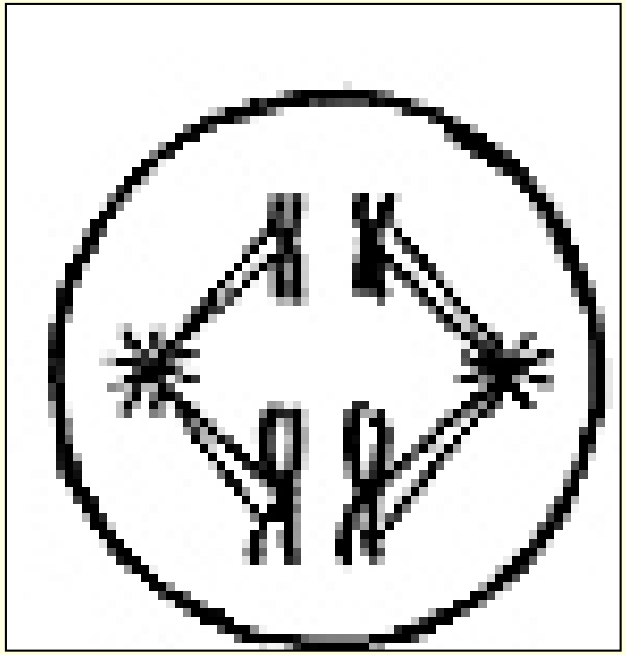
- Prophase I- chromosomes start to supercoil. Homologous chromosomes pair up during synapsis.

- Crossing over can occur at this stage at the chiasmata.



10.1.1b Describe the behavior of chromosomes in the phases of meiosis.

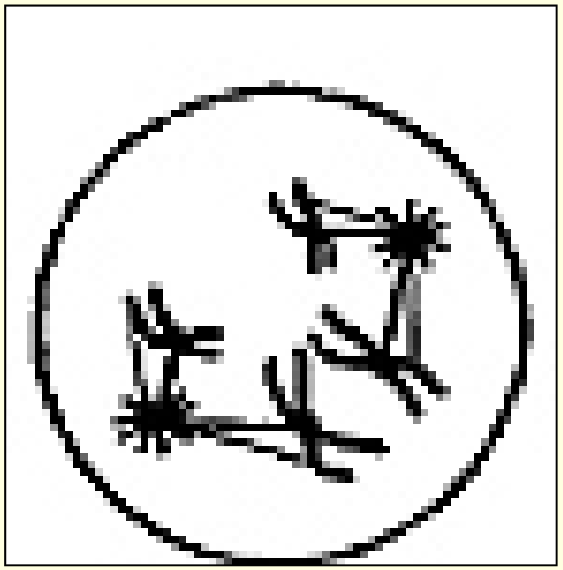
- Metaphase I- homologous chromosomes line up along the equatorial plane.



10.1.1c Describe the behavior of chromosomes in the phases of meiosis.

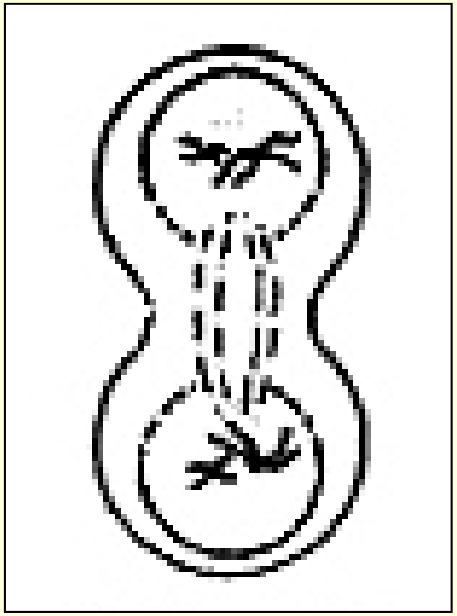
- Anaphase I- homologous chromosomes separate, and move toward opposite poles.

- (Note: there is no uncoupling of centromeres, as chromatids are still attached to each other.)



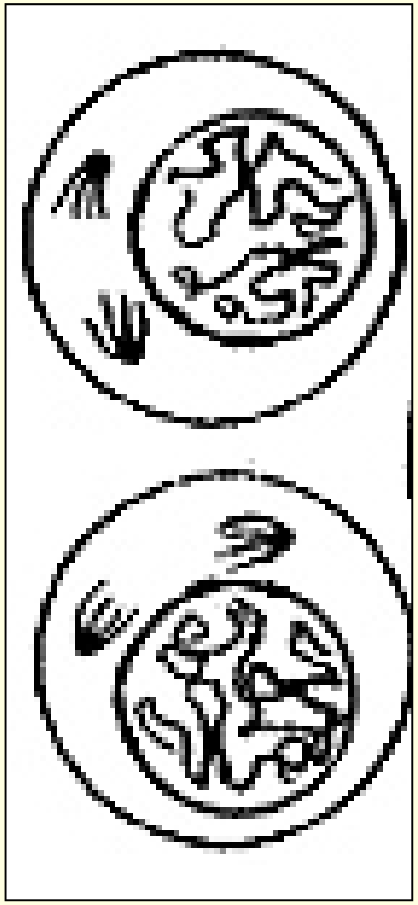
10.1.1d Describe the behavior of chromosomes in the phases of meiosis.

- Telophase I- chromosomes arrive at poles. Spindle microtubules disappear. Cytokinesis follows, resulting in two separate cells.



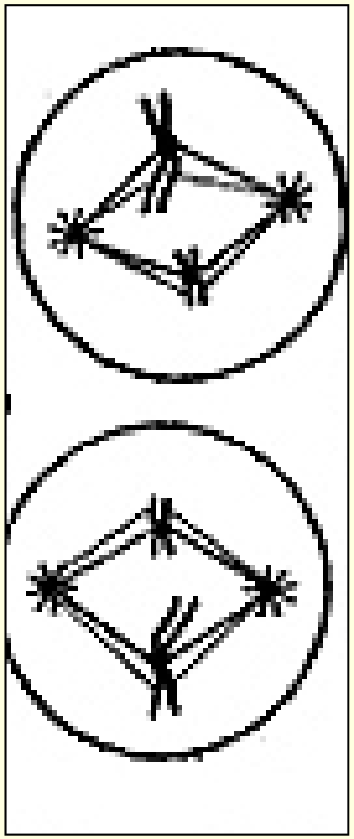
10.1.1e Describe the behavior of chromosomes in the phases of meiosis.

- Prophase II- new spindle microtubules attach to the centromeres.



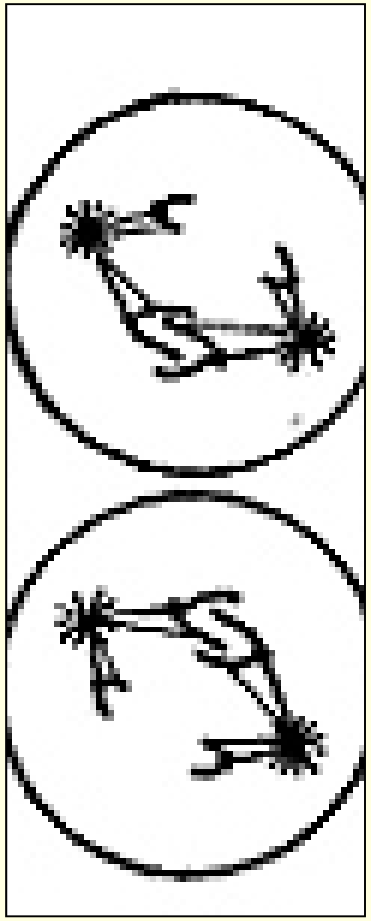
10.1.1f Describe the behavior of chromosomes in the phases of meiosis.

- Metaphase II- chromosomes line up along the equatorial plane.



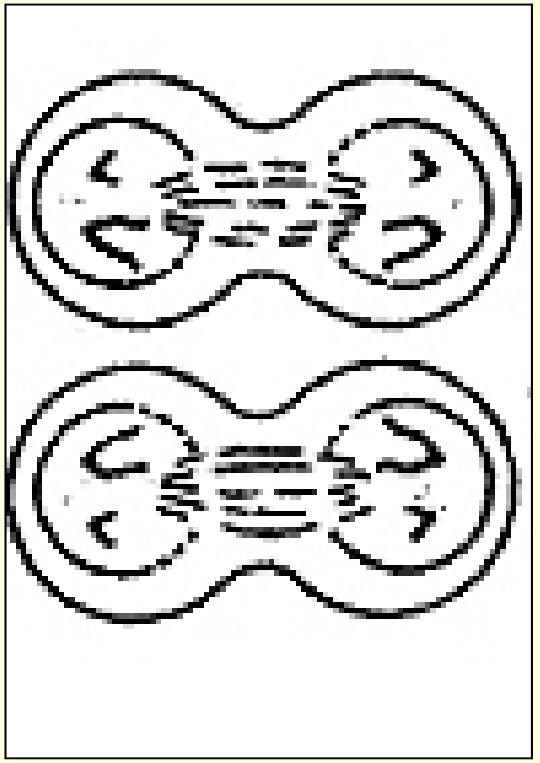
10.1.1g Describe the behavior of chromosomes in the phases of meiosis.

- Anaphase II- chromosomes separate and move toward opposite poles.



10.1.1h Describe the behavior of chromosomes in the phases of meiosis.

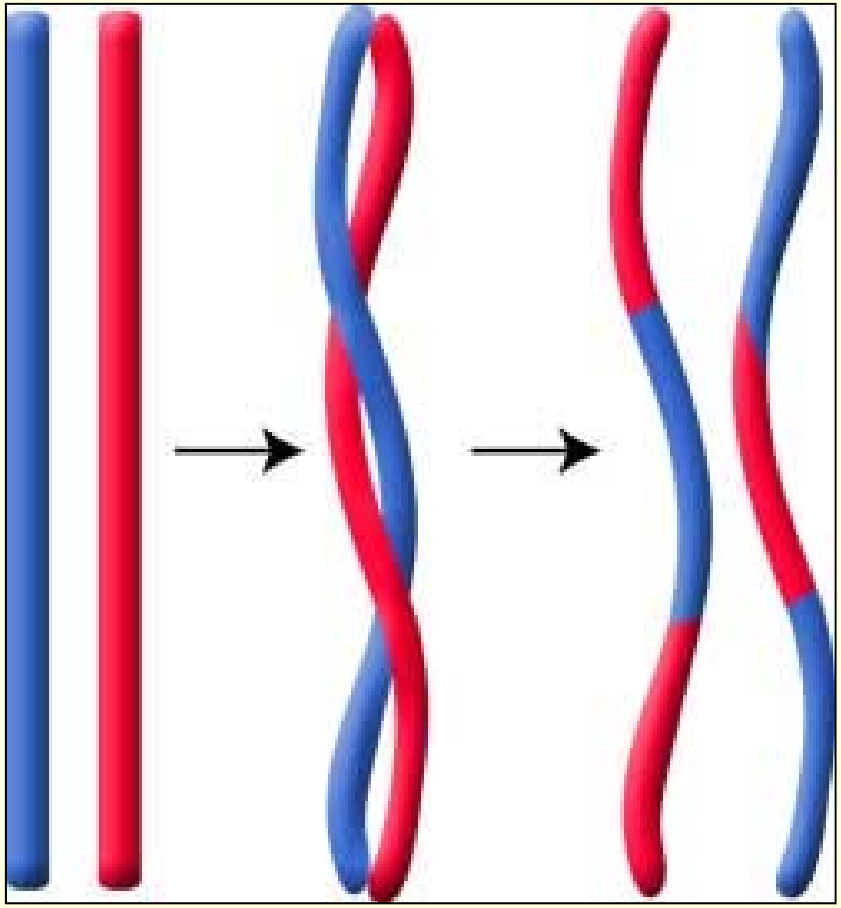
- Telophase II- spindle microtubules disappear. Nuclear membrane reforms. Chromosomes relax into chromatin.



10.1.2 Outline the formation of chiasmata in the process of crossing over.

- Crossing over occurs when homologous chromosomes bend around each other. The crossing point is called the chiasmata. The result is that potions of each chromosome are interchanged.

- Pictured: double crossing over.



10.1.3 Explain how meiosis results in an effectively infinite genetic variety in gametes.

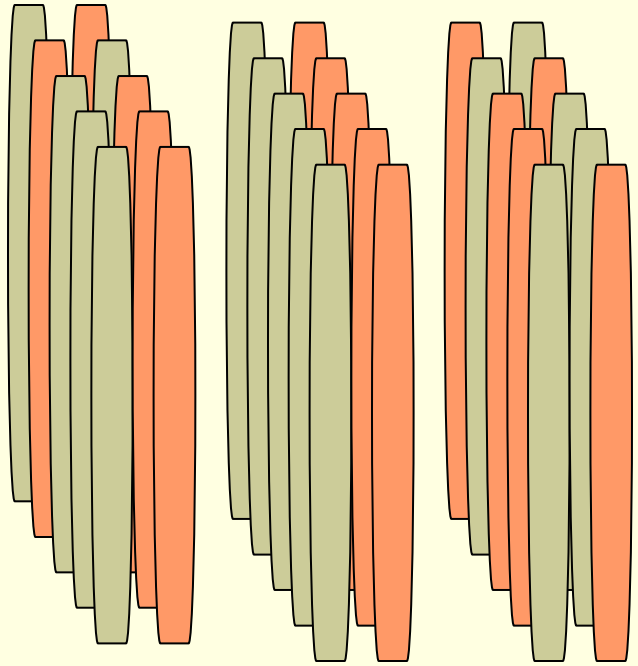
- Crossing over in prophase I- Since crossing over can occur at any point along the chromosome, there is unlimited potential for genetic variety when it occurs.

- Random orientation in metaphase 1- Homologous chromosomes line up along the equatorial plane independently of each other, eg. If chromosome 1 from the mother is on the left, chromosome two on the left is not necessarily also from the mother.

- Without crossing over, the number of different gametes able to be produced, is 2^n, with n= haploid number.

10.1.4 State Mendel's law of independent assortment.

- Law of independent assortment- homologous chromosomes separate independently of other homologous chromosomes, allowing for many combinations in gametes, and ultimately, in the zygote that if formed by egg and sperm.



10.1.5 Explain the relationship between Mendel's law of independent assortment and meiosis.

- Independent assortment occurs during metaphase I of meiosis, when homologous chromosomes line up along the equatorial plane.
- As chromosomes sort randomly, they create opportunities for new recombinants during fertilization, in essence shuffling the genetic deck.

Unit 10: Genetics

Lesson 10.2 Dihybrid Crosses and Gene Linkage

10.2.1 Calculate and predict the genotypic and phenotypic ratios of offspring of dihybrid crosses involving unlinked autosomal genes.

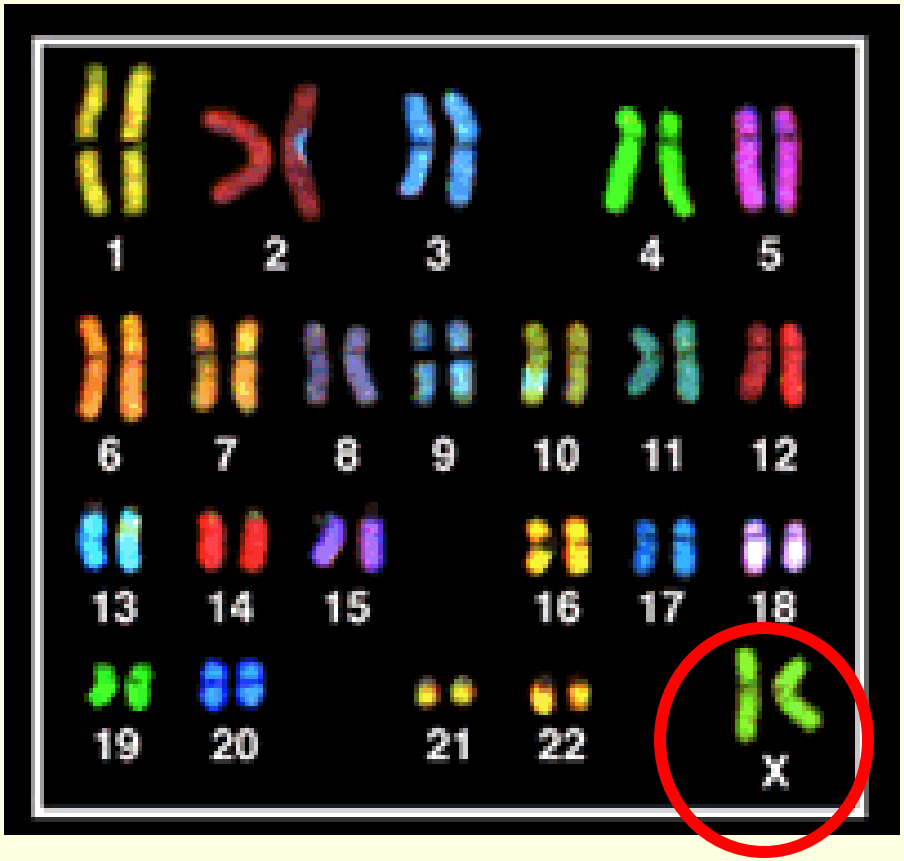
Pea seedlings:

- T = tall t = short
- Y = yellow y = green
- Predicted offspring ration is 9:3:3:1

	TY	Ty	tY	ty
TY	TTYY	TTYy	TtYY	TtYy
Ty	TTYy	TTyy	TtYy	Ttyy
tY	TtYY	TtYy	ttYY	ttYy
ty	TtYy	Ttyy	ttYy	ttyy

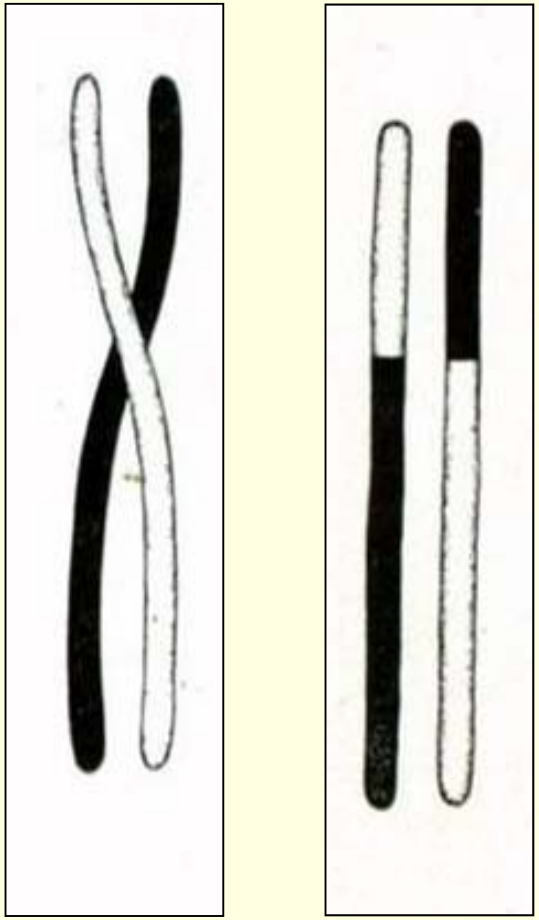
10.2.2 Distinguish between autosomes and sex chromosomes.

- Autosomes- chromosomes pairs #1-22.
- Sex chromosomes- X and y chromosomes, found as pair #23 (either as XX or Xy).



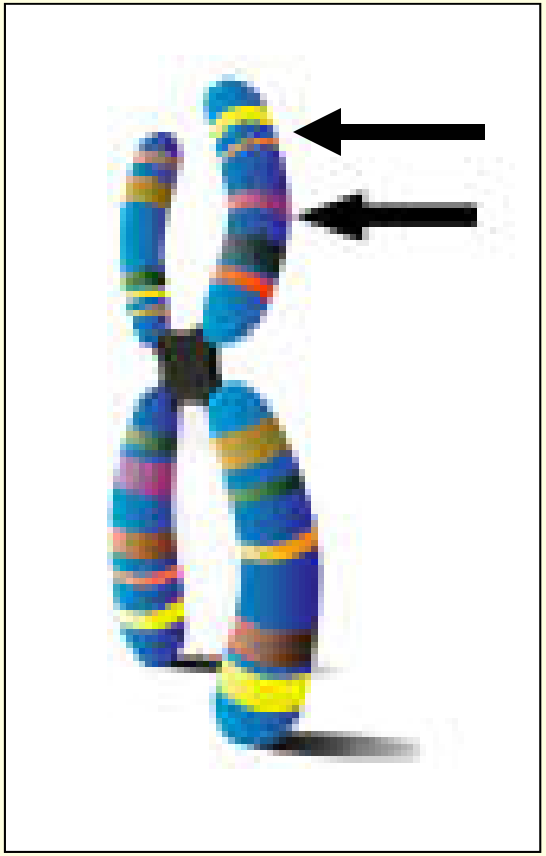
10.2.3 Explain how crossing over in prophase I (between non-sister chromatids of a homologous pair) can result in an exchange of alleles.

- Crossing over in prophase I- Since crossing over can occur at any point along the chromosome, there is unlimited potential for the exchange of alleles and genetic variety.



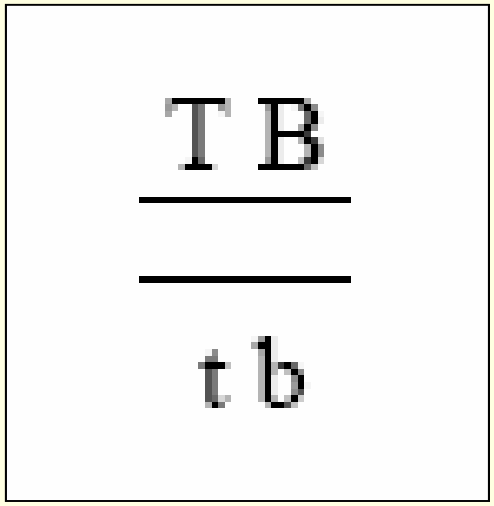
10.2.4 Define linkage group.

- Linkage group- a group of alleles located on the same strand of DNA.



10.2.5 Explain an example of a cross between two linked genes.

- Alleles are usually shown side-by-side in dihybrid crosses eg. TtBb. In representing crosses involving linkage it is more common to show them as vertical pairs:



10.2.6 Identify which of the offspring in such dihybrid crosses are recombinants.

- In a test cross of:

$$\frac{T\ B}{t\ b}$$

- The recombinants will be:

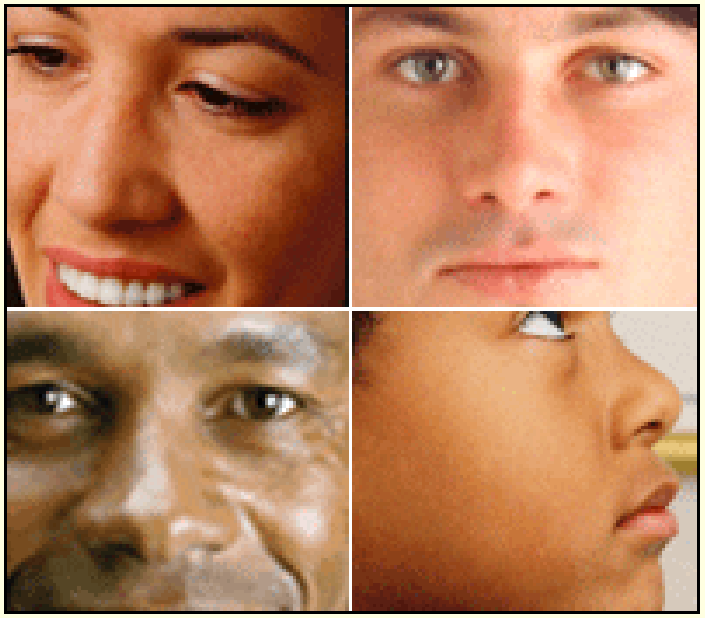
$$\frac{T\ b}{t\ b} \quad \text{and} \quad \frac{t\ B}{t\ b}$$

Unit 10: Genetics

Lesson 10.3 Polygenic Inheritance

10.3.1 Define *polygenic inheritance*.

Polygenic inheritance- occurs when a phenotype is controlled by more than one gene, resulting in a mosaic of phenotypes.



Courtesy of Scientific American

10.3.2 Explain that polygenic inheritance can contribute to continuous variation using two examples.

1) Human skin color- is thought to be controlled by at least 3 independent genes.

AABBCC x aabbcc

F_1 = AaBbCc , then perform a dihybird cross (AaBbCc), and there are *many* possible outcomes, such as:

AABBCc, AABBcc, AABbcc, AAbbcc, etc.

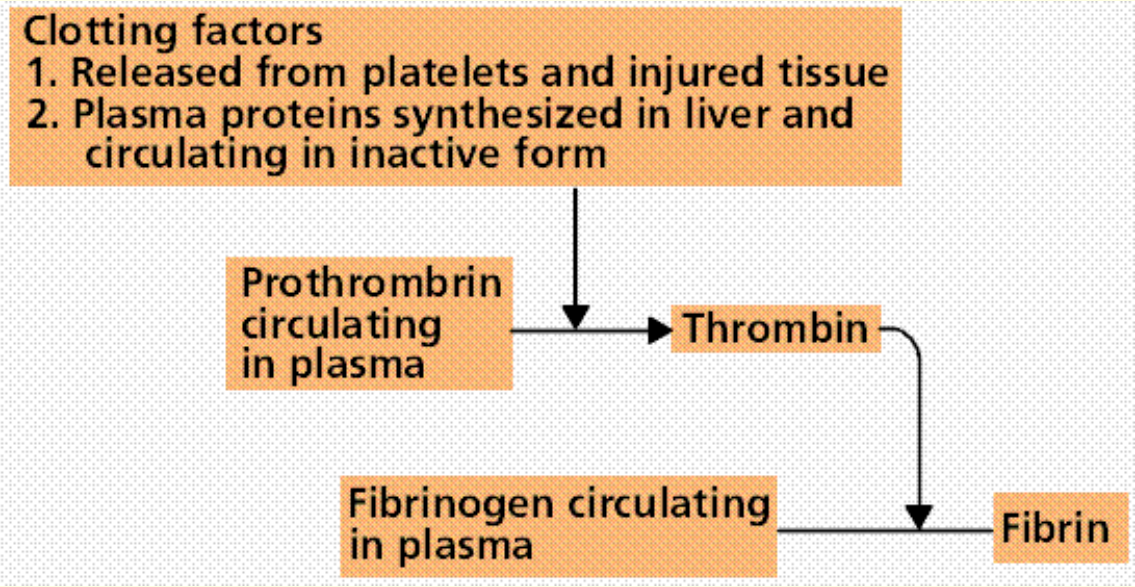
2) Human hair color- is also thought to be controlled but multiple genes, accounting for the large variety in shade.

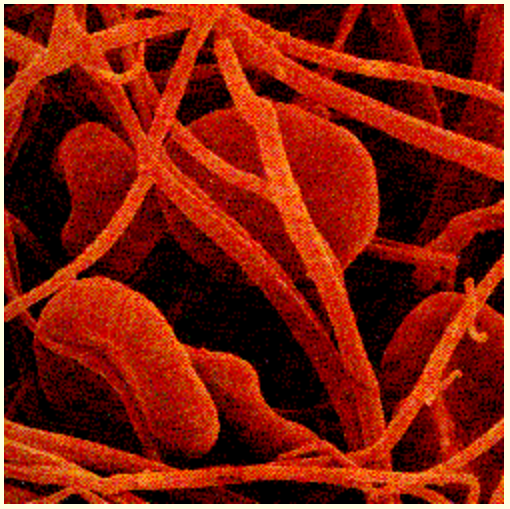
Unit 11: Human Health and Physiology

Lesson 11.1 Defense Against Infectious Disease

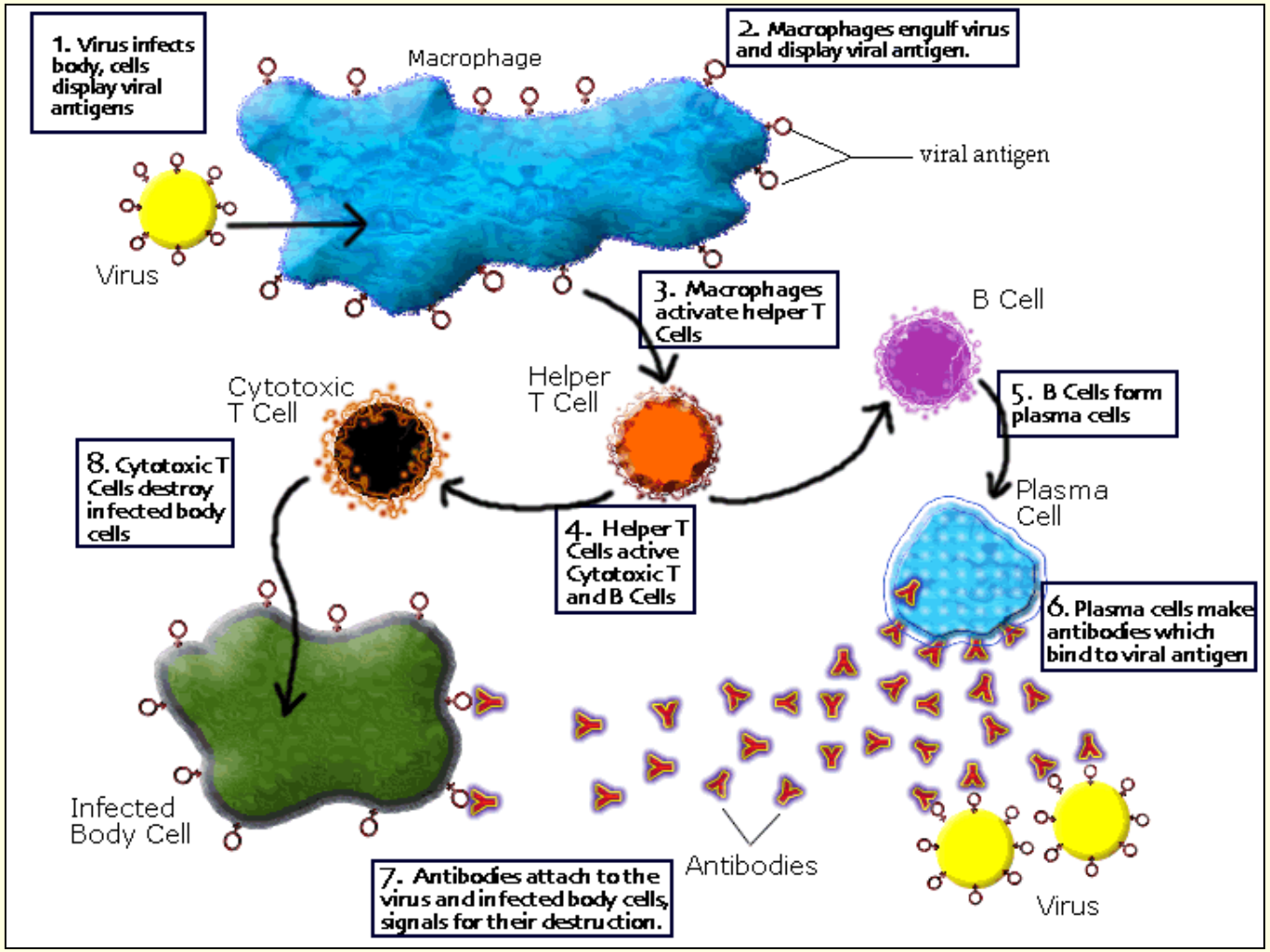
11.1.1 Describe the process of clotting.

- 1) Platelets and damaged cells release clotting factors.
- 2) Prothrombin→thrombin
- 3) Fibrinogen→fibrin, which captures red blood cells.





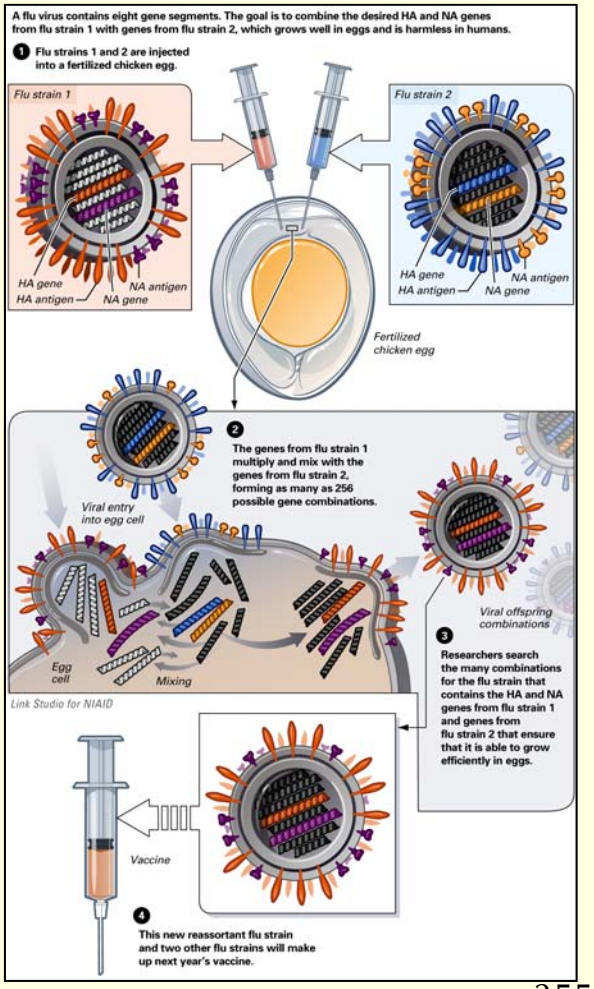
11.1.2 Outline the principle of challenge and response, clonal selection and memory cells as the basis of immunity.



11.1.3 Define active immunity and passive immunity.

Active immunity- immunity due to the production of antibodies by the organism itself after the body's defense mechanisms have been stimulated by invasion of foreign microorganisms.

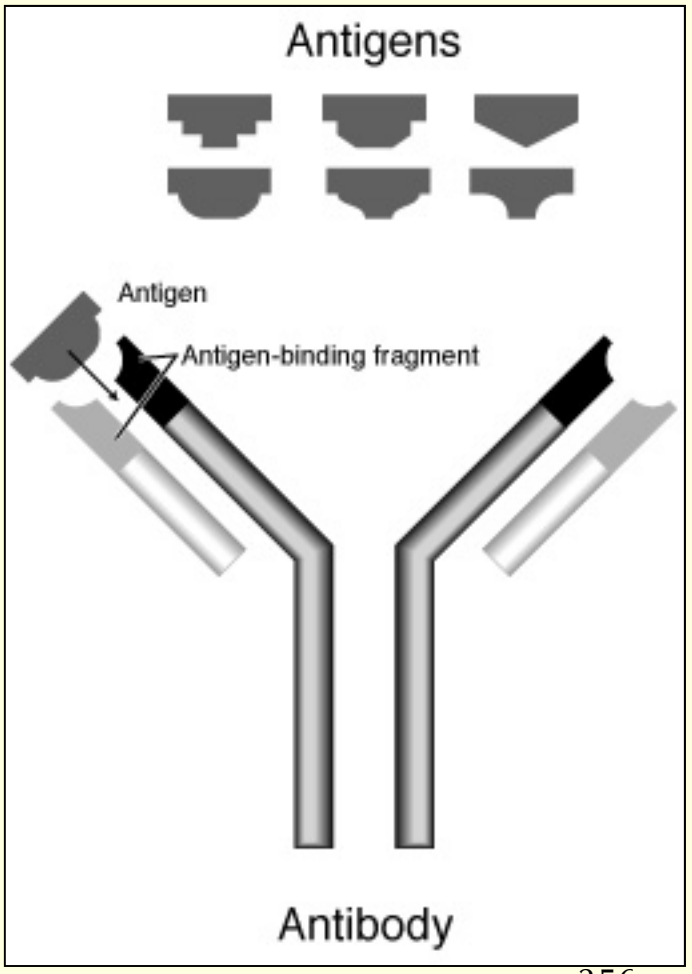
Passive immunity- immunity due to the acquisition of antibodies from another organism in which active immunity has been stimulated, including via placenta or in the colostrum.



11.1.4 Explain antibody production.

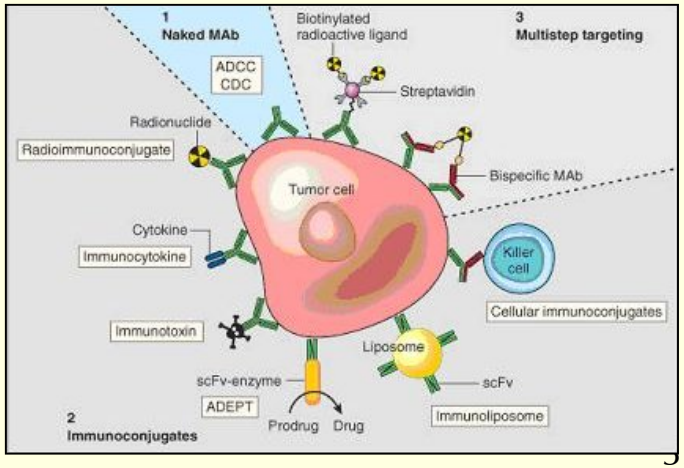
- 1) Macrophage presents antigen to helper T cell
- 2) Helper T cell activates B cell
- 3) B cells divide to form clones of plasma cells and memory cells, which secrete antibodies.

- Plasma cells- fight the pathogen immediately.
- Memory cells- stay in body, armed and ready if the pathogen appears in again in the future.



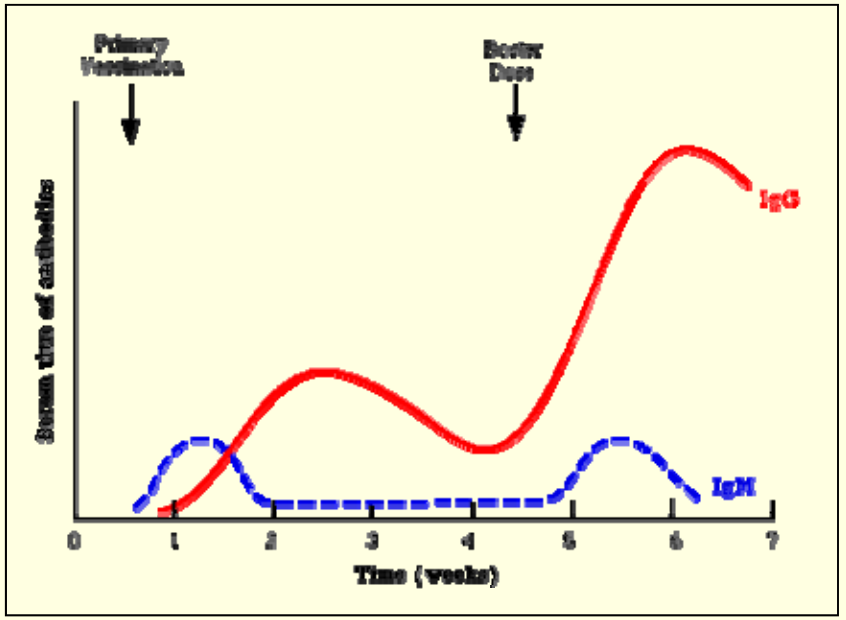
11.1.5 Describe the production of monoclonal antibodies, and include one use in diagnosis and one use in treatment.

- Monoclonal antibodies are produced by fusing cancerous tumor cells with B-cells. This hybrid cell then proliferates and produces antibodies in perpetuity.
- Diagnosis- used to detect HIV in the blood stream, as well as HCG in pregnancy tests.
- Treatment- emergency treatment of rabies, blood and tissue typing for transplants.



11.1.6 Explain the principle of vaccination.

- A vaccine introduces the disabled pathogen in some for to the body, stimulating an immune response. Memory cells are created and circulate in the body, in case the real pathogen ever shows up.



11.1.7 Discuss the benefits and dangers of vaccination.

- Benefits: total elimination of diseases, prevention of pandemics and epidemics, decreaded health-care costs and prevention of harmful side-effects of disease.

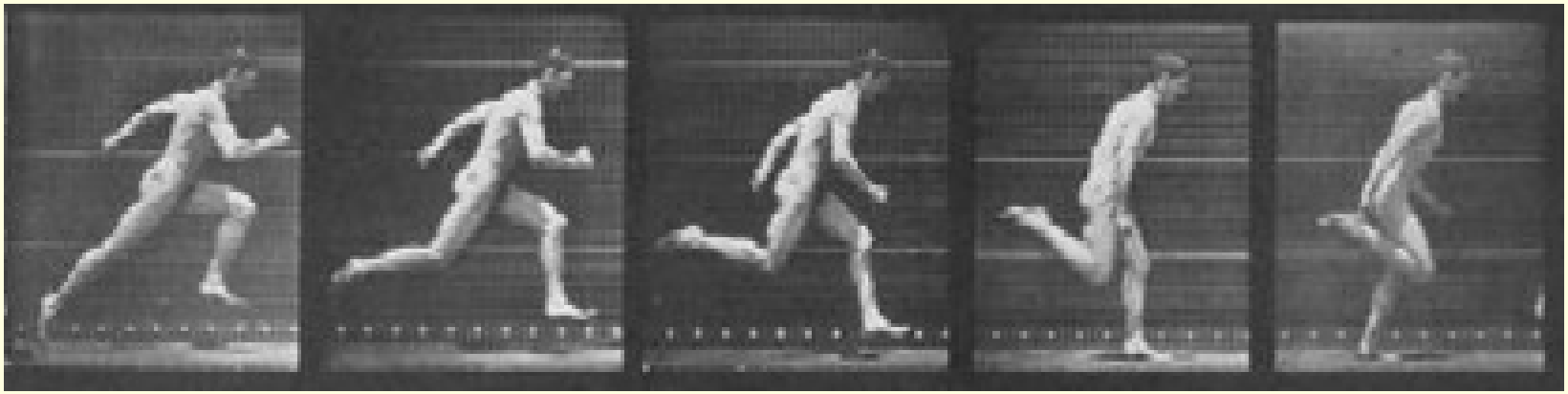
- Dangers: possible toxic effects of mercury in vaccines, possible overload of immune system, possible links with autism.

Unit 11: Human Health and Physiology

Lesson 11.2 Muscles and Movement

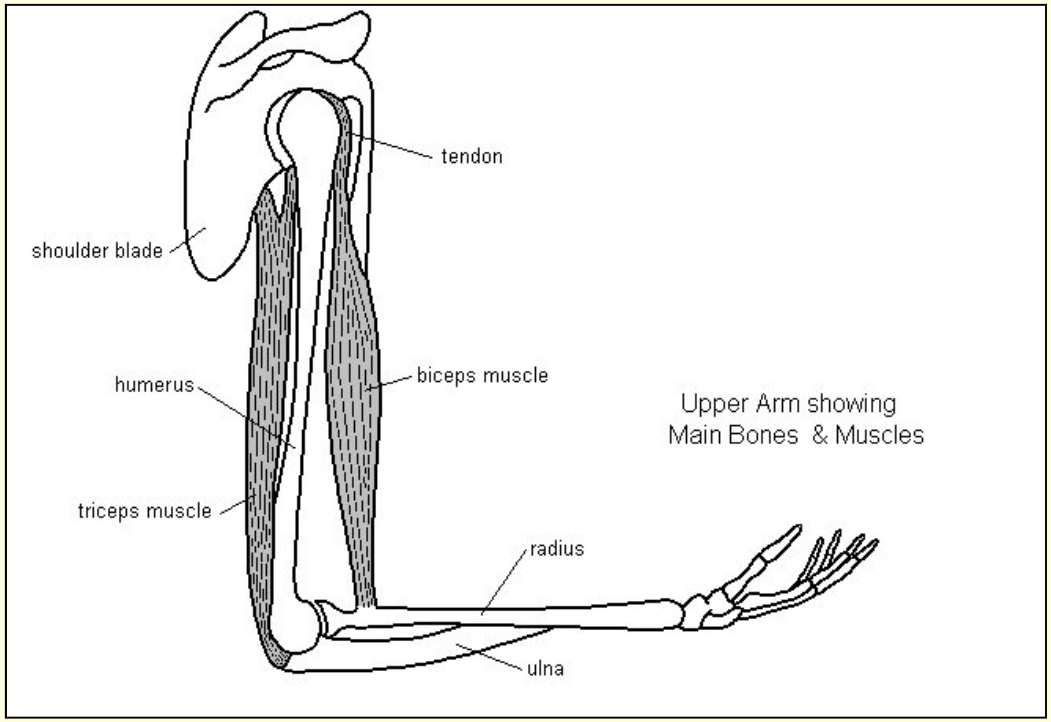
11.2.1 State the role of bones, ligaments, muscles, tendons and nerves in human movement.

1) A nerve impulse reaches muscle.
2) The impulse triggers muscle contraction.
3) Muscles are attached to bone by tendon.
4) Bone moves.
5) Bones are attached to other bones by ligaments.



11.2.2 Draw a diagram of the human elbow joint.

- Identify: cartilage, synovial fluid, tendons, ligaments, radius, ulna, bicep, tricep.

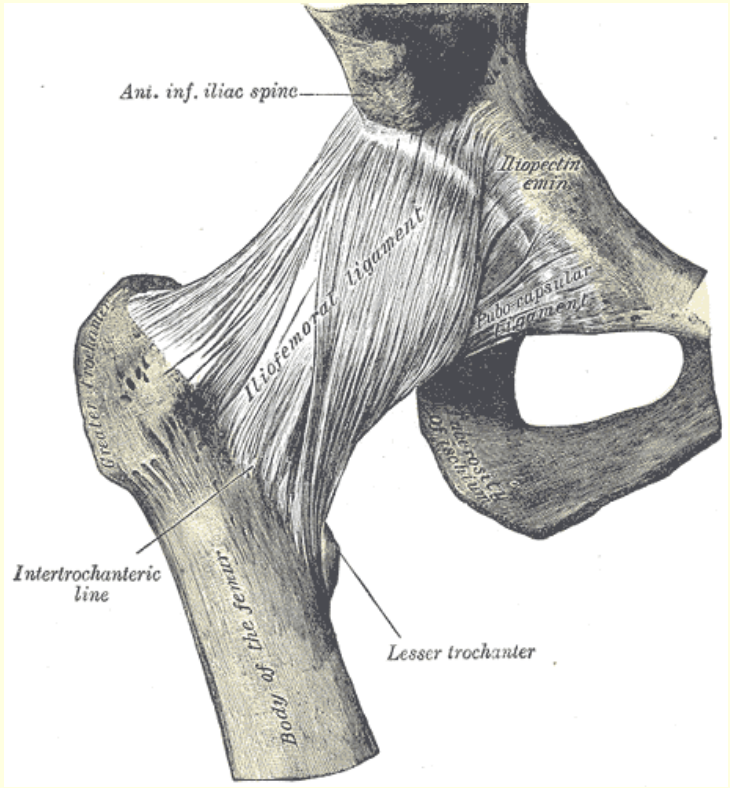


11.2.3 Outline the function of each of the structures named in the elbow joint.

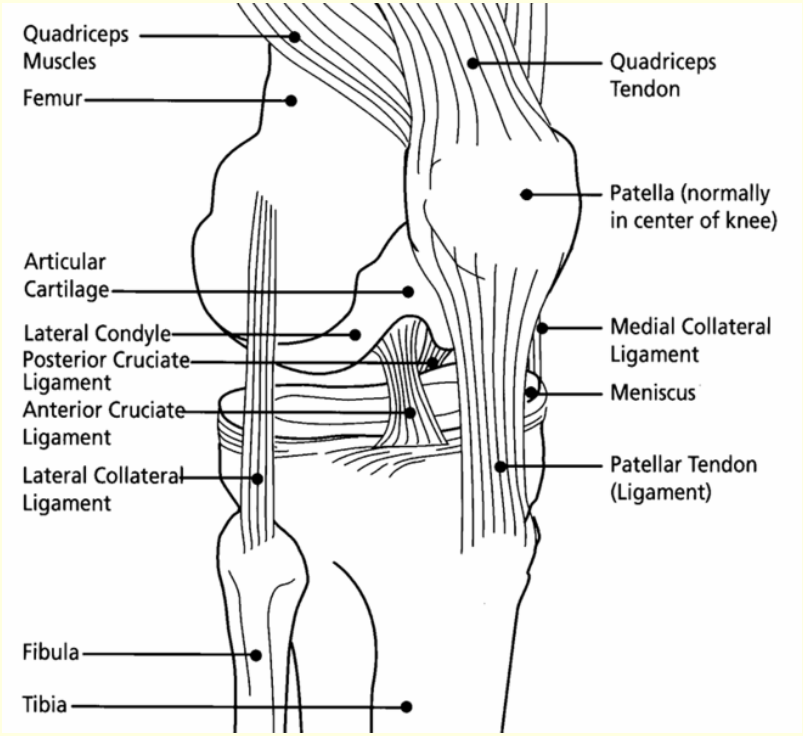
- Cartilage and synovial fluid- cushion against friction.
- Tendons- connect bone to muscle.
- Ligaments- connect bone to bone.
- Humerous- connected to bicep and tricep muscle.
- Radius/Ulna- help rotate forearm.
- Bicep/Tricep- help lift and lower forearm.

11.2.4 Compare the movements of the hip joint and the knee joint.

- Hip joint- flexion, extension, abduction, adduction, medial and lateral rotation, circumduction.

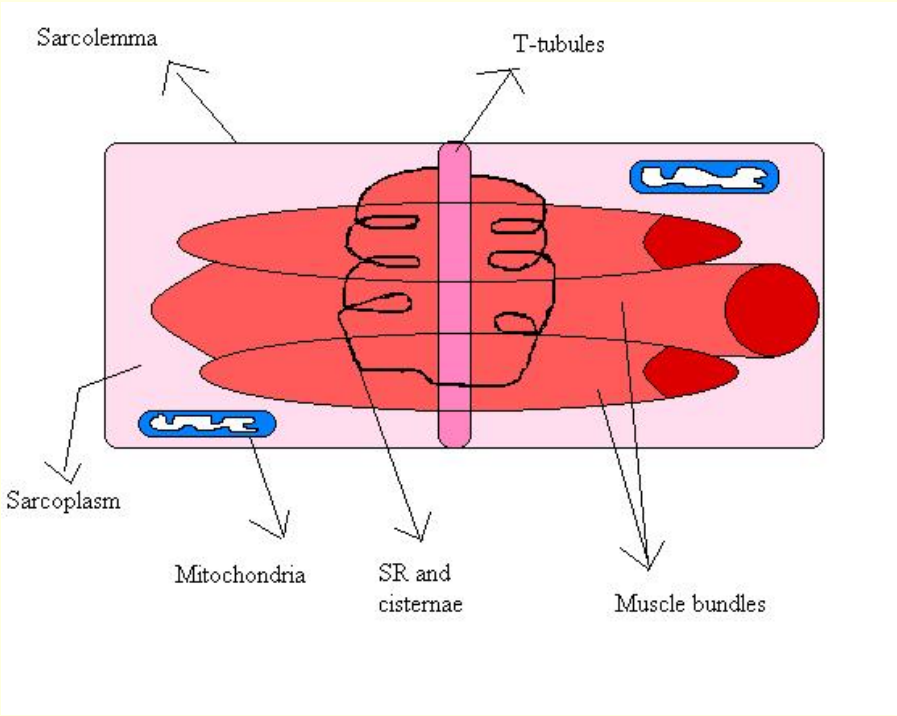


- Knee joint- flexion, extension.



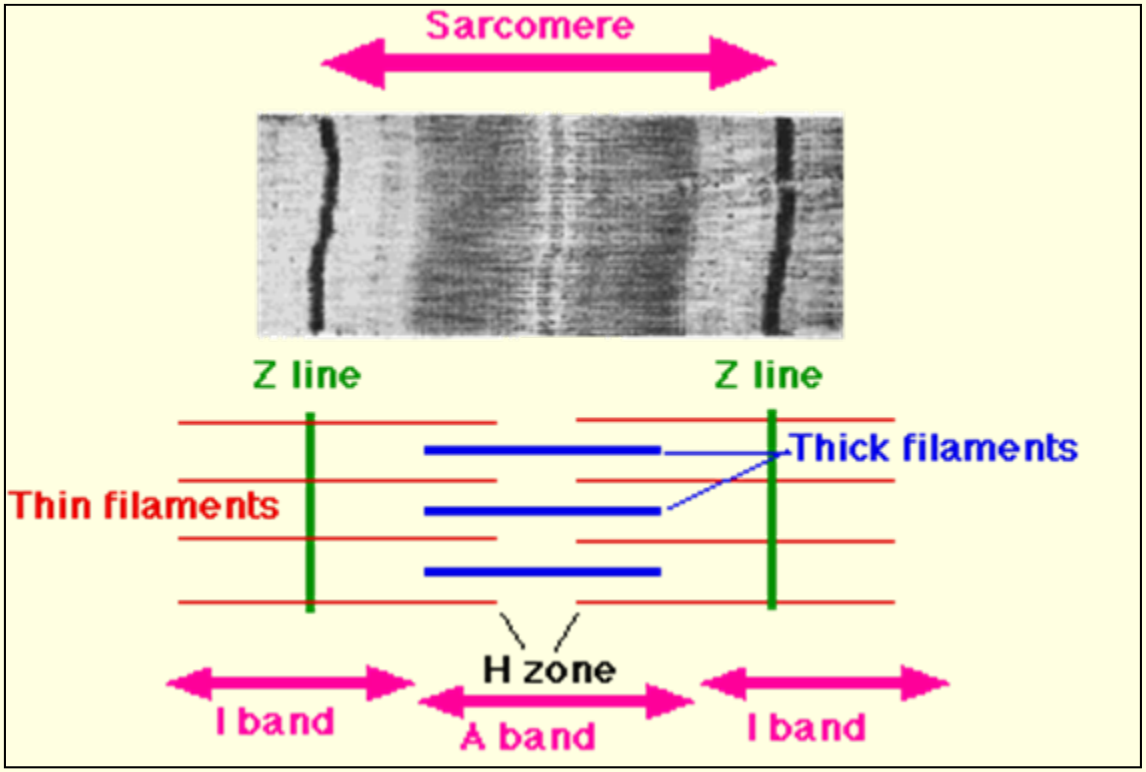
11.2.5 Describe the structure of striated muscle fibers.

- Myofibrils- bundled muscle filaments
- Light bands- primarily actin filaments
- Dark bands- protein discs found between sarcomeres
- Mitochondria- provide energy for contraction.
- Sarcoplasmic reticulum- similar to smooth ER with large stores of calcium.
- Nuclei- fibers are multinucleated.
- Sarcolemma- membrane surrounding muscle fiber



11.2.6 Draw the structure of skeletal muscle fibers as seen in electron micrographs.

- Identify: sarcomere, light and dark bands, actin (thin) filaments, myosin (thick) filaments, sarcoplasmic reticulum.



11.2.7 Explain how skeletal muscle contracts by the sliding of filaments.

1) Calcum ions flood sarcoplasmic reticulum.

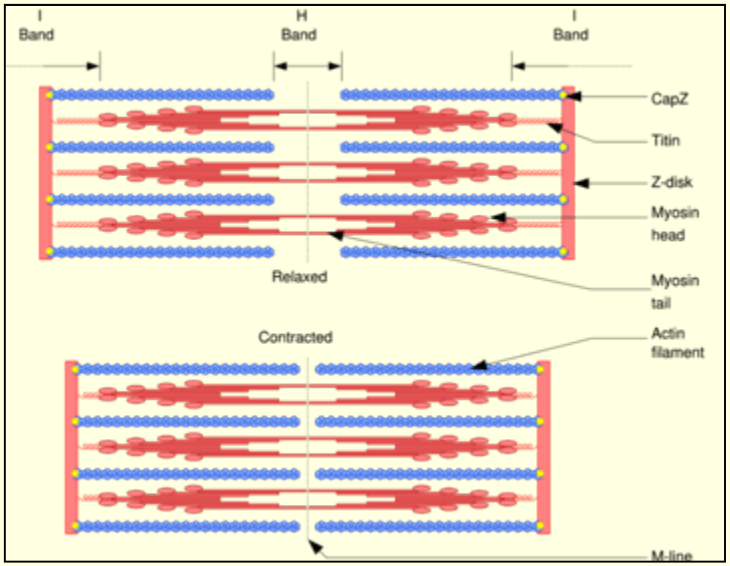
2) Myosin binds to ATP→ADP +P→Myosin in high energy configuration (SET).

3) Actin/myosin cross-bridge forms.

4) Myosin releases ADP + P→relaxes to low energy state, cross bridge moves actin filament.

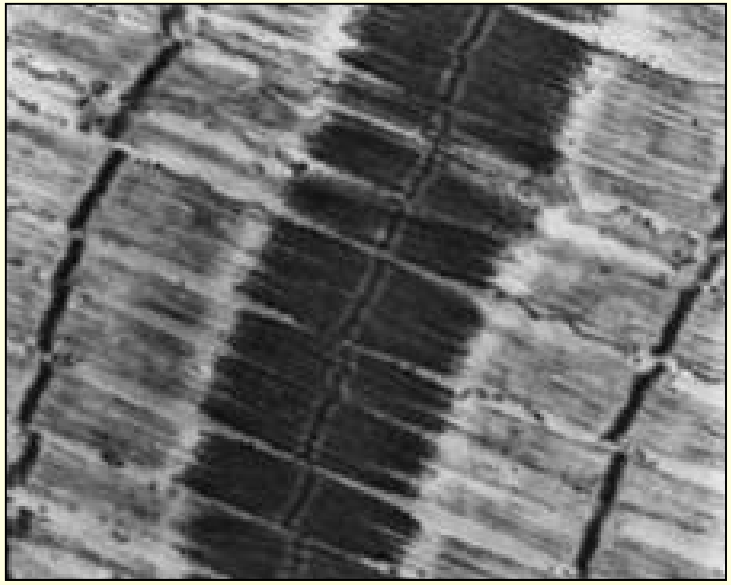
5) Myosin binds to new ATP→ releases cross-bridge.

6) ATP→ADP + P→Myosin back in high energy configuration.



Courtesy of David Richfield

11.2.8 Analyze electron micrographs to find the state of contraction of muscle fibers.



Courtesy of University of British Columbia

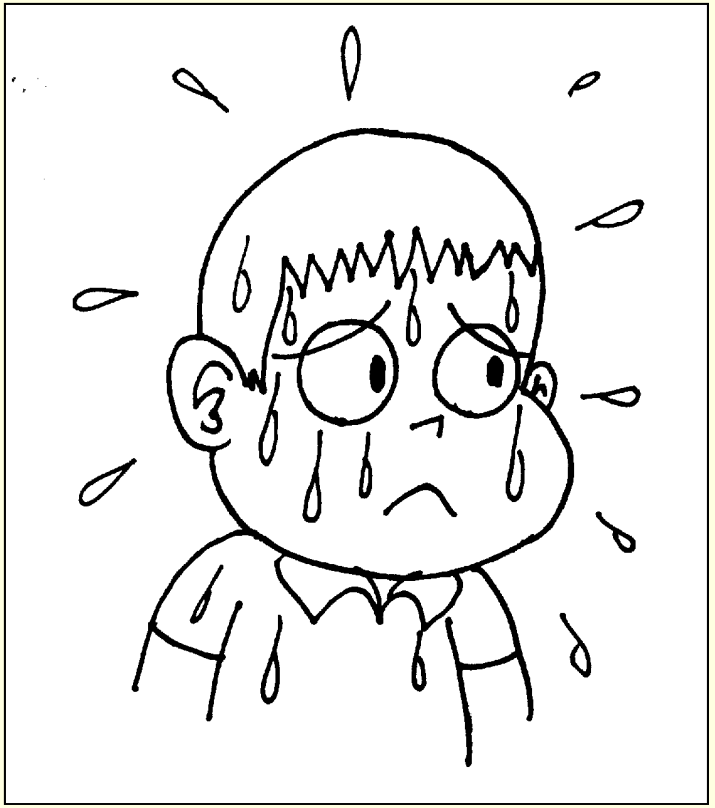
Courtesy of Ronnie Burns

Unit 11: Human Health and Physiology

Lesson 11.3 The Kidney

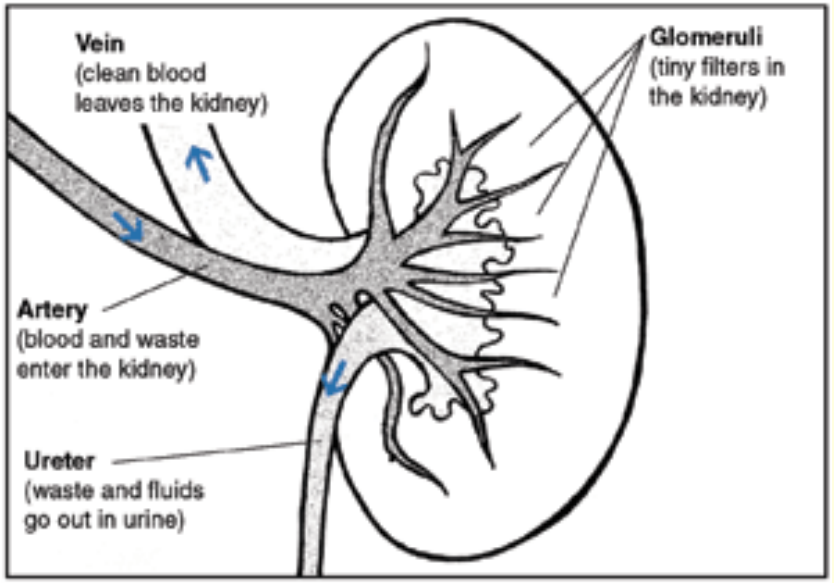
11.3.1 Define Excretion.

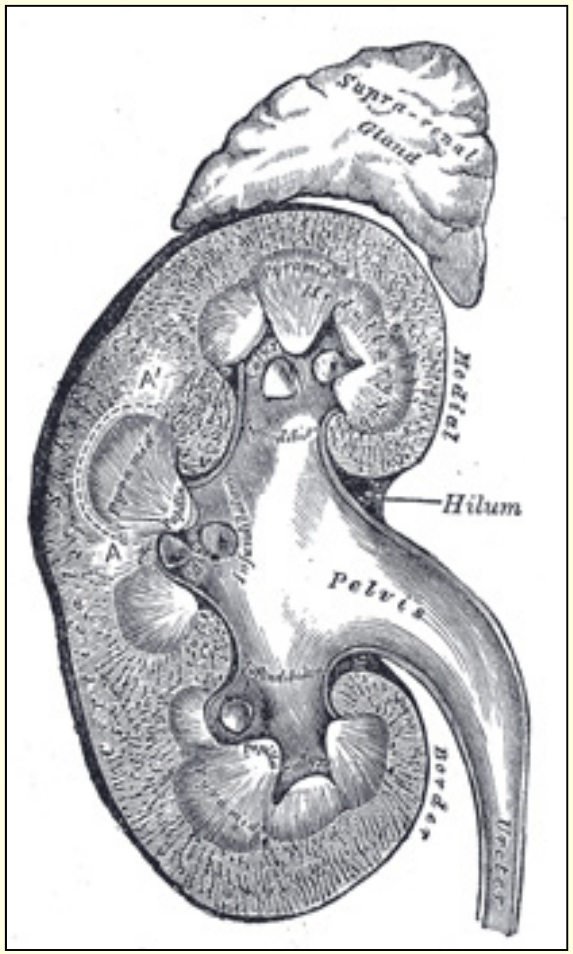
- Excretion- the removal from the body of the waste products of metabolic pathways.



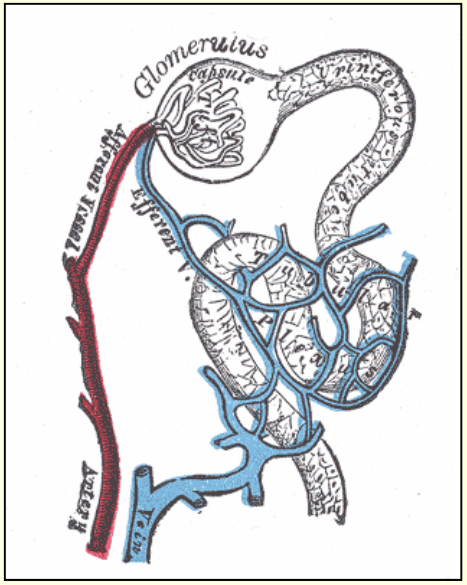
11.3.2 Draw and label a diagram of the kidney.

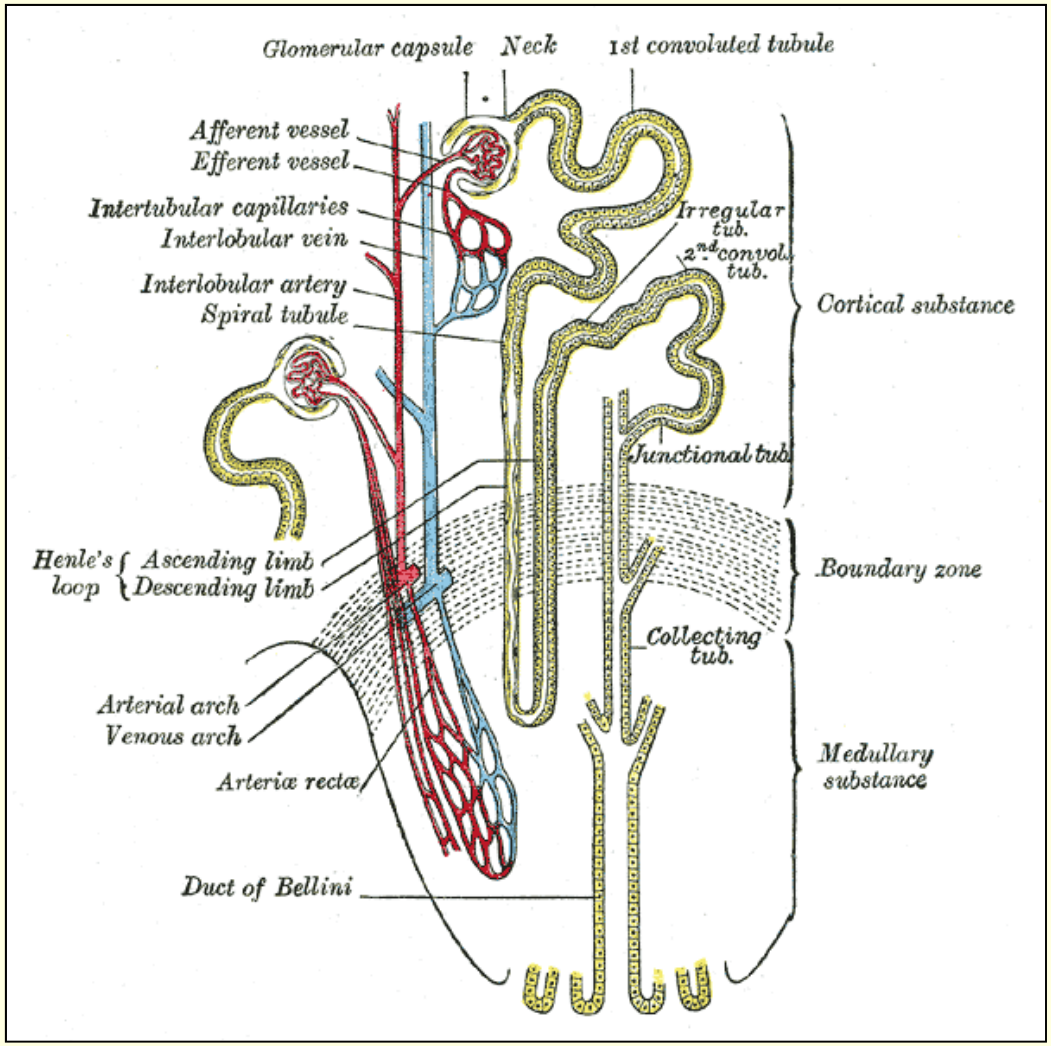
- Cortex
- Medulla
- Pelvis
- Ureter
- Renal blood vessels





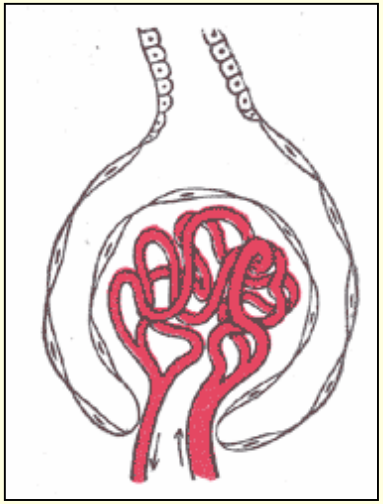
11.3.3 Annotate a diagram of a glomerulus and associated nephron to show the function of each part.





11.3.4 Explain the process of ultrafiltration.

- Ultrafiltration- Blood pressure from the pumping heart forces fluid and materials out of the glomerulus (across a semi-permeable membrane) into the nephron.

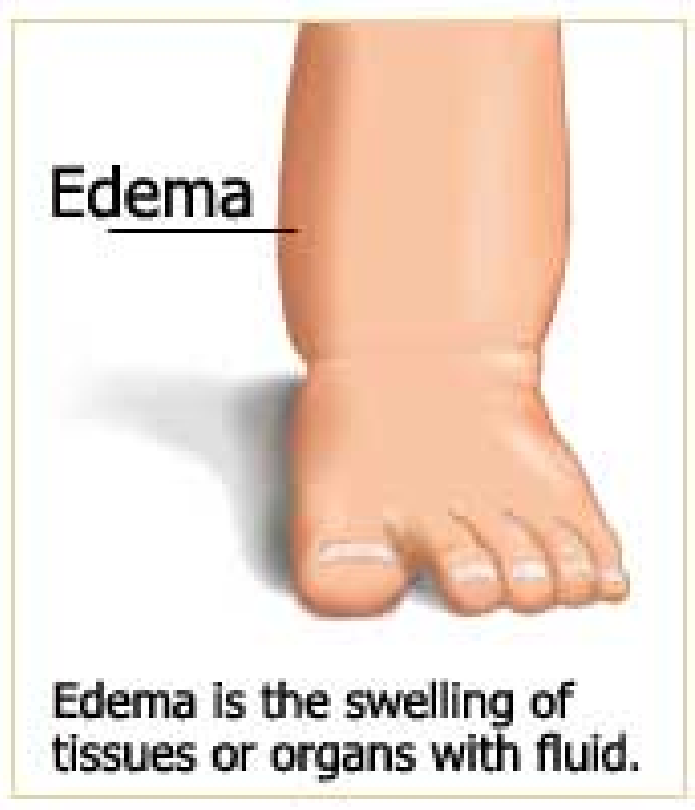


- Fenestrated blood capillaries- are elastic in nature to help with ultrafiltration.

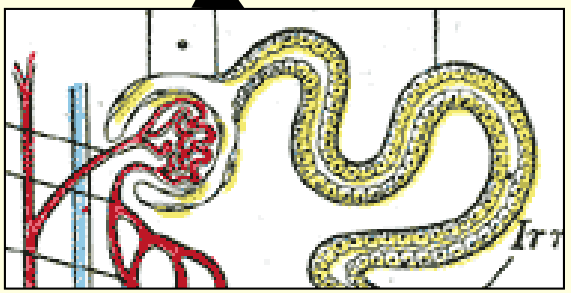
- Basement membrane- thick, layer of negatively charges tissue which helps keep negatively charged particles from crossing into the nephron.

11.3.5 Define *osmoregulation*.

- Osmoregulation- the control of the water balance of the blood, tissue or cytoplasm of a living organism. An inability to osmoregulate may result in edema.



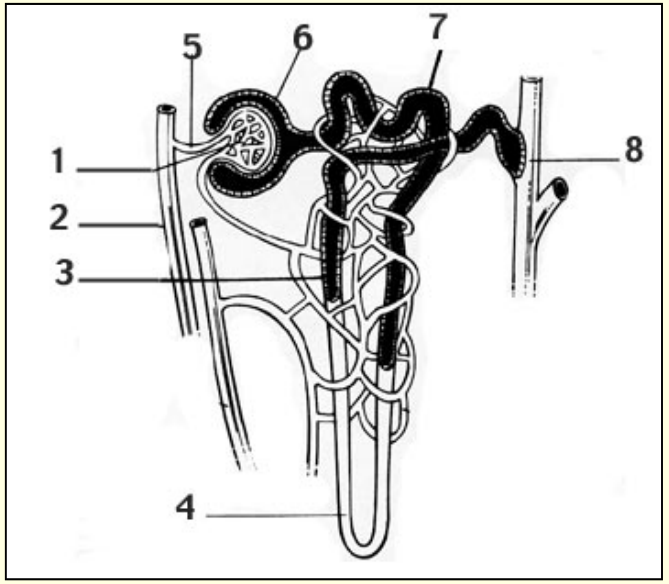
11.3.6 Explain the reabsorption of glucose, water and salts in the proximal convoluted tubule.



- Reabsorption- water and solutes which have been removed from the blood from ultrafiltration are moved back into the blood. Reabsorption involves:
  - Microvilli- increase surface area to help facilitate reabsorption
  - Osmosis- water is diverted back into the blood due to a concentration gradient.
  - Active transport- some solutes are actively transported back into the blood.

11.3.7 Explain the roles of the loop of Henle, medulla, collecting duct and ADH in maintaining water balance of the blood.

The primary role of the Loop of Henle is to reabsorb water. Water leaves the descending loop due to a concentration gradient, sodium leaves the ascending side due to active transport.



ADH= antidiuretic hormone.

ADH increase = more water reabsorbed.

ADH decrease = more water released in urine.

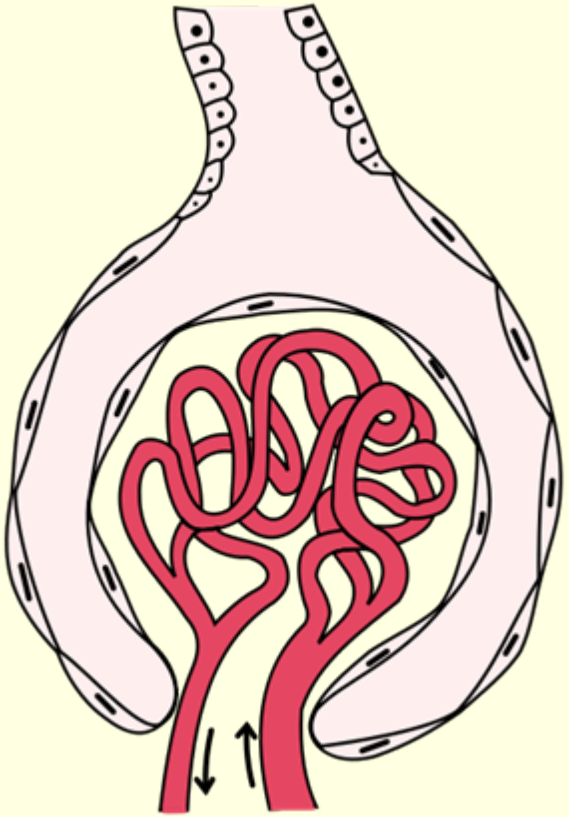
Collecting duct- funnels water into the ureter for excretion.

11.3.8 Explain the differences in the concentration of proteins, glucose and urea between blood plasma, glomerular filtrate and urine.

- The flow sequence is:

blood plasma →glomerular filtrate→urine

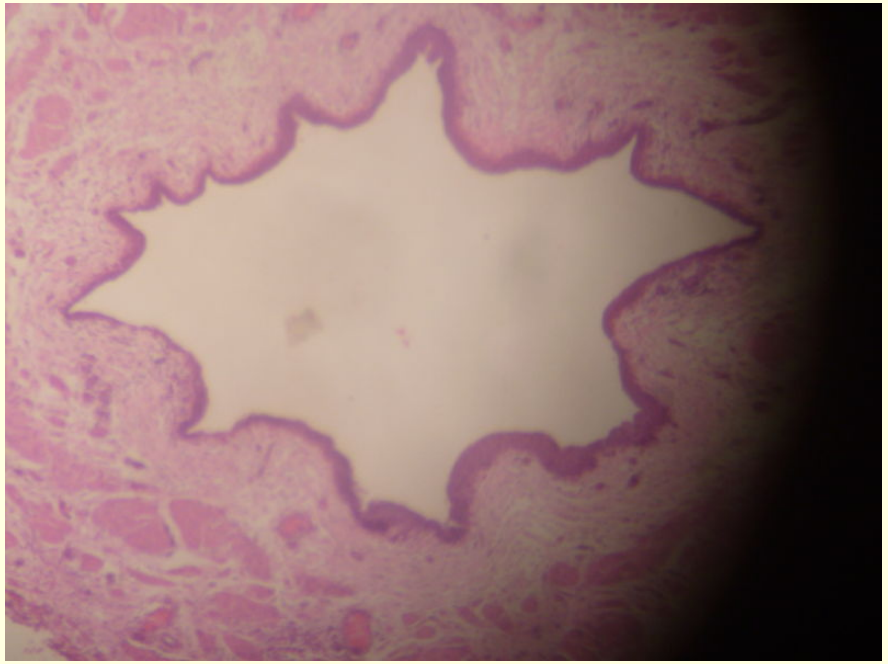
As fluid progresses through the renal system, nitrogenous waste (urea) moves into the filtrate and is eliminated through the urine. Glucose also moves into the filtrate but is reabsorbed back into the blood. Large proteins remain in the blood plasma, and are not moved into the glomerular filtrate.



11.3.9 Explain the presence of glucose in the urine of untreated diabetic patients.

A diabetic's inability metabolize glucose can result in hyperglycemia.

Elevated levels of glucose in the blood will move into the glomerular filtrate, but will not be reabsorbed back into the blood. Instead, excess glucose will be found in the urine.

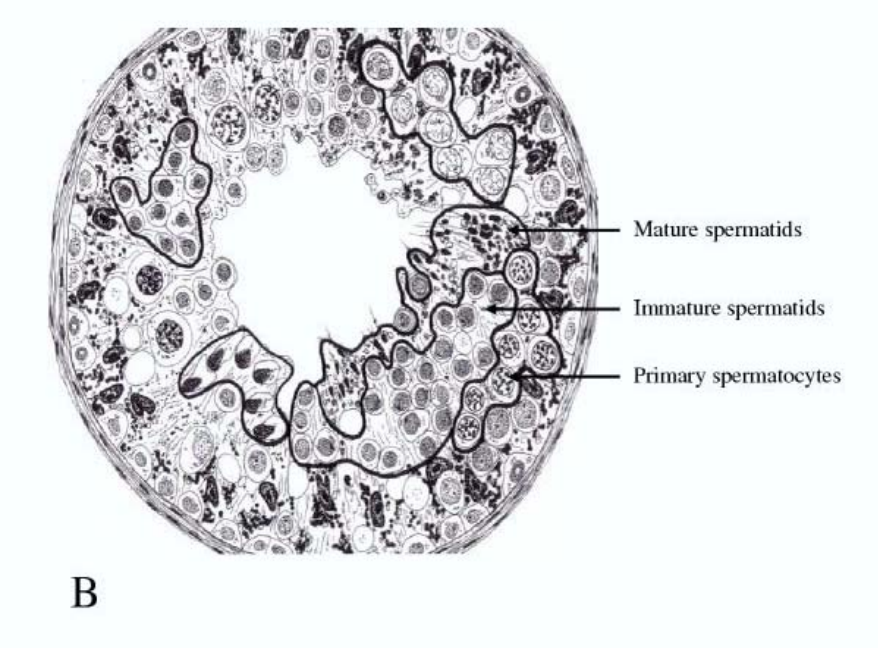


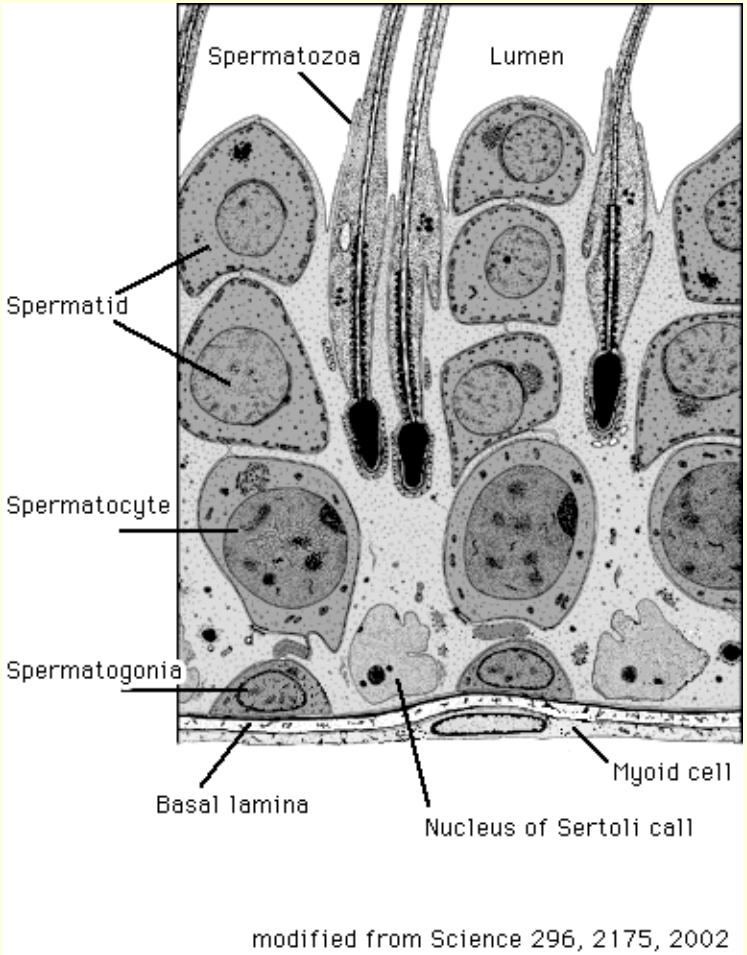
Cross section of human ureter

Unit 11: Human Health and Physiology

Lesson 11.4 Reproduction

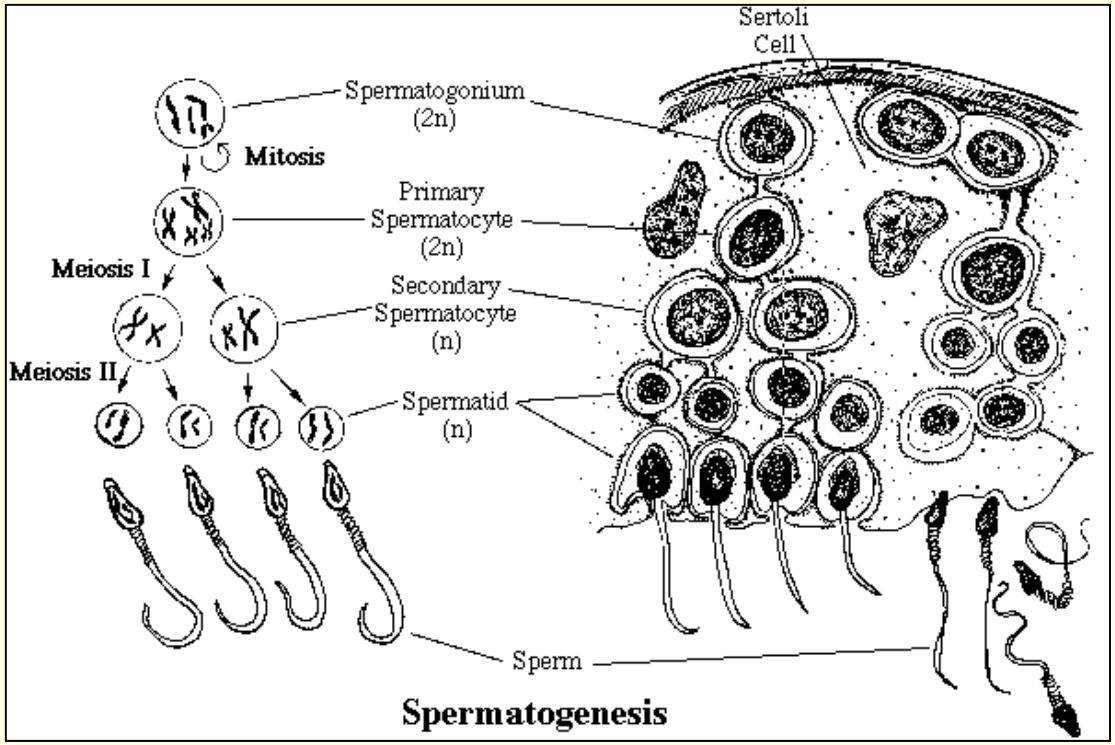
11.4.1 Annotate a light micrograph of testis tissue to show the location and function of interstitial (Leydig) cells, germinal epithelium cells, developing spermatozoa and Sertoli cells.





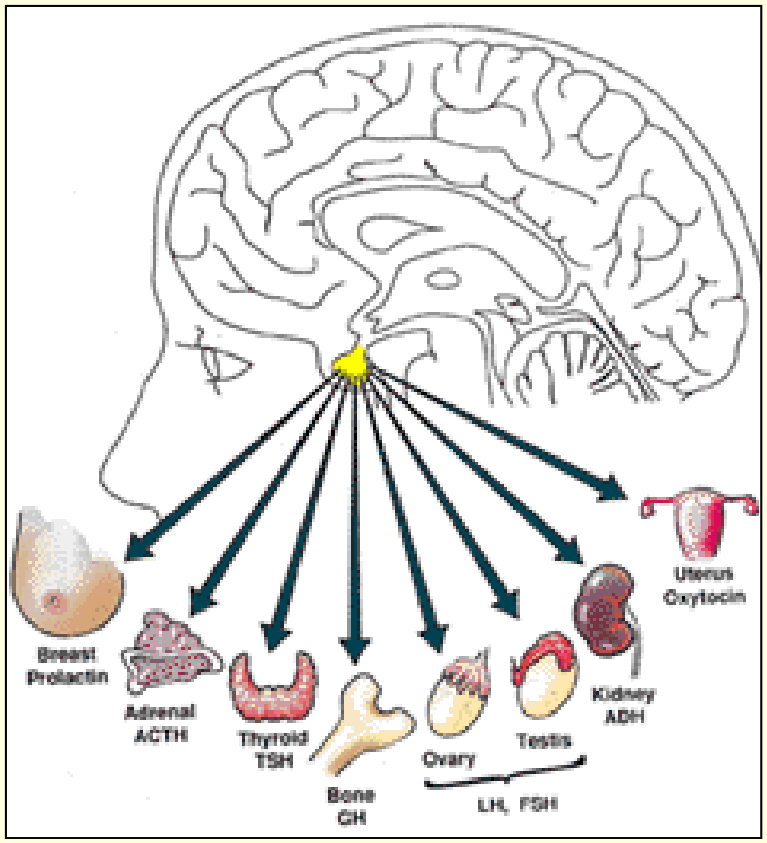
11.4.2 Outline the processes involved in spermatogenesis within the testes.

- 1) mitosis
- 2) cell growth
- 2) two cell divisions
- 3) cell differentiation



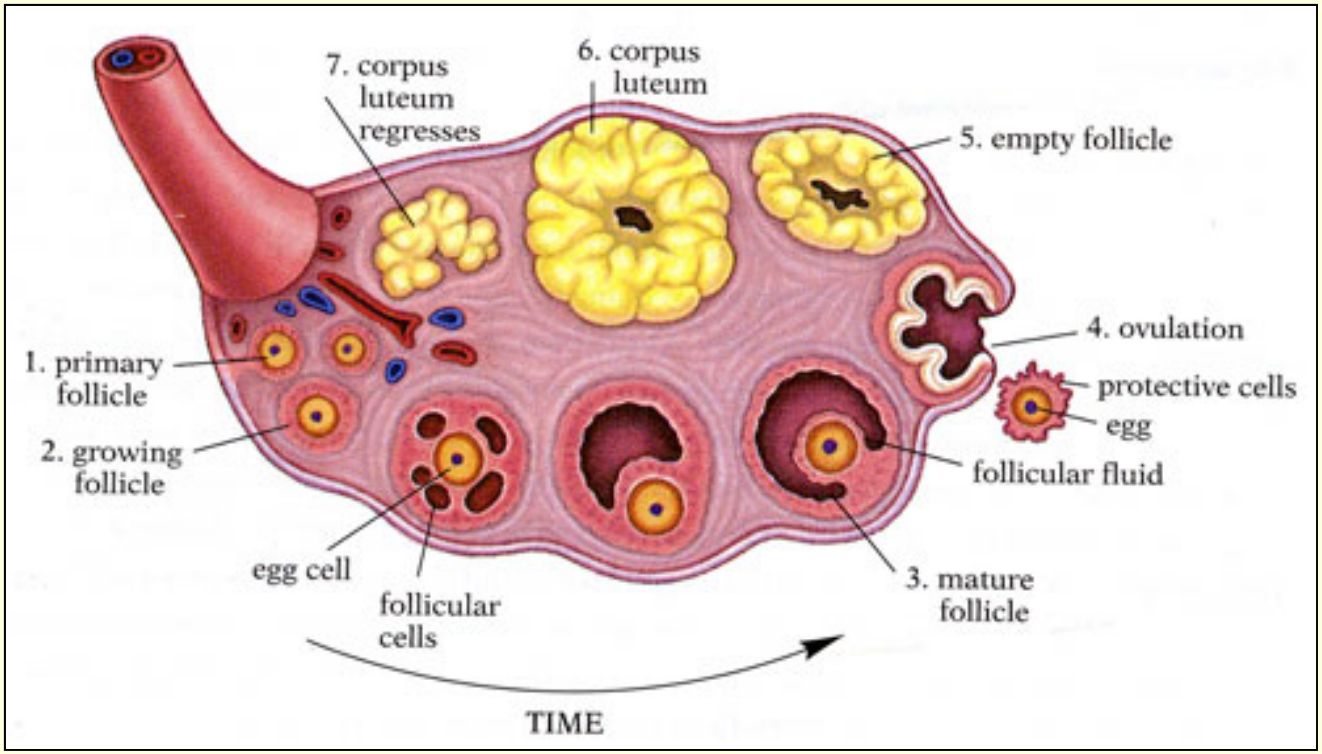
11.4.3 State the role of LH, testosterone and FSH in spermatogenesis.

- FSH- secreted by the pituitary gland, facilitates spermatogenesis
- LH- secreted by the pituitary gland, facilitates development of interstitial cells. The interstitial cells then secrete testosterone.
- Testosterone- secreted by the testes, facilitates spermatogenesis.



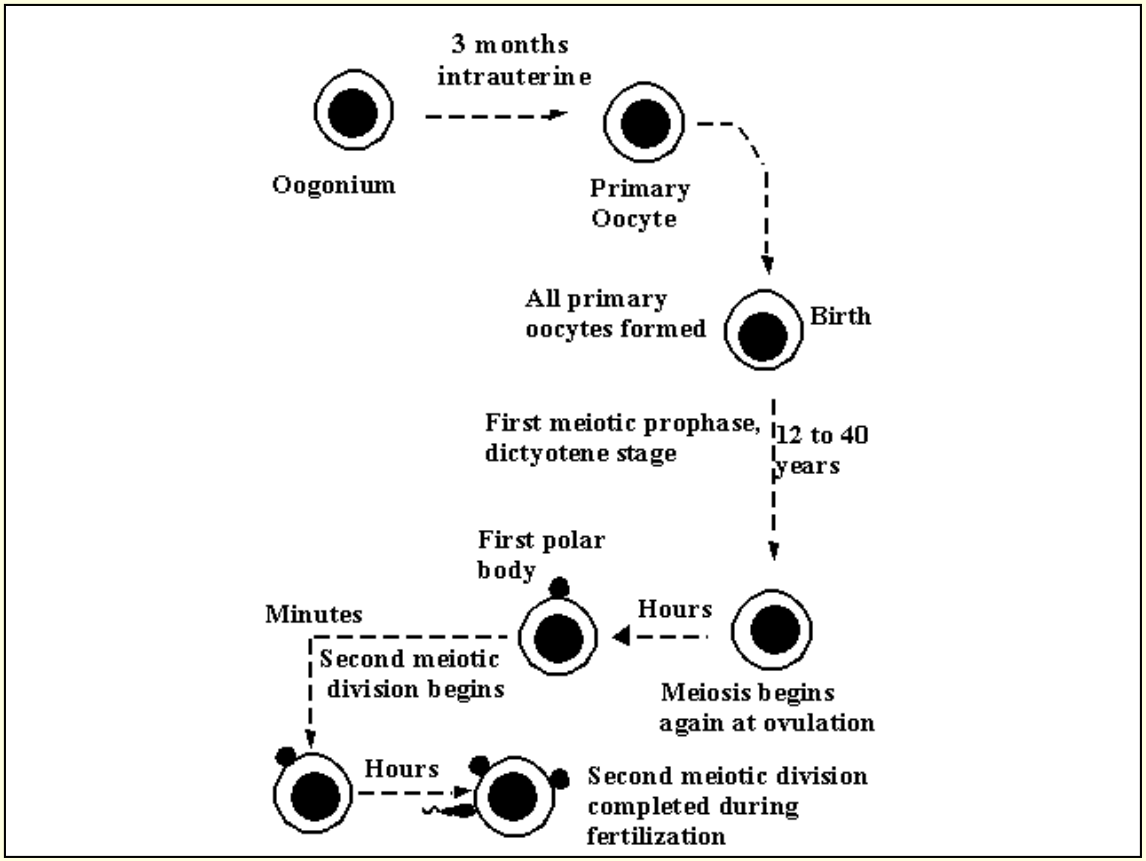
11.4.4 Annotate a diagram of the ovary to show the location and function of germinal epithelium, primary follicles, mature follice and secondary oocyte.

- Identify- developing oocytes, Graafian follicle, primary oocyte, zona pellucida.

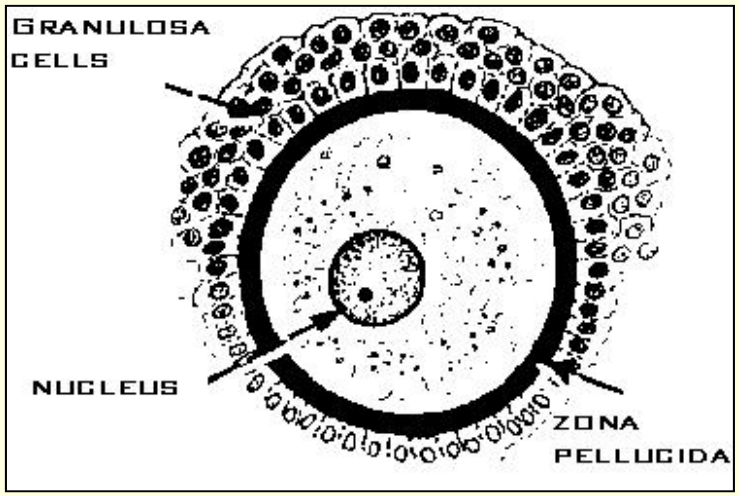


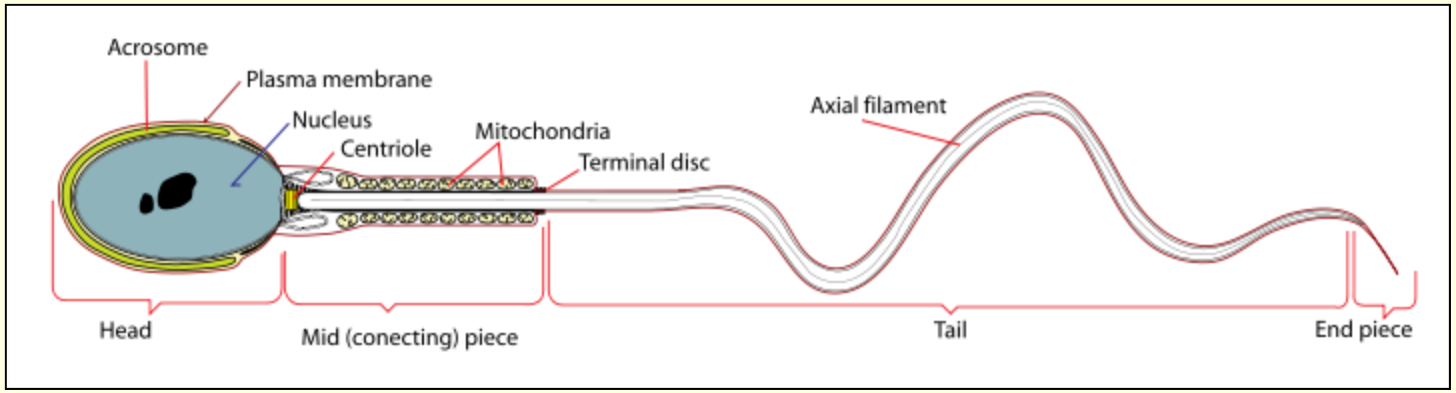
11.4.5 Outline the processes involved in oogenesis within the ovary.

- 1) mitosis
- 2) cell growth
- 3) two divisions of meiosis
- 4) unequal division of cytoplasm
- 5) degeneration of polar body



11.4.6 Draw and label a diagram of a mature sperm and egg.



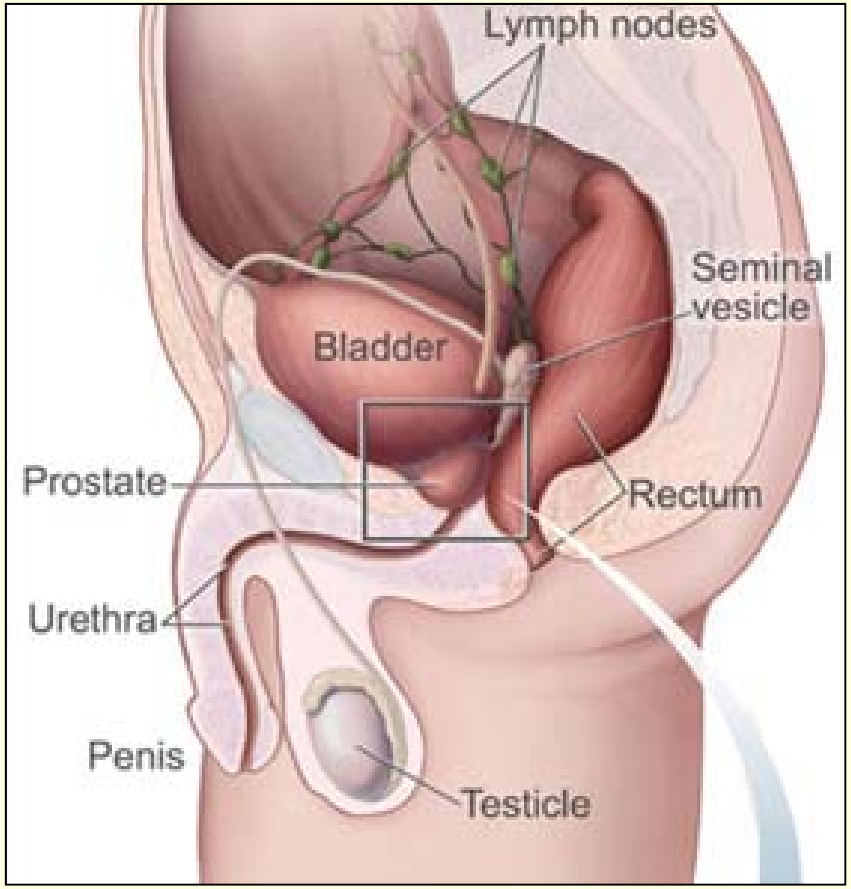


11.4.7 Outline the role of the epididymis, seminal vesicle and prostate gland in the production of semen.

Epididymis- an area above the testicle where sperm is stored until ejaculation.

Seminal vesicle- gland that contributes most of the fluid volume of semen (about 70%).

Prostate gland- also contributes to seminal fluid (about 10-30%).



11.4.8 Compare the processes of spermatogenesis and oogenesis.

Number of viable gametes formed from one stem cell:

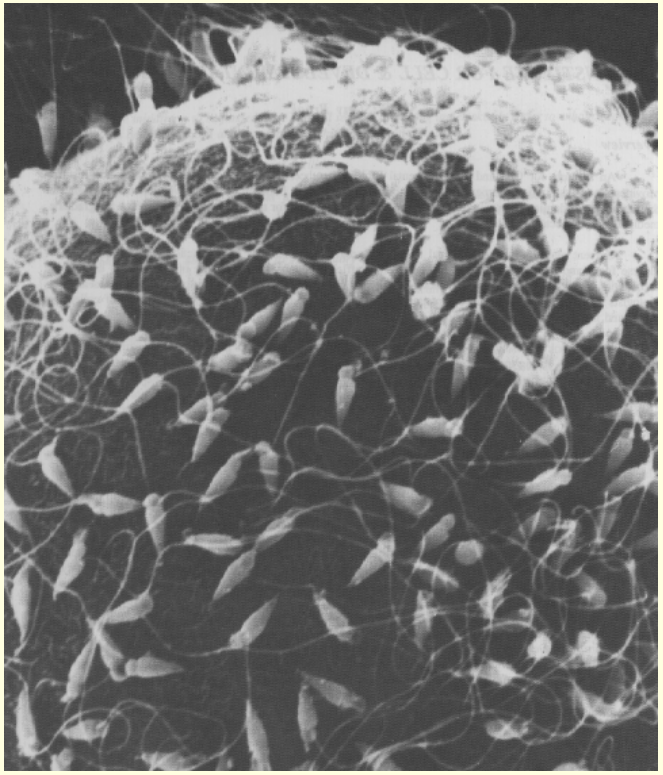
spermatogenesis → 4

oogenesis → 1

Timing and formation of gametes:

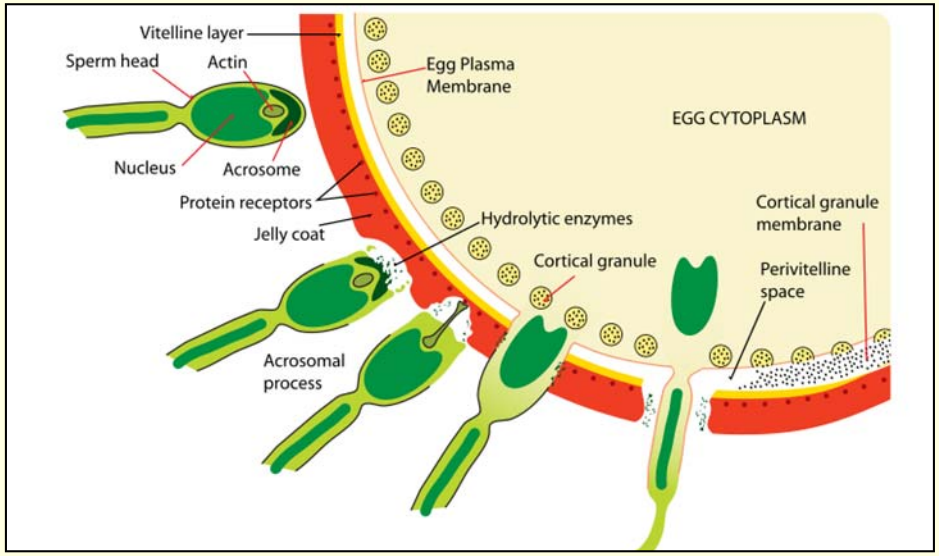
spermatogenesis- development of sperm is continuous from puberty onward.

oogenesis- development occurs in a monthly cycle, beginning with puberty and ending with menopause.



11.4.9 Describe the process of fertilization.

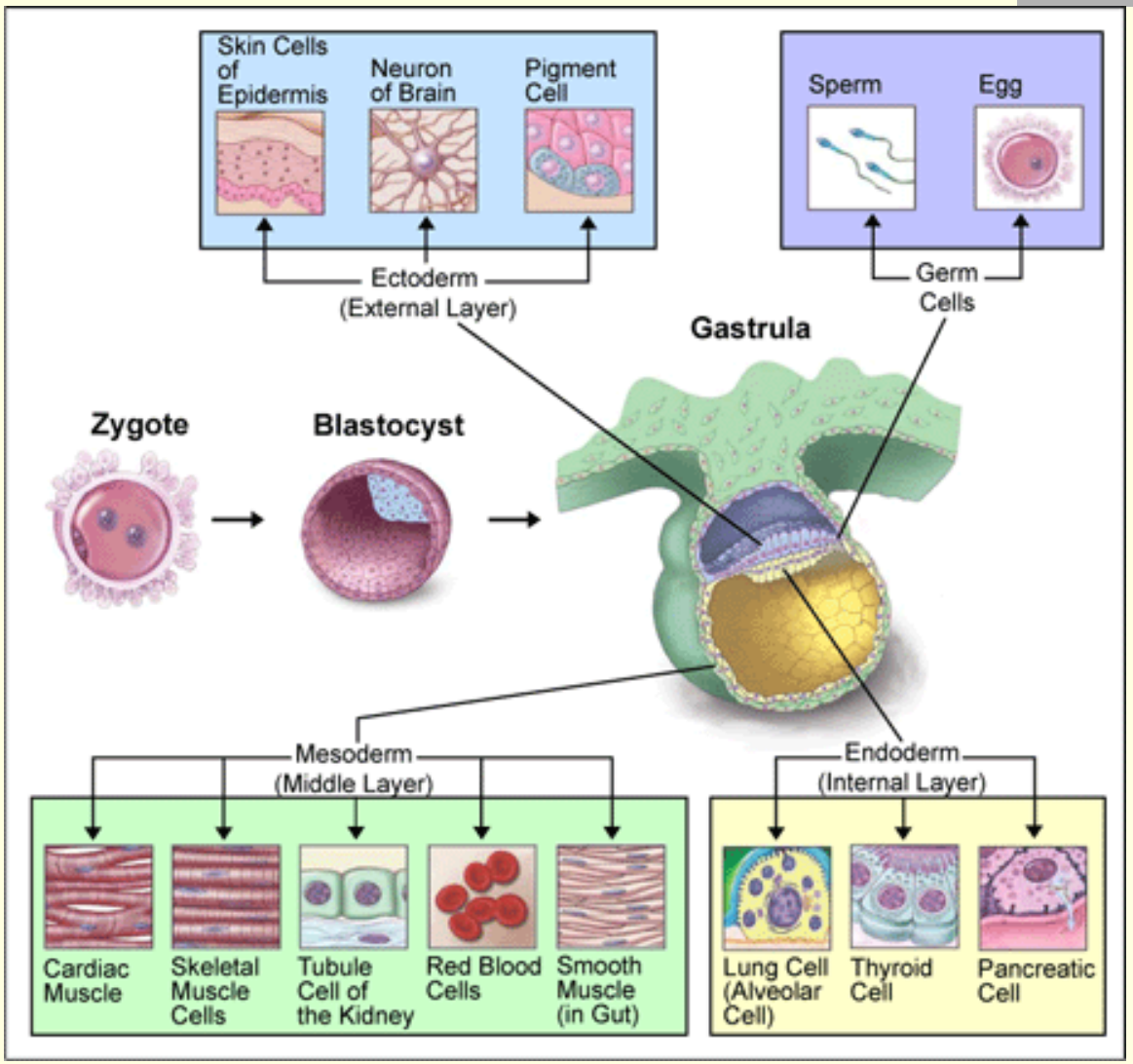
- 1) acrosome reaction- acrosome releases enzymes which digest the surrounding layer of the egg.
- 2) penetration of egg membrane by sperm
- 3) cortical reaction- cortical granules are secreted by the egg via exocytosis, rendering the egg impermeable to future sperm.



11.4.10 Outline the role of human chorionic gonadoprophin (HCG) in early pregnancy.

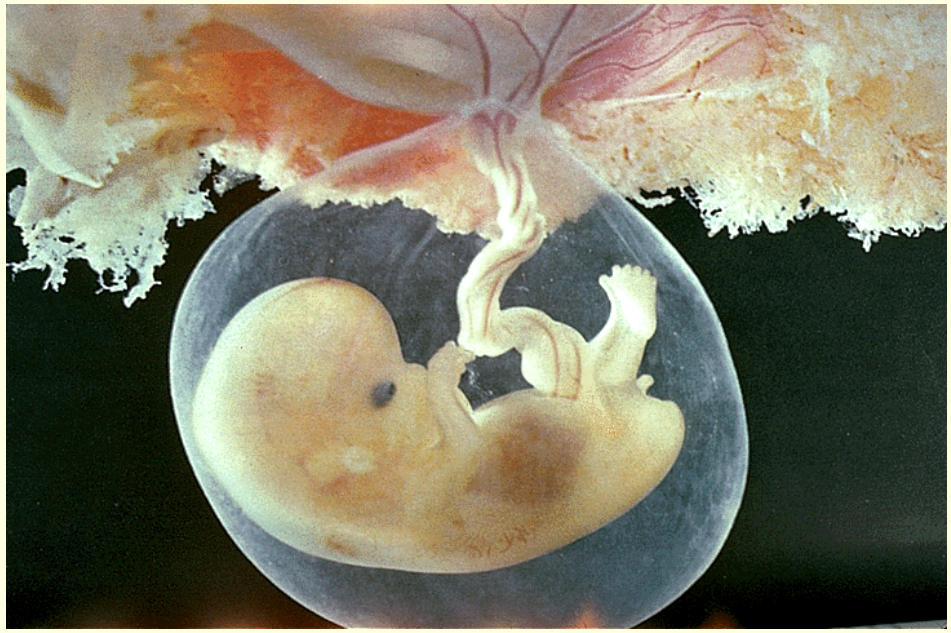
- HCG is secreted by the embryo during early pregnancy. HCG helps signals the corpus luteum to stay active by continuing to secrete progesterone, which maintains the pregnancy.

11.4.11 Outline early embryo development up to the implantation of the blastocyst.

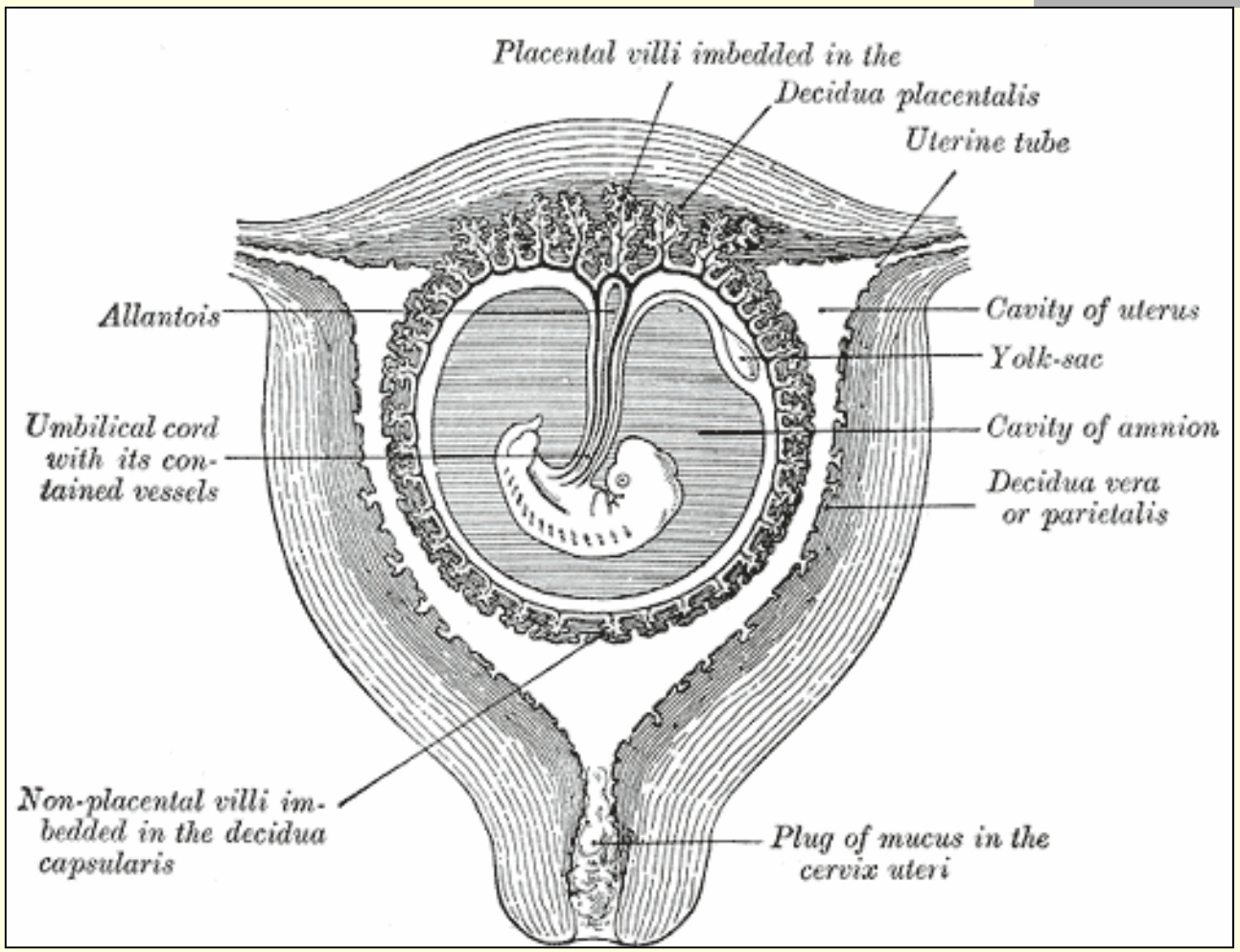


11.4.12 Explain how the structure and functions of the placenta, including it's hormonal role in secretion of estrogen and progesterone, maintain pregnancy.

- The placenta's primary purpose is to bridge the blood supply between mother and fetus.
- Secretion of progesterone helps maintain the uterine lining and placenta.
- Secretion of estrogen inhibits the development of new follicles.



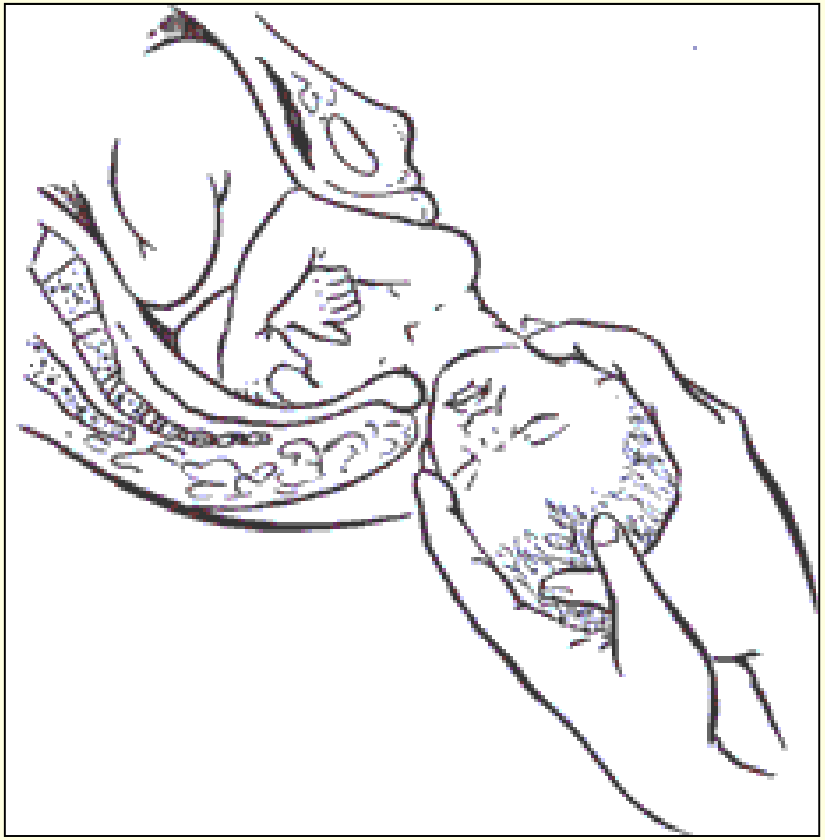
11.4.13 State that the fetus is supported and protected by the amniotic sac and amniotic fluid.



11.14.14 State that materials are exchanged between maternal and fetal blood in the placenta.

11.4.15 Outline the process of birth and its hormonal control.

- Reduction in the level of progesterone results in the release of oxytocin. Oxytocin causes uterine contractions that trigger further release of oxytocin. In this way, the contractions get stronger and more rapid. This is an example of positive feedback.



Option D: Evolution

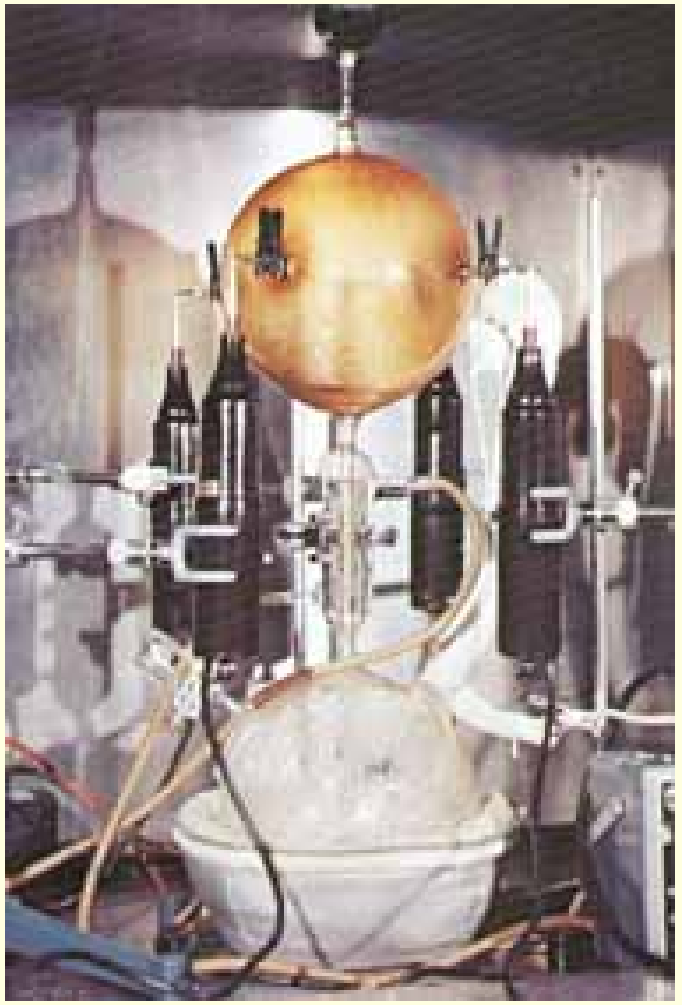
Lesson D:1 Origin of Life on Earth

D.1.1 Describe four processes needed for the spontaneous origin of life on Earth

- The non-living synthesis of simple organic molecules
- The assembly of these molecules into polymers
- The origin of self-replicating molecules that made inheritance possible
- The packaging of these molecules into membranes with an internal chemistry different from their surroundings.

D.1.2 Outline the experiments of Miller and Urey into the origin of organic compounds.

- Purpose- to test the hypothesis that organic molecules can form spontaneously under the right conditions.
- Gases used: ammonia, methane and hydrogen, which created a reducing atmosphere.
- It worked! Amino acids and other simple organic molecules were formed by the apparatus.

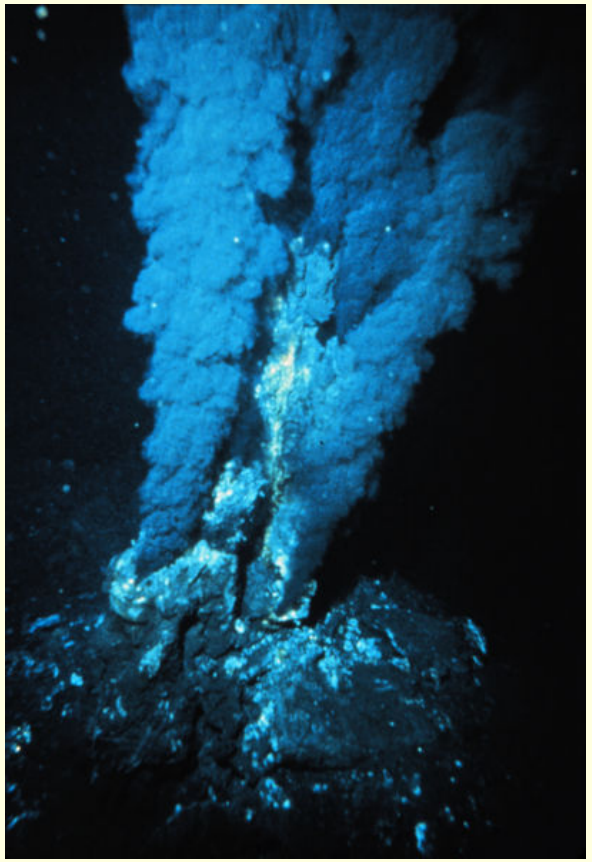


D.1.3 State that comets may have delivered organic compounds to Earth.

Courtesy of Philipp Salzgeber

D.1.4 Discuss possible locations where conditions would have allowed the synthesis of organic compounds.

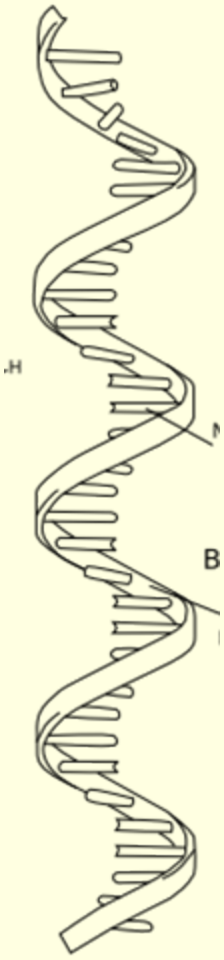
- Communities around deep-sea hydrothermal vents
- Volcanos
- Extraterrestrial locations



D.1.5 Outline two properties of RNA that would have allowed it to play a role in the origin of life.

- RNA is composed of a single helix, versus DNA's double helix. The bases are exposed and ready to combine with a complement, giving them the ability to self-replicate.

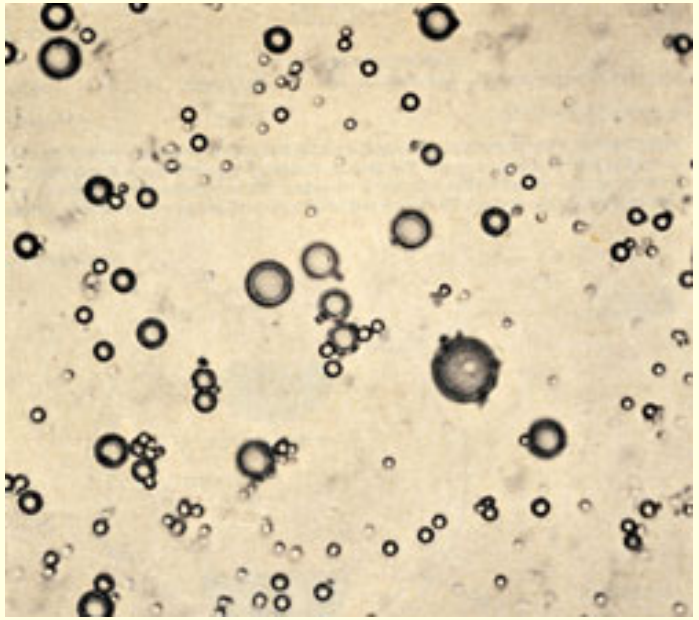
- Clay contains Zinc and other substances which help it act like a template, facilitating the replication of RNA. The theory proposes that without clay, 5-chain polymer could replicate, whereas with clay, up to 20 chain polymer could replicate.



RNA

D.1.6 State that living cells may have been preceded by protobionts, with an internal chemical environment different from their surroundings.

- Protobionts are *abiotic* spheres in which an internal environment can be maintained. Two examples are:



  - Coacervates- small spheres which maintain an internal environment different from the external environment. Can grow, shrink and split due to a semi-permeable membrane.

  - Microspheres- spheres formed upon the cooling of thermal proteins. Considered more stable than coacervates.

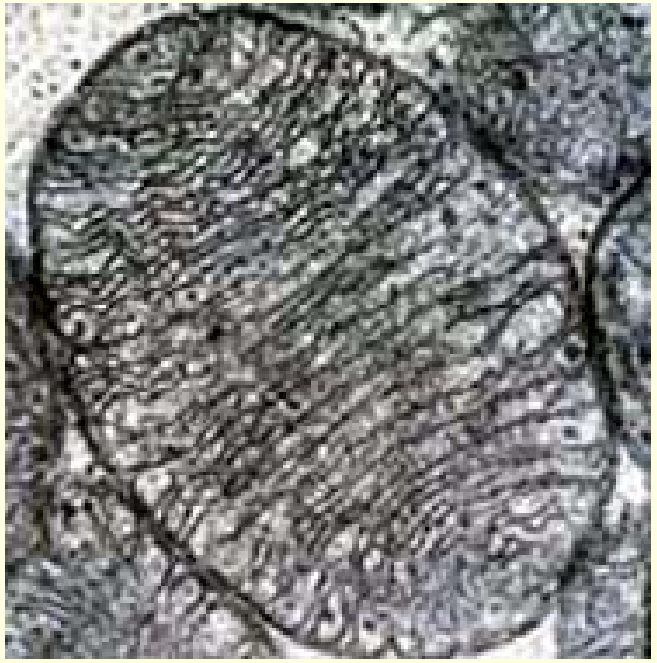
D.1.7 Outline the contribution of prokaryotes to the creation of an oxygen-rich atmosphere.

- Cyanobacteria, which are photosynthetic, converted the Earth's early atmosphere from anoxia to one which contained free oxygen. This occurred approximately 2.7 to 2.2 billion years ago.

Courtesy of Ralf Wagner

D.1.8 Discuss the endosymbiotic theory for the origin of eukaryotes.

- According to the theory, mitochondria were originally independent organisms that were engulfed by another independent organism. Instead of being dismantled for nutritional purposes, the host found it more beneficial to keep the mitochondria intact. Similar circumstances are believed to have occurred with chloroplasts.



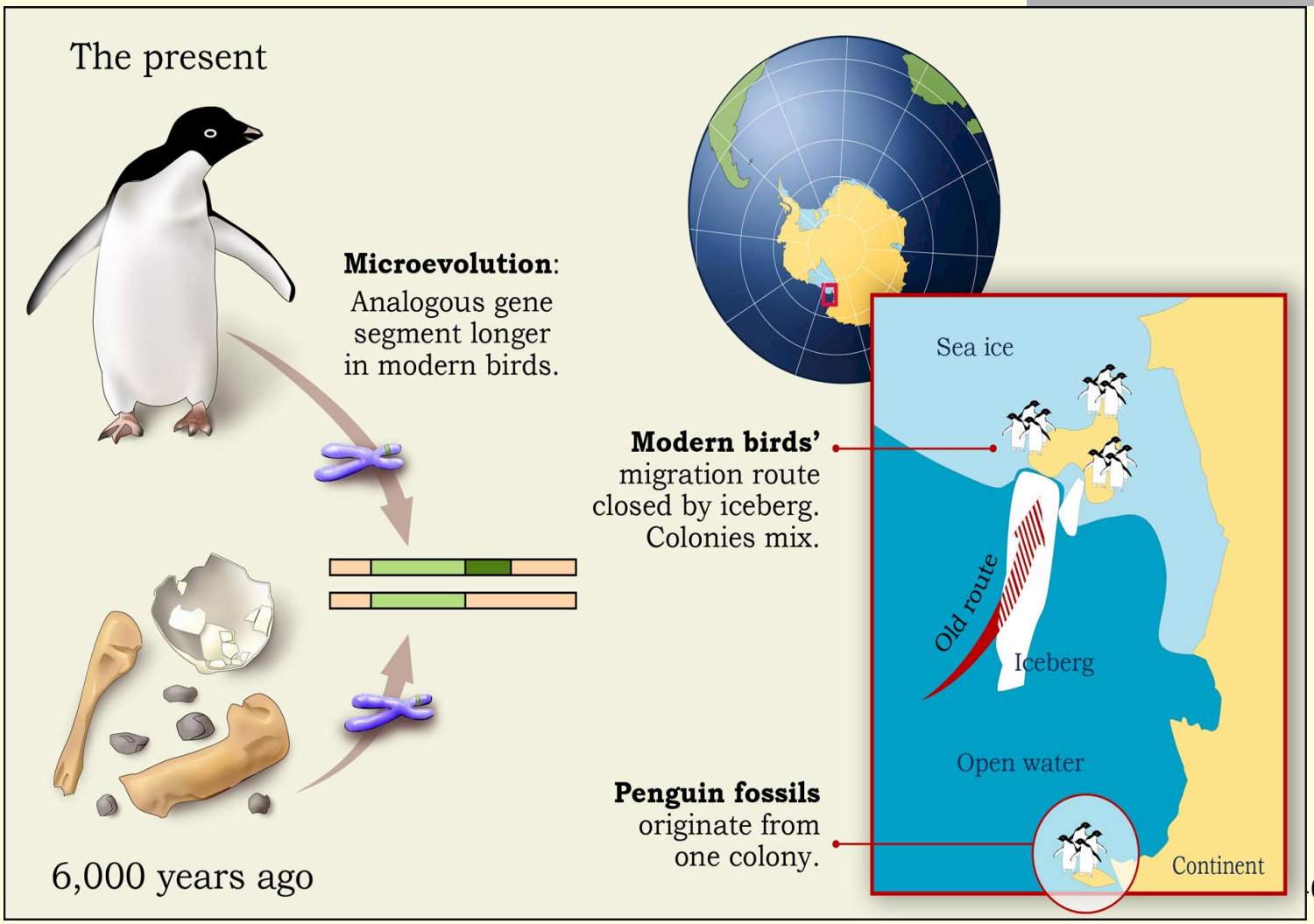
Option D: Evolution

Lesson D:2 Species and Speciation

D.2.1 Define allele frequency and gene pool

- Allele frequency- the percentage with which a specific allele is found in a population.
- Gene Pool- the sum total of all alleles present in all populations of a particular species.

D.2.2 State that evolution involved a change in allele frequency in a population's gene pool over a number of generations.



D.2.3 Discuss the definition of the term *species*.

New Species- result from the accumulation of *many* advantageous alleles in the gene pool of a population over a long period of time. In other words, new species result from Macroevolution.

Macroevolution- the accumulation of multiple microevolutionary steps, combined with reproductive isolation. An example would be Darwin's finches.

D.2.4 Describe three examples of barriers between gene pools.

- 1) Geographical isolation- occurs when a population is physically separated, usually due to a natural disaster such as an avalanche, fire, earthquake, etc.

- 2) Temporal isolation- due to timed barriers, e.g. reproducing during different seasons.

- 3) Behavioral isolation- courtship mating displays may only be recognized by members of the same species, e.g. bird songs.

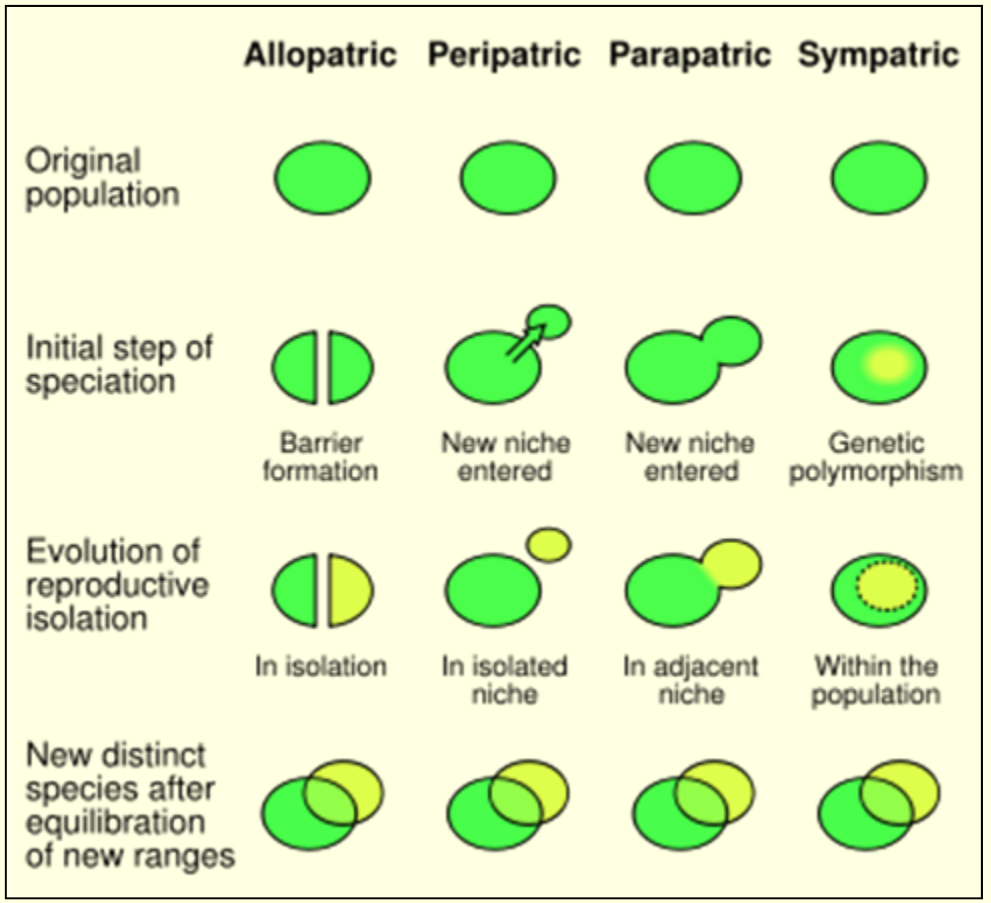
D.2.5 Explain how polyploidy can contribute to speciation.

- Polyploidy occurs when more than two sets of homologous chromosomes are present. Examples such as triploidy (3x) and tetraploidy (4x) are often due to a disruption in the meiotic sequence. Chromosomes replicate, but remain together in the same cell.

- Once polyploidy occurs, the individual is often unable to mate with the original species, causing immediate species divergence.

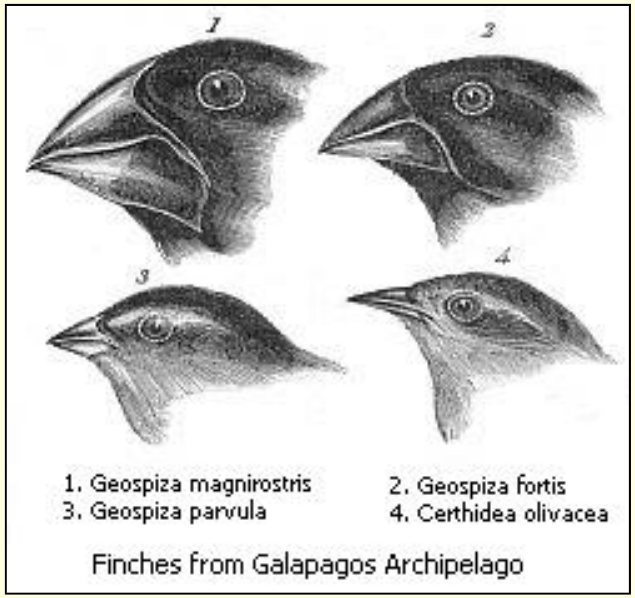
D.2.6 Compare allopatric and sympatric speciation.

- Speciation- the formation of a new species by splitting of an existing species.
- Sympatric speciation- occurs in the same geographical area.
- Allopatric speciation- occurs in different geographical areas.



D.2.7 Outline the process of adaptive radiation.

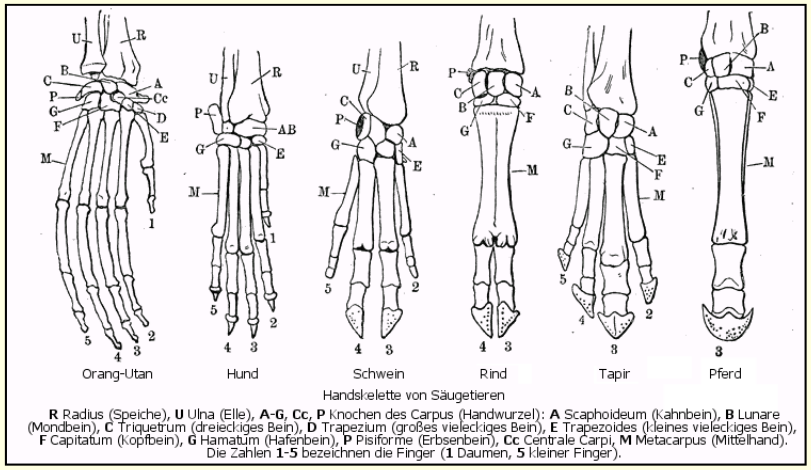
- As populations drift or expand to different geographical locales, local environmental conditions will favor some traits over others, causing phenotypes in different areas to diverge. This can result in radiant speciation. A classic example are the Galapagos Islands, which Darwin first studied.



D.2.8 Compare convergent and divergent evolution.

- Convergent Evolution- individuals of different species develop similar traits in response to living in the same habitat. For example, many species of desert plants develop thick cuticles to deter water loss.

- Divergent Evolution- occurs when different traits share a common evolutionary origin. For example, vertebrate limbs have many unique shapes, but their bone patterns trace back to a common ancestral configuration.



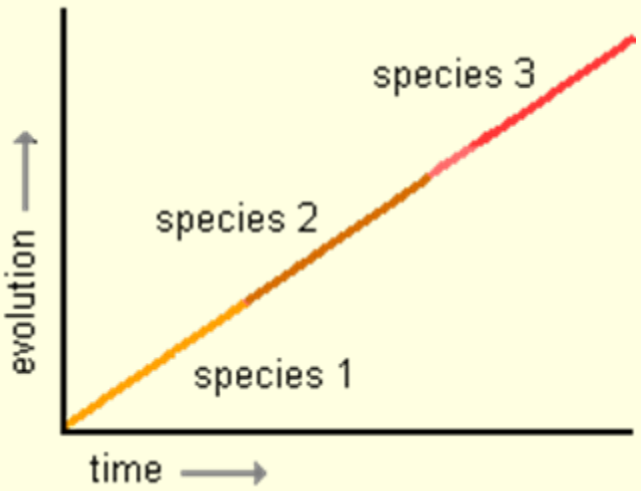
Handskelette von Säugetieren

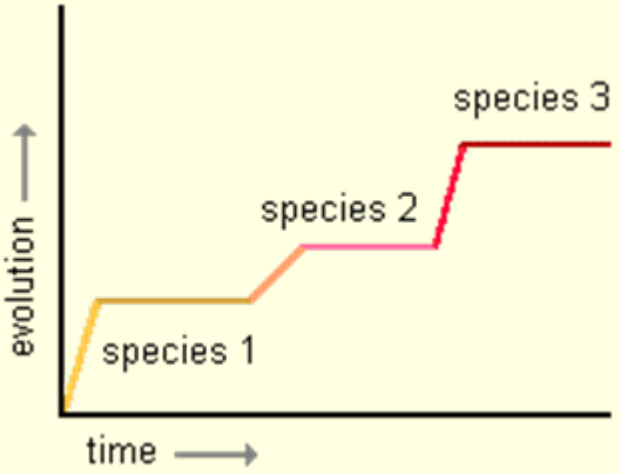
R Radius (Speiche), **U** Ulna (Elle), **A-G, Cc, P** Knochen des Carpus (Handwurzel): **A** Scaphoideum (Kahnbein), **B** Lunare (Mondbein), **C** Triquetrum (dreieckiges Bein), **D** Trapezium (großes vieleckiges Bein), **E** Trapezoides (kleines vieleckiges Bein), **F** Capitatum (Kopfbein), **G** Hamatum (Hakenbein), **P** Pisiforme (Erbsenbein), **Cc** Centrale Carpi, **M** Metacarpus (Mittelhand). Die Zahlen **1-5** bezeichnen die Finger (**1** Daumen, **5** kleiner Finger).

D.2.9 Discuss ideas on the pace of evolution, including gradualism and punctuated equilibrium

- Gradualism- the slow change from one form to another.

- Punctuated equilibrium- long periods of no change and short periods of rapid evolution. Some causes are volcanic eruptions and meteor impacts on Earth.



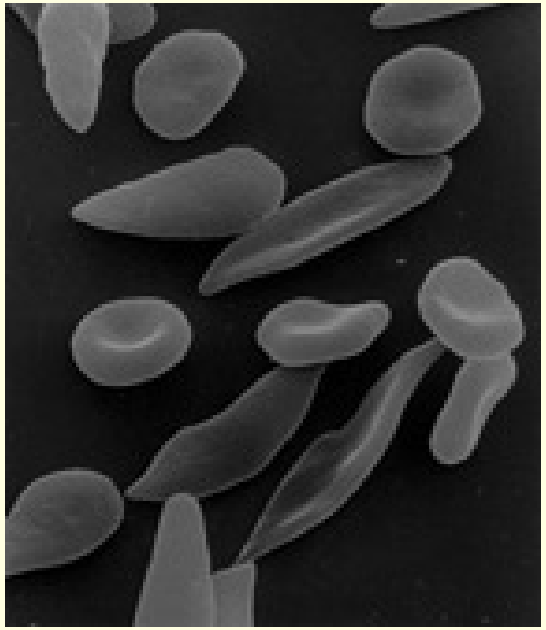


D.2.10 Describe one example of transient polymorphism.

- Transient polymorphism- Before the industrial revolution, the peppered moths with lighter phenotypes were more common because they blended in with the light colored tree-trunks they rested on. With factories came soot, which darkened the tree barks. In the span of several decades, the predominant phenotype was a much darker grey.

D.2.11 Describe sickle-cell anemia as an example of balanced polymorphism.

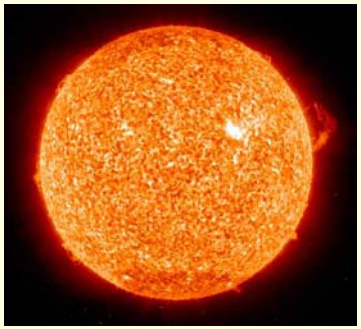
- Sickle cell anemia is a homozygous recessive disorder (ss). The heterozygous individual (Ss) does not have sickle cell anemia, but is more resistant to malaria than an individual who does not carry a sickle cell gene at all (SS). This creates selective pressure to keep the sickle cell gene in the gene pool, resulting in balanced polymorphism.



Option D: Evolution

Lesson D:3 Human Evolution

D.3.1 Outline the method for dating rocks and fossils using radioisotopes, with reference to C^{14} and K^{40}.

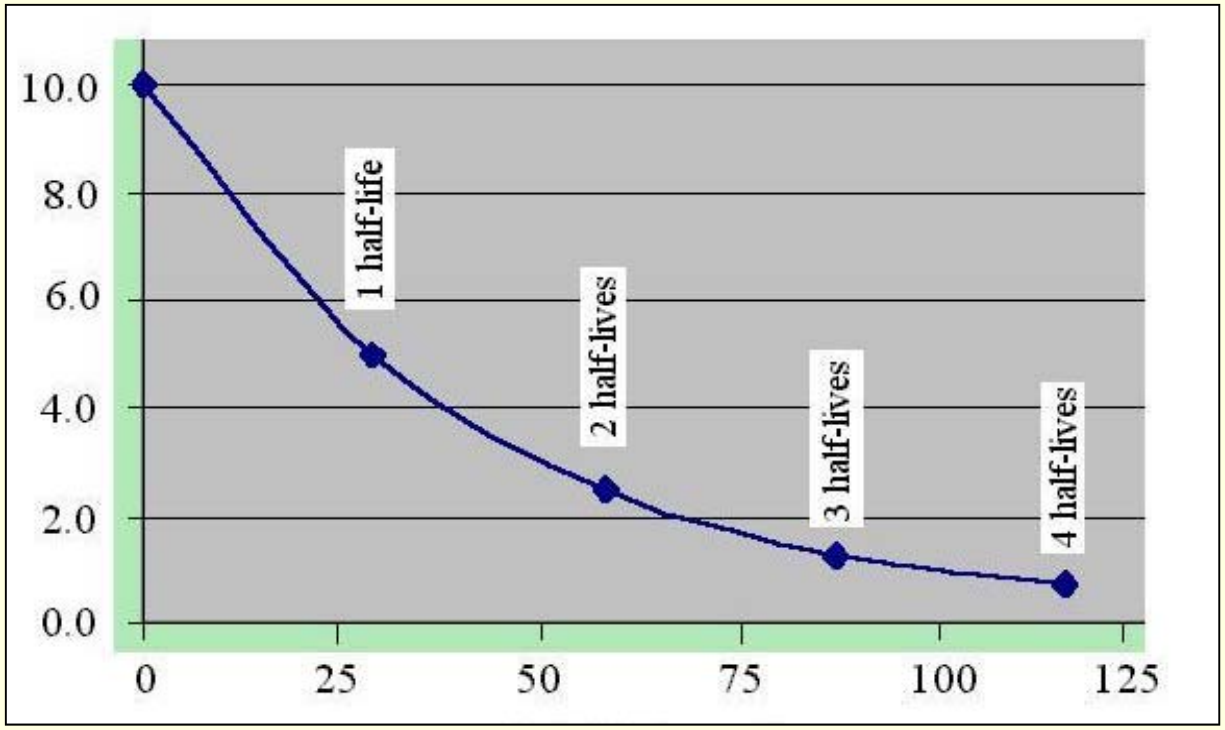


The sun causes a certain percentage of Carbon to become an isotope. Living systems incorporate carbon, and have the same % of Carbon isotopes as the atmosphere. Upon death, no new carbon is incorporated into the body, and the isotopes start to decay at the half-life rate.

The half-life of C^{14} is 5730 years, and can be used to date material up to 50,000 years old. The half-file of K^{40} is 2.3 billion years, and can be used to date rocks over one million years old.

D.3.2 Define *half-life*.

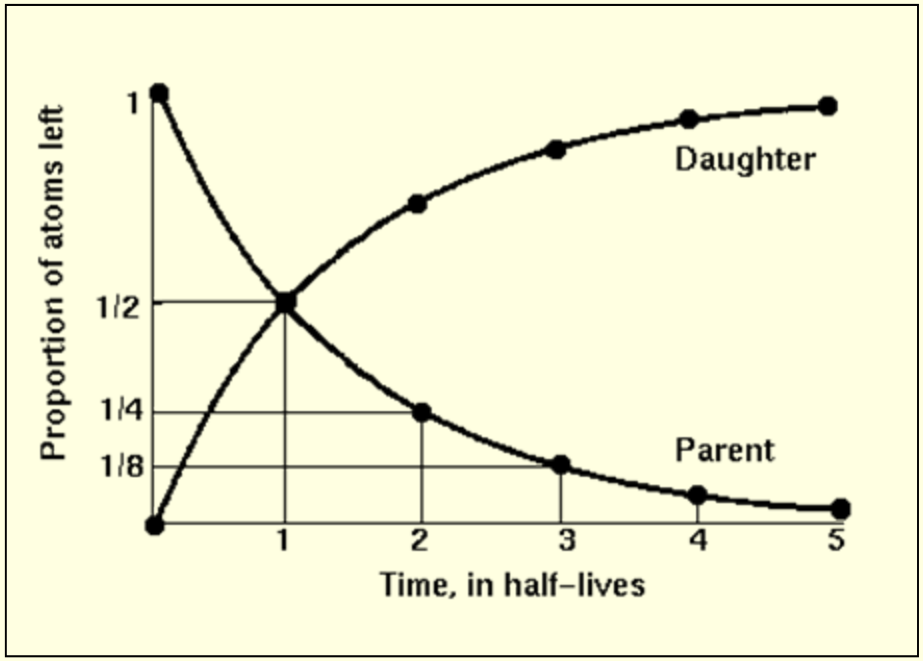
Half life- the amount of time it takes for half of the radioactive isotopes of a particular substance to decay.



D.3.3 Deduce the approximate age of materials based on a simple decay curve for a radioisotope.

- Problem: If the half-life of C^{14} is 5730 years, after how many years would a sample have a quarter of it's isotopes left?

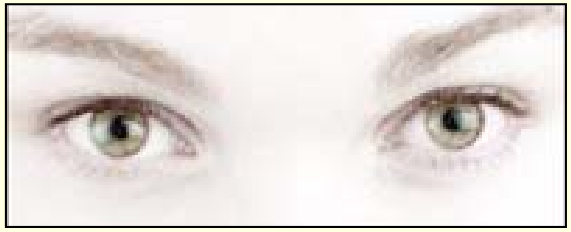
- Answer: 11,460 years



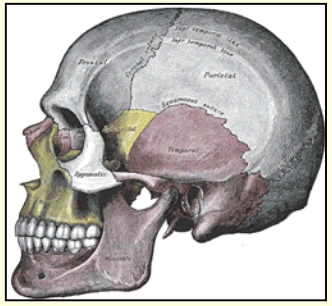
D.3.4 Describe the major physical features, such as the adaptations for tree life, that define humans as primates.

1) Opposable Thumb

2) Acute Vision



3) Large Cranial Capacity



D.3.5a Outline the trends illustrated by the fossils of Ardiphithecus ramidus, Australopithecus, and the genus Homo.

- *A. ramidus*- 5.8-5.2 million years ago. Oldest known hominid. Large canines. Evidence of bipedalism is inconclusive.
- *A. afarensis*- 3.9-2.9 million years ago. Bipedal. Reduced canines.
- *A. africanus*- 3.3-2.5 million years ago. Similar to *A. afarensis*, but slightly larger brain.

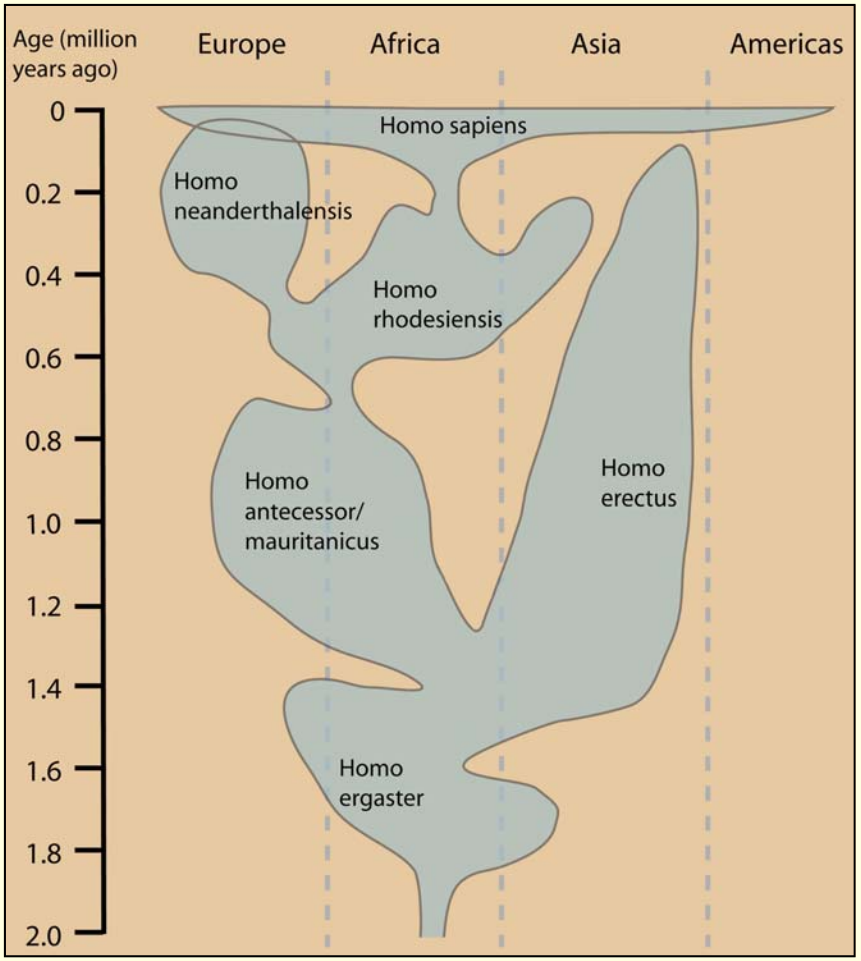
Artist's interpretation of A. africanus.

D.3.5b Outline the trends illustrated by the fossils of Ardiphithecus ramidus, Australopithecus, and the genus Homo.

- *H. habilis*- 2.6-1.4 million years ago. Used first simple, stone tools. Protrusions in face starting to reduce.
- *H. erectus*- 1.8-1 million years ago. More advanced tool, possibly used fire.
- *H. neanderthalensis*- 500,000-24,000 years ago. Short, thick bodies adapted to cold climate. Largest cranial capacity.
- *H. sapiens*- 50,000-present. Cranial capacity not as large as *N. neanderthalensis*, but better able to use their brains to develop agricultural and hunting skills.

Neanderthal skull

D.3.6 State that, at various stages in hominid evolution, several species may have coexisted.



Courtesy of Tim Vickers

D.3.7 Discuss the incompleteness of the fossil record and the resulting uncertainties about human evolution.

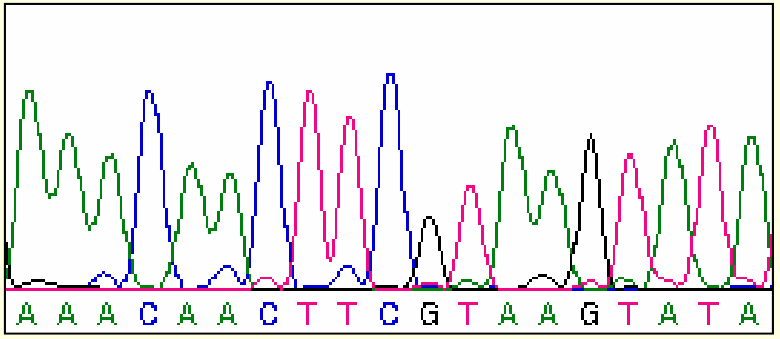
- Many fossils, from Australopithecines through the genus Homo, are incomplete. Often only partial skulls and just a few bones are found, because only a small percentage of organic matter is ever fossilized. There are also very few neanderthal fossils.

D.3.8 Discuss the correlation between the change in diet and increase in brain size during hominid evolution.

- As brain size increased, the ability to hunt and farm more efficiently increased. This leads to a better nutrition, which in turn supported an even greater increase in cranial capacity. In essence, an evolutionary positive feedback loop.

D.3.9 Distinguish between genetic and cultural evolution.

- Genetic Evolution- the random change of base pair sequences, coupled with the relative resonance of these changes based on environmental conditions.



- Cultural Evolution- the change in practices and traditions, not through genetics but rather communicated in some form from generation to generation.

D.3.10 Discuss the relative importance of genetic and cultural evolution in the evolution of humans.

- Genetic evolution has profoundly influenced our physical traits, whereas cultural evolution has profoundly influenced traditions and societal touchstones. Cultural evolution accounts for art, music and language developments in society.

Option D: Evolution

Lesson D:4 The Hardy-Weinberg Principle

D.4.1 Explain how the Hardy-Weinberg equation $p^2 + 2pq + q^2=1$ is derived.

- Assuming a STATIC population,
- and A=p and a =q:
- P + q = 1 (1.0 = 100%)
- Possible genotypes are: pp, pq, qp qq
- p x p = p^2, etc., therefore…
- $P^2 + 2pq + q^2 = 1$

D.4.2 Calculate allele, genotype and phenotype frequencies for two alleles of a gene, using the Hardy-Weinberg equation.

- Cystic Fibrosis is a recessive genetic disorder. In a certain population, 2 out of every 2000 individuals have cystic fibrosis. What are the values of p & q? What percentage of the population are carriers?

- $q^2 = 2/2000 = .001$
- $q = \sqrt{.001} = .031$
- $p + .031 = 1$
- $p = .969$
- $2pq = .06$
- Hence, 6% of the population are carriers.

D.4.3 State the assumptions made when the Hardy-Weinberg equation is used.

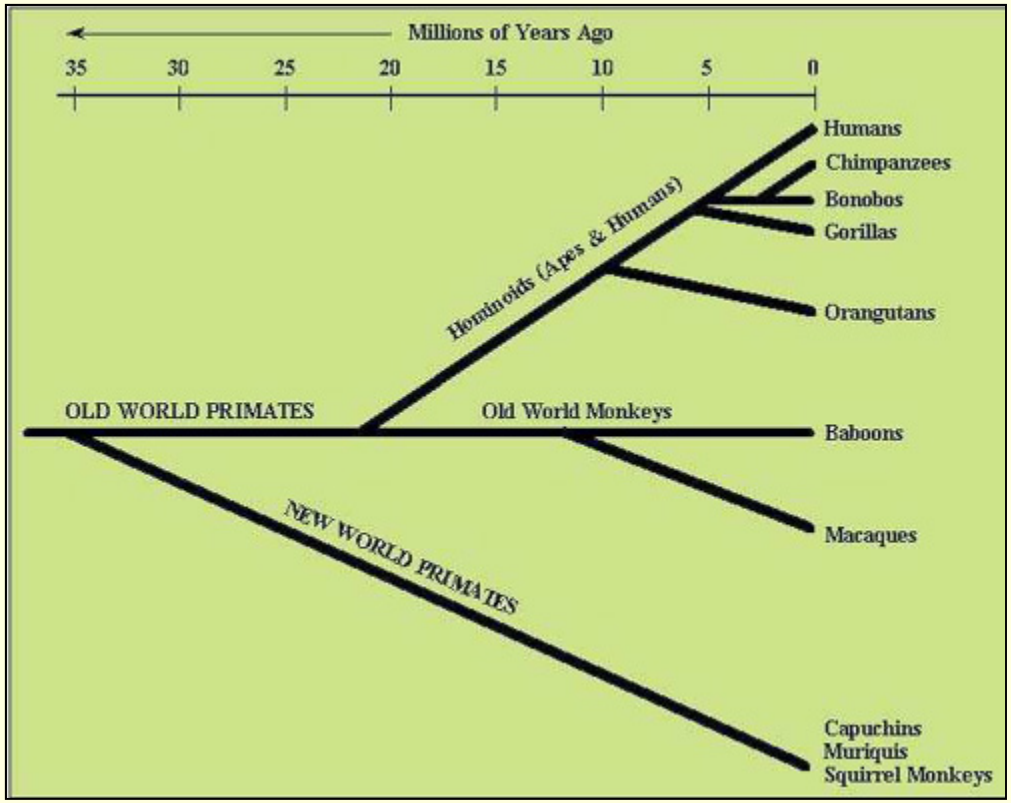
- Hardy-Weinberg assumptions:
  1) Large population
  2) Random mating
  3) Constant allele frequency over time
  4) No allele-specific mortality
  5) No mutation
  6) No immigration or emmigration

Option D: Evolution

Lesson D.5 Phylogeny and Systematics

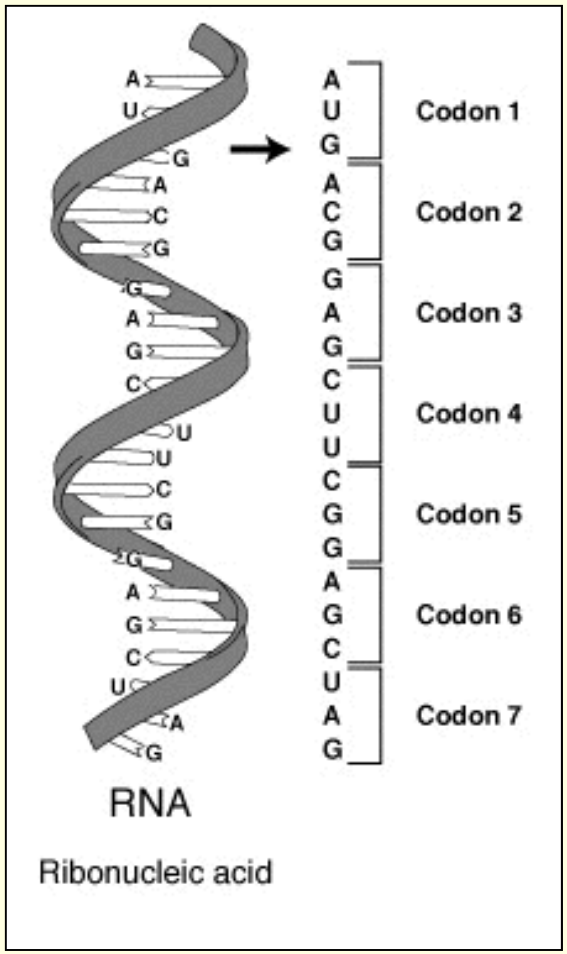
D.5.1 Outline the value of classifying organisms.

- The organization of data about living organisms helps identify them, show evolutionary links, and enables prediction of characteristics shared by members of a group.



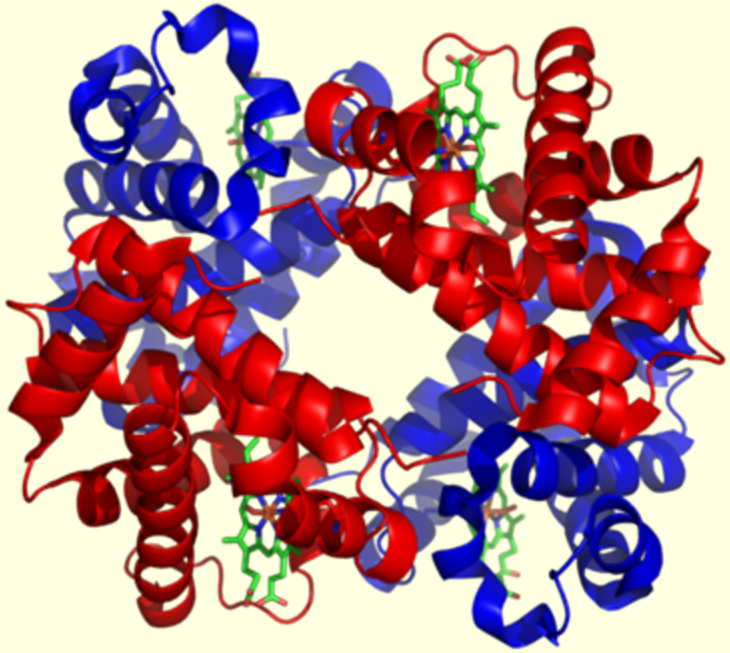
D.5.2 Explain the biochemical evidence provided by the universality of DNA and protein structures for the common ancestry of living organisms.

- All amino acids are coded for by mRNA codon sequences, which are transcribed from DNA codons. Codons are derived from the same four bases regardless of species: A,T,G and C. The universality of the code points to a common evolutionary ancestry.



D.5.3 Explain how variations in specific molecules can indicate phylogeny.

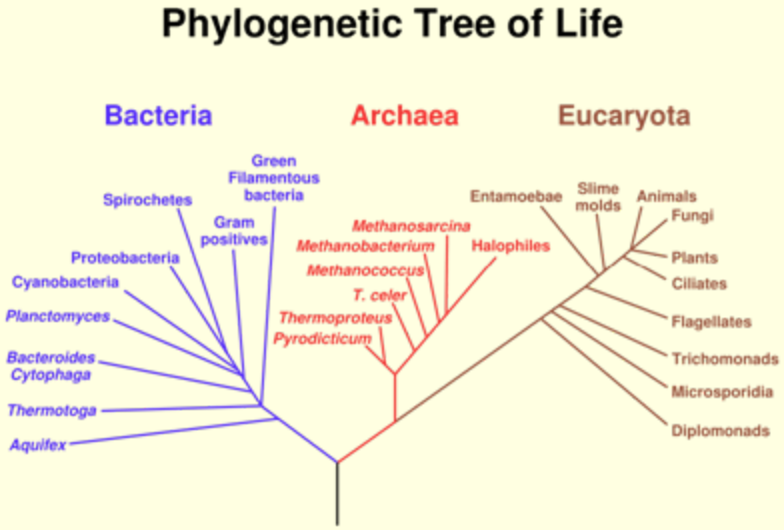
- Hemoglobin is found in most animals, but the nucleotide sequence can vary by species. Tracking and comparing these variations can help place species relative to each other on a phylogenetic tree.



Hemoglobin molecule, courtesy of Richard Wheeler

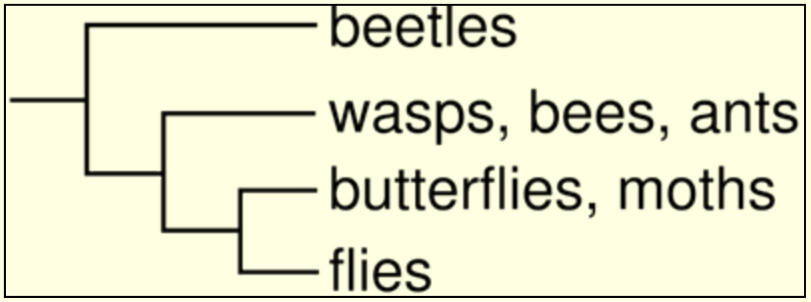
D.5.4 Discuss how biochemical variations can be used as an evolutionary clock.

- DNA replication errors occur with specific frequency over time. These errors can act as a molecular clock, helping determine how closely related two branches are on the phylogenetic tree. The greater the variation in replication errors, the further apart two groups are on the tree.



D.5.5 Define *clade* and *cladistics*.

- Clade- a group of organisms who share common characteristics.
- Cladistics- a taxonomic system of separating clades based on the differentiation of characteristics.

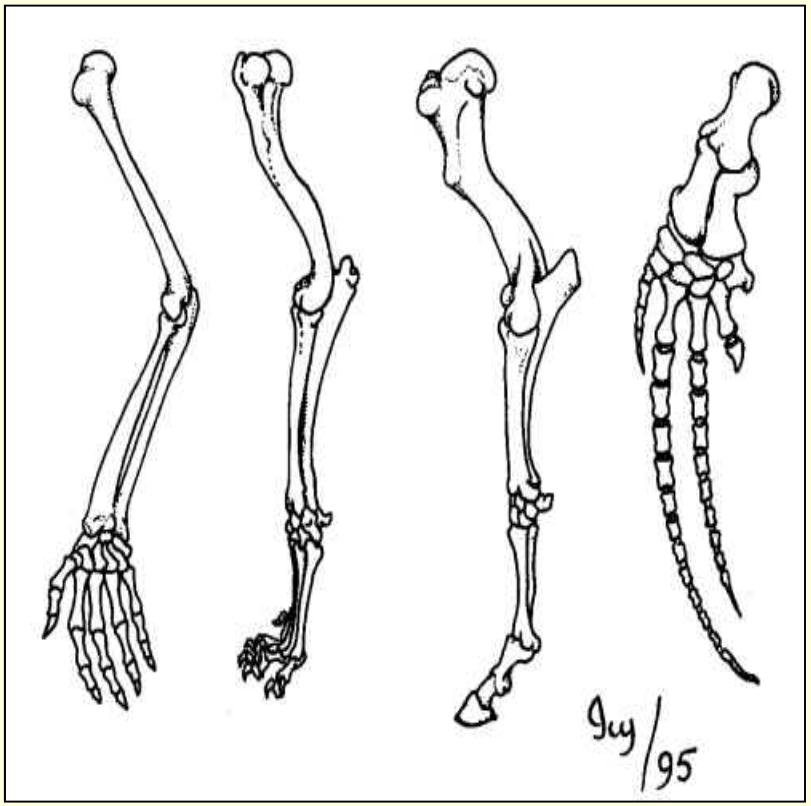


Courtesy of Geoffrey Adams

D.5.6 Distinguish, with examples, between analogous and homologous characteristics.

- Analogous characteristics- show similarity without necessarily having a common ancestor. Example: the spines on a porcupine and the needles on a cactus.

- Homologous characteristics- show similarity due to the sharing of a common ancestor. Example: the flipper of a whale and the human hand.

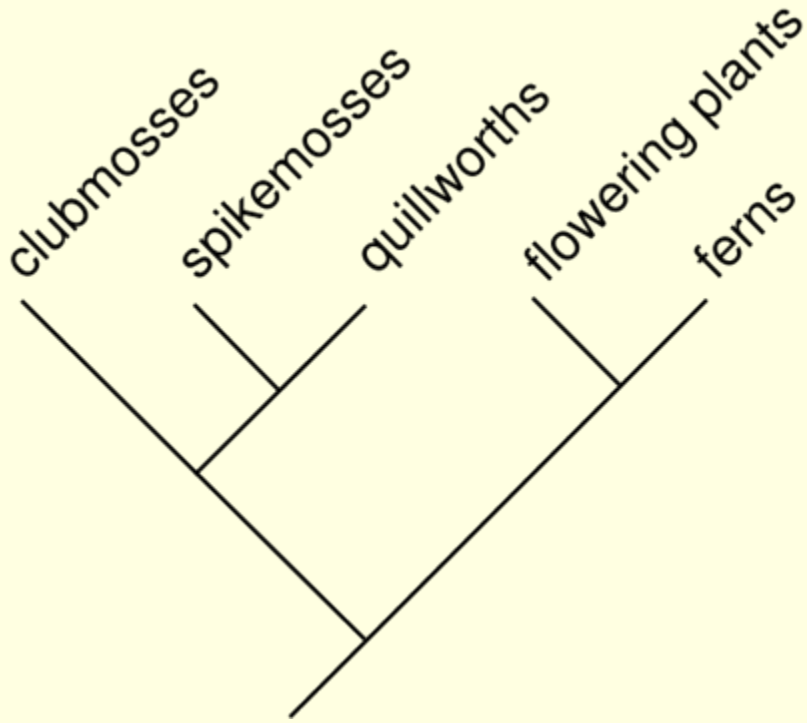


Homologous structures

D.5.7 Outline the methods used to construct cladograms and the conclusions that can be drawn from them.

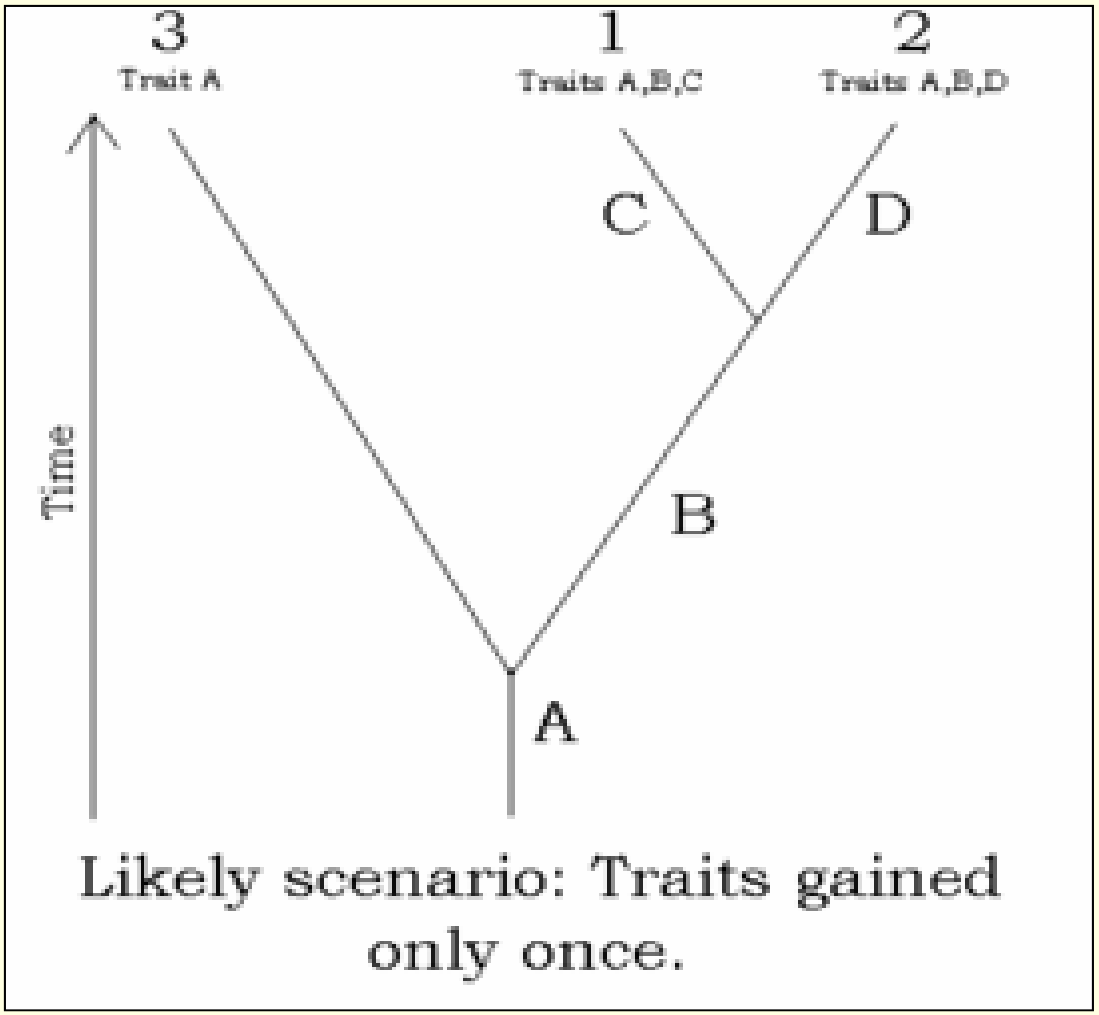
- Cladograms start with an "in-group", which contain certain characteristics. Another group is then compared to the in-group. If the second group illustrates all the same characteristics, it is placed in the in-group. If it differs in any way, it is placed in its own clade. Clades are separated from each other based on single differences, and are then placed in sequence.

- Note that a cladograms do not make any assumptions about the time period involved in an evolutionary change, rather, they indicate that one has occurred.



Courtesy of Geoffrey Adams

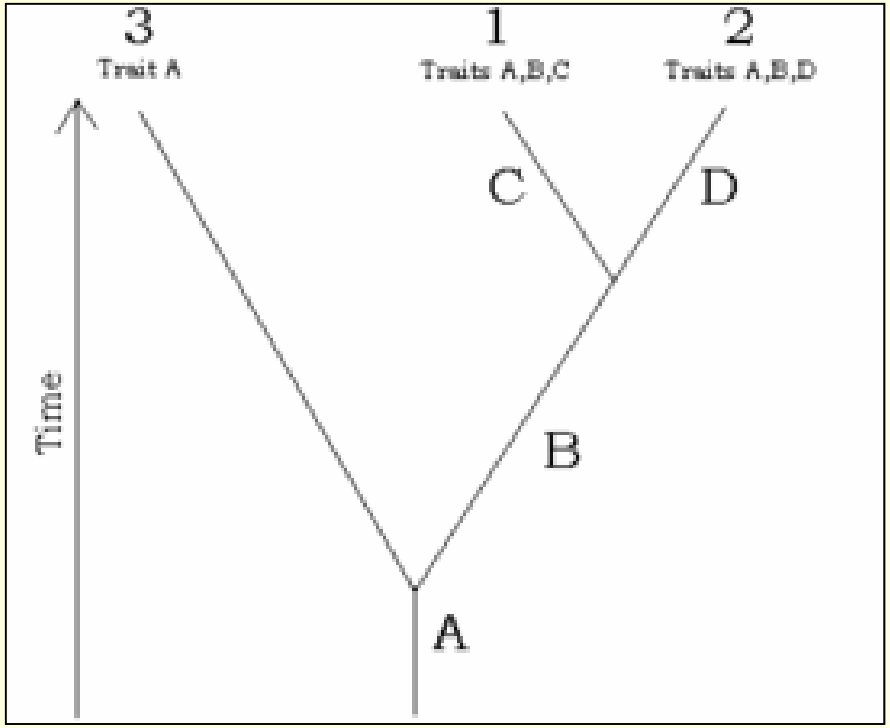
D.5.8 Construct a simple cladogram.



Likely scenario: Traits gained only once.

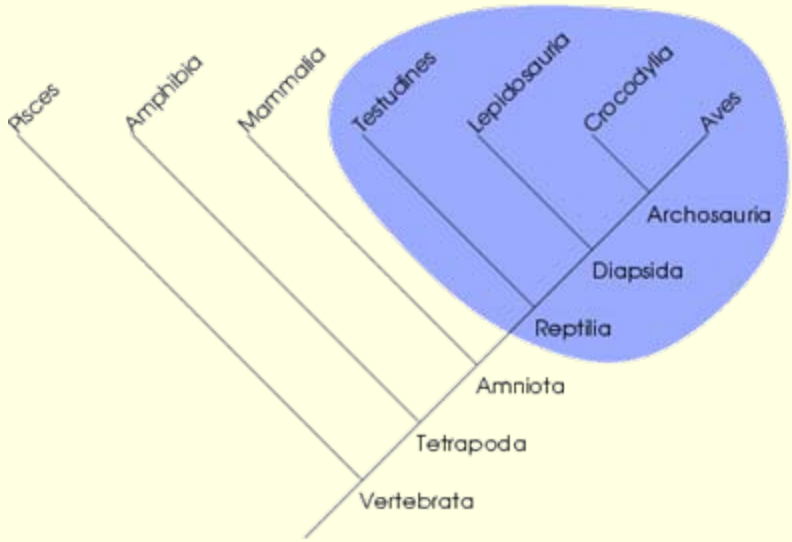
D.5.9 Analyze cladograms in terms of phylogenetic relationships.

- Organisms “C” and “D” are more closely related to each other, because they both share traits “A” and “B”.



D.5.10 Discuss relationships between cladograms and the classification of living organisms.

- Monophyletic- a group which shares a common ancestor.
- Paraphyletic- a group which contains some, but not all members associated with a common ancestor.
- Polyphyletic- a group which does not share a common ancestor.



Reptiles and birds are believed to be monophyletic.

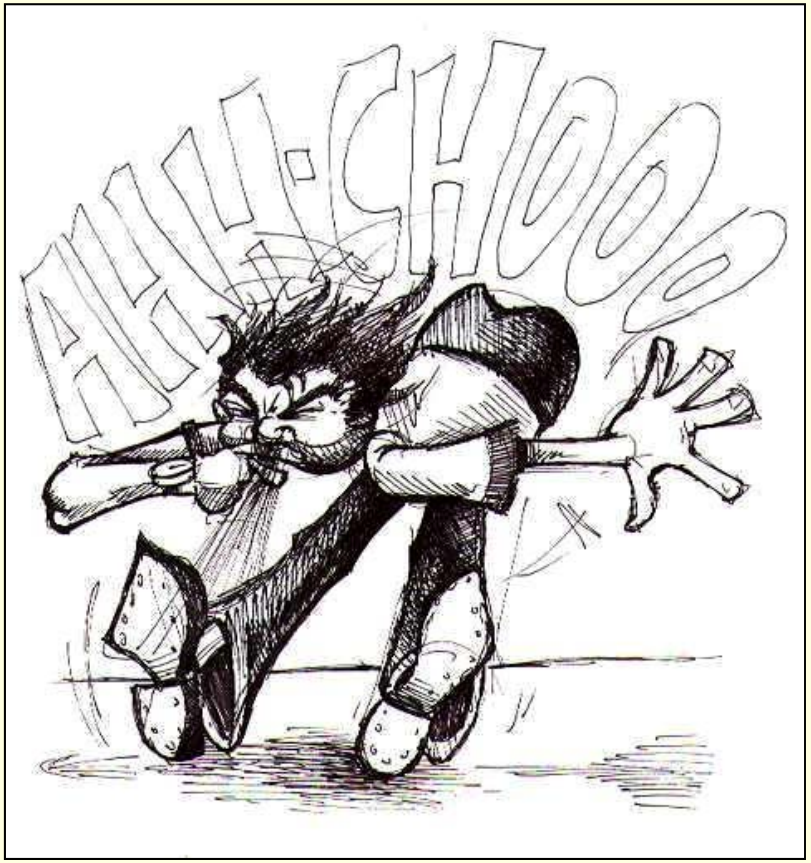
Image courtesy of Stanislav Traykov

Option E: Neurobiology and Behavior

Lesson E:1 Stimulus and Response

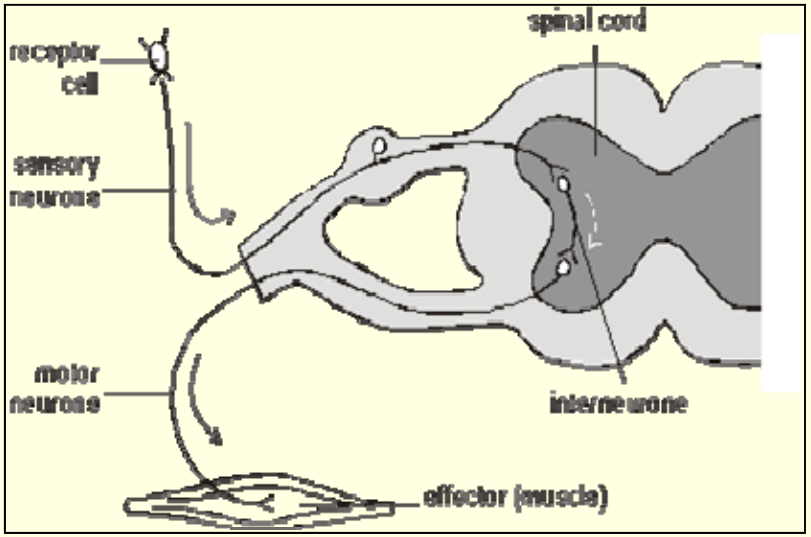
E.1.1 Define the terms *stimulus*, *response*, and *reflex* in the context of animal behavior.

- Stimulus- an external, behavioral trigger.
- Response- an internal reaction to the stimulus.
- Reflex- A predictable neurological sequence linking stimulus and response. Example: sneeze.



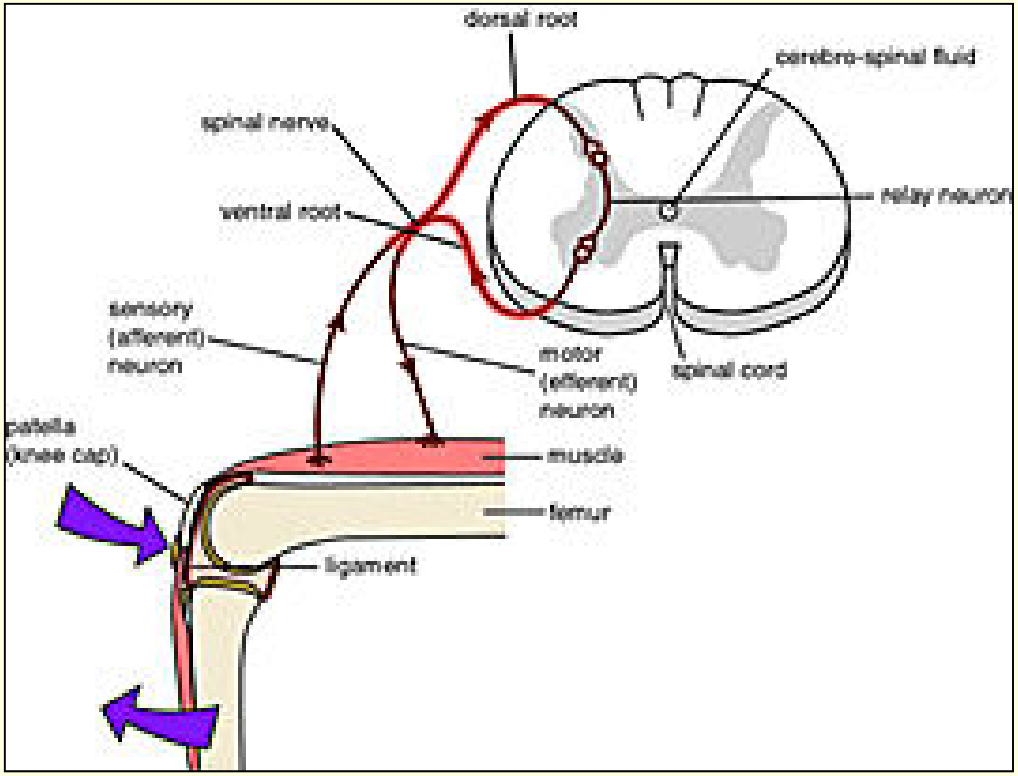
E.1.2 Explain the role of receptors, sensory neurons, relay neurons, motor neurons, synapses and effectors in the response of animals to stimuli.

- Receptors- detects the external stimulus
- Sensory neurons- translate the external stimulus into a neurological impulse.
- Relay neurons- intermediary neurons which propagate the impulse through the CNS.
- Motor neurons- transmit neurological responses from the brain to the body.
- Synapses- Gaps between nerve cells that rely on chemical neurotransmitters to continue impulse propagation between nerves.
- Effectors- carry out the body's response to a stimulus.



E.1.3 Draw and label a diagram of a reflex arc for a pain withdrawal reflex.

- Be able to identify the spinal cord and nerves, the receptor cell, sensory neuron, relay neuron, motor neuron and effector.



E.1.4 Explain how animal responses can be affected by natural selection, using two examples.

1) Bird hatchlings who cheep frequently are more likely to get their mother's attention and be fed. Therefore, natural selection will favor hatchlings who cheep more often in response to seeing their mother.
2) Aggressive male lions are more likely to mate with females and sire offspring. Natural selection will favor those lions who aggressively fight off their male competitors.

Option E: Neurobiology and Behavior

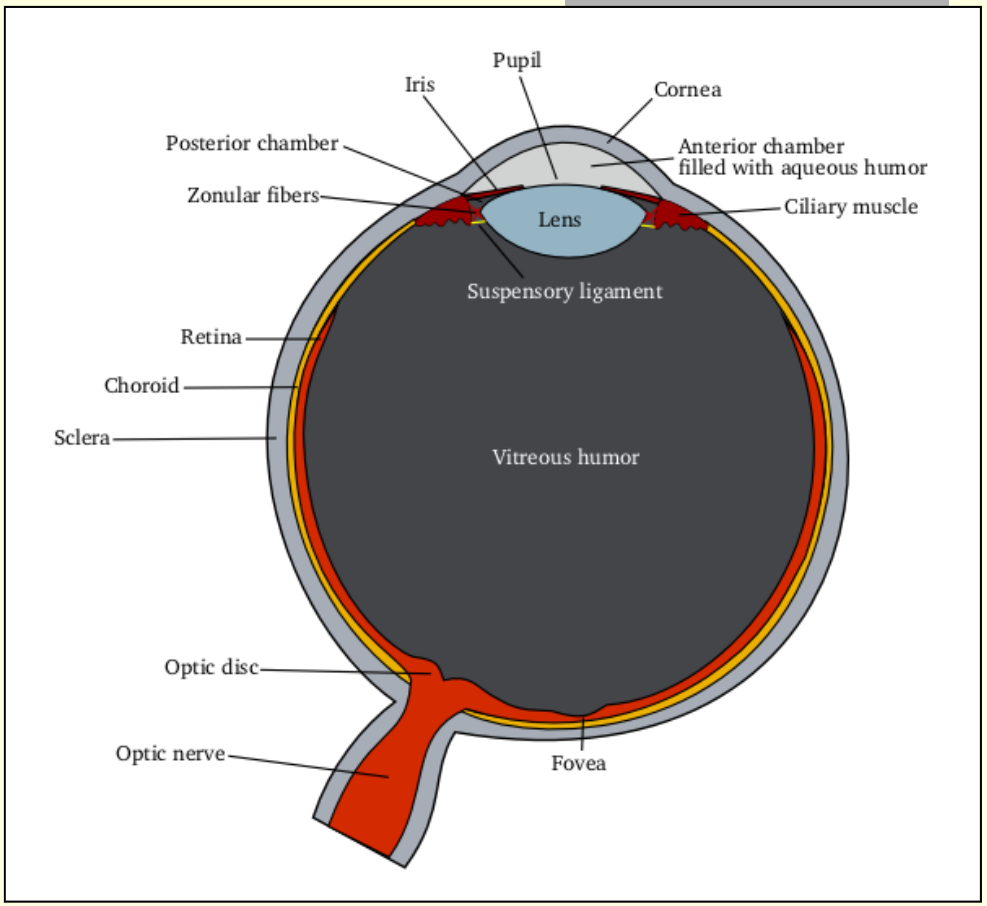
Lesson E:2 Perception of Stimuli

E.2.1 Outline the diversity of stimuli that can be detected by human sensory receptors.

- Mechanoreceptors- sense touch, pressure and vibration.
- Chemoreceptors- sense smell and taste.
- Thermoreceptors- sense heat.
- Photoreceptors- sense light.

E.2.2 Draw the structure of the human eye.

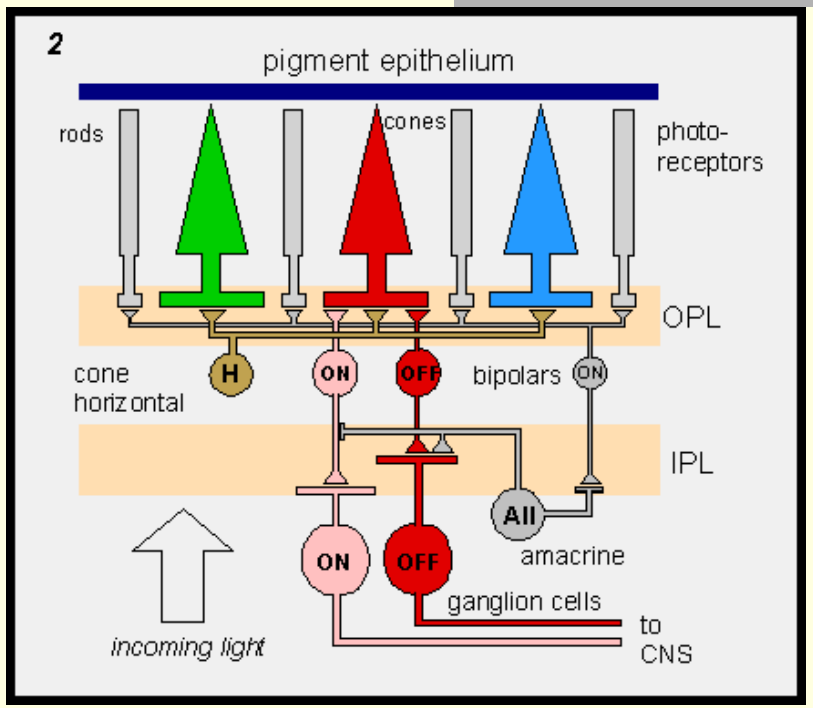
- Identify:
  - Sclera
  - Cornea
  - Conjunctiva
  - Eyelid
  - Choroid
  - Aqueous humor
  - Pupil
  - Lens
  - Iris
  - Vitreous humor
  - Retina
  - Fovea
  - Optic nerve
  - Blind spot

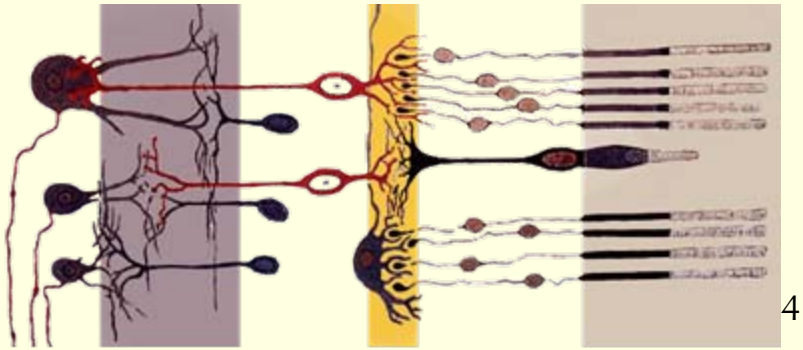


E.2.3 Annotate a diagram of the retina to show the cell types and the direction in which light moves.

Light travels through the cornea→lens→vitreous humor→retina→through nerve cells to rods and cones.

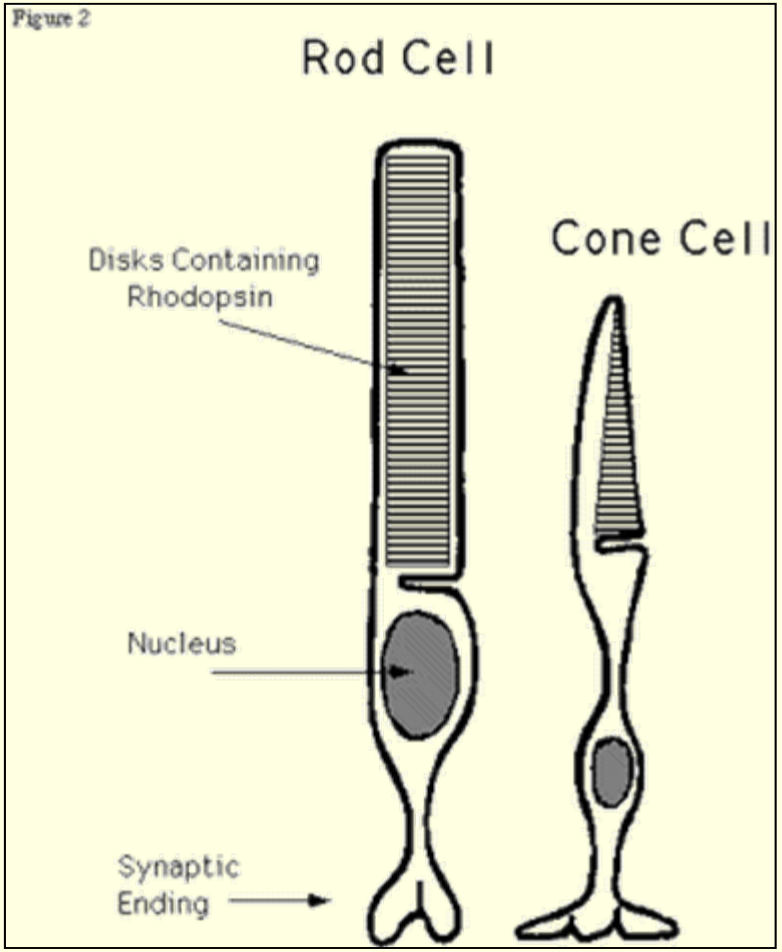
Reception is then processed backwards through bipolar neurons →ganglion cells→optic nerve→brain.





E.2.4 Compare rod and cone cells.

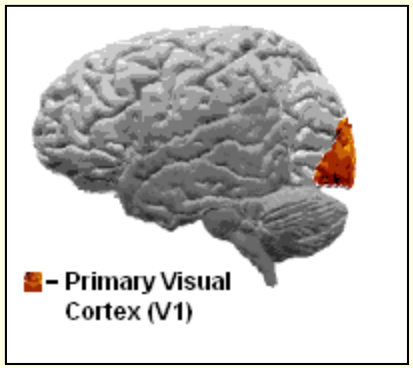
- Rod cells- sense dim light, sensitive to all visible wavelengths, passage from a group of rod cells to a single nerve fiber
- Cone cells- sense bright light, sensitive to red, blue and green light, primarily found in fovea, passage from a single cone cell to a single nerve fiber



Courtesy of Access Excellence

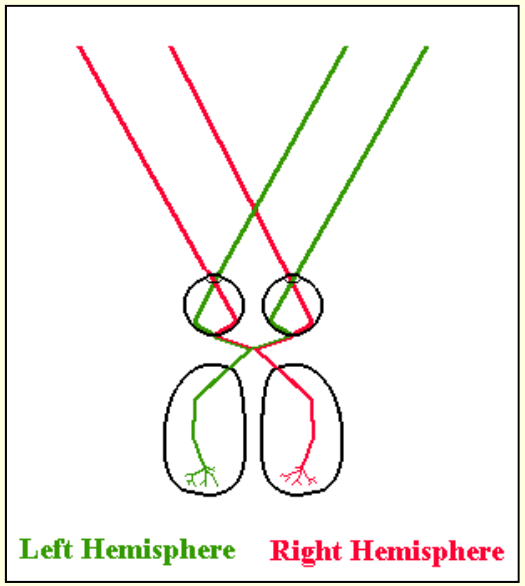
E.2.5 Explain the processing of visual stimuli, including edge enhancement and contralateral processing.

The visual cortex, located in the occipital lobe, is dedicated to processing visual stimuli.

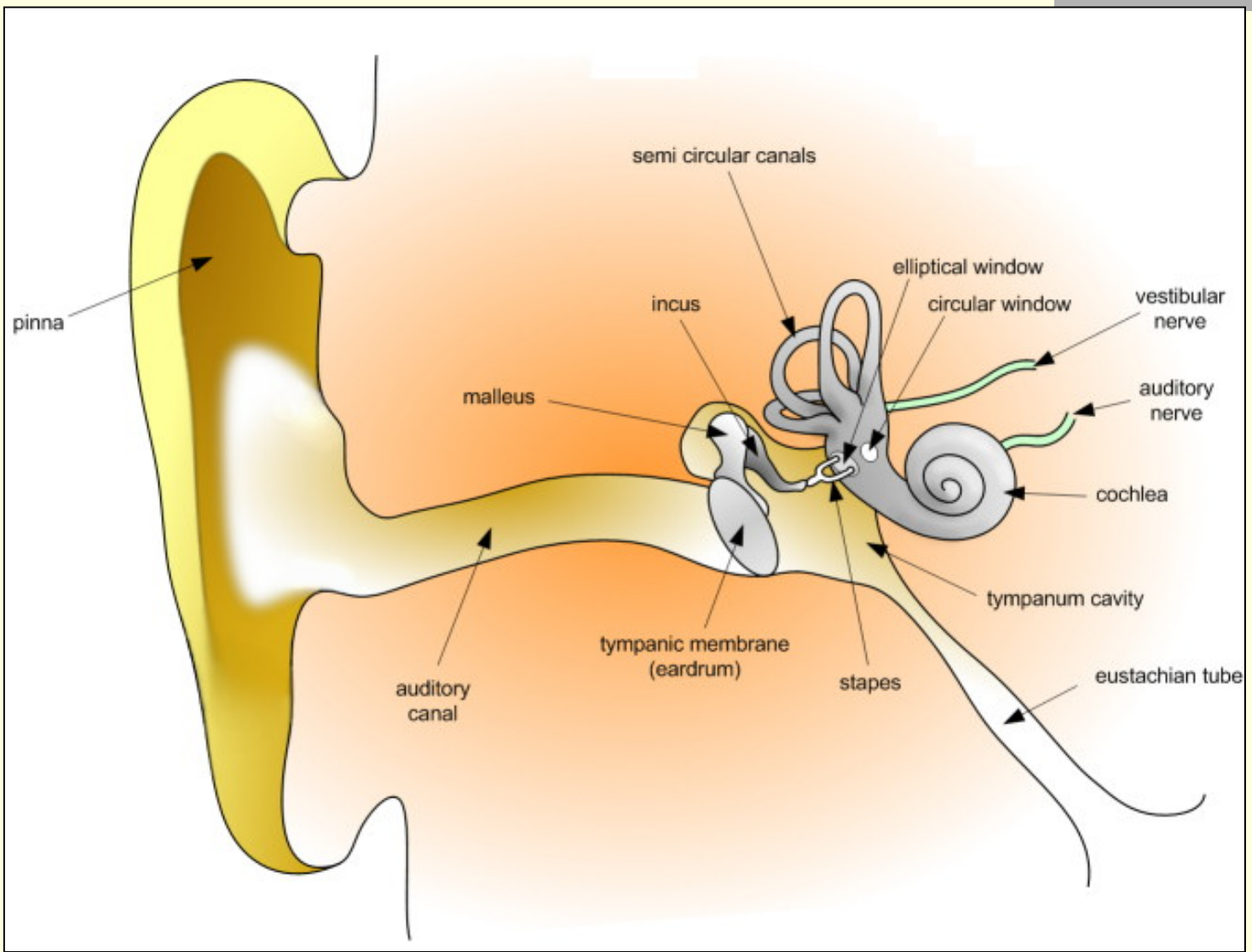


- Edge enhancement refers to the ability to detect contrast (sharpness) in a visual field.

- Contralateral processing, refers to the fact that images in the left part of the visual field are processed on the right side of the brain, and vice versa.

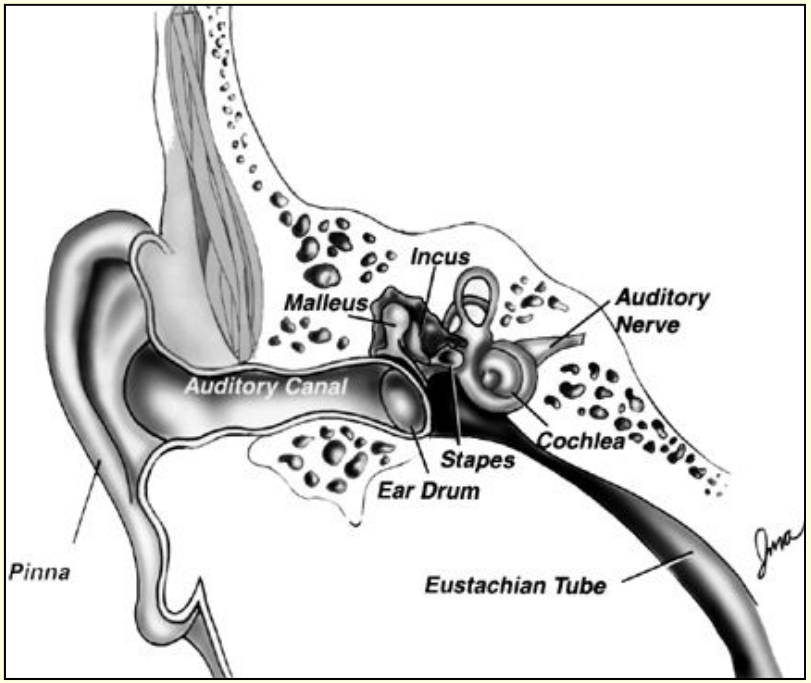


E.2.6 Label a diagram of the ear.



E.2.7 Explain how sound is perceived by the ear, including the roles of the eardrum, bones of the middle ear, oval and round windows, and the hair cells of the cochlea.

- Ear drum- senses external vibrations
- Bones of the middle ear- malleus, incus, and stapes conduct the vibrations in the middle ear.
- Oval and round windows- connect the middle ear to the inner ear.
- Hair cells of the cochlea- receptor cells in the inner ear which receives the vibrational stimuli and converts it into a neurological impulse in the auditory nerve.



Option E: Neurobiology and Behavior

Lesson E:3 Innate and Learned Behavior

E.3.1 Distinguish between *innate* behavior and *learned* behavior.

- Innate behavior- behavior which normally occurs in all members of a species despite natural variation in environmental influences. Some texts refer to innate behavior as species-specific behavior, e.g. suckling response in newborns.

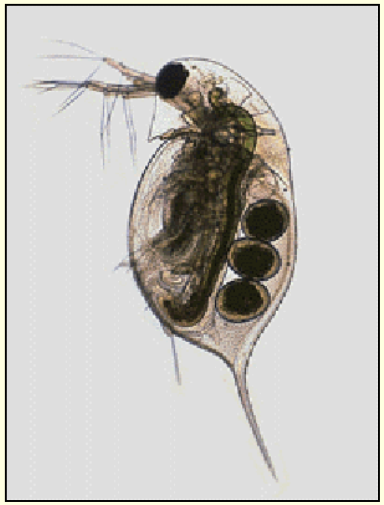
- Learned behavior- develops and is modified through experience.

E.3.2 Design experiments to investigate innate behavior in invertebrates, including either a taxis or a kinesis.

Suggestions:

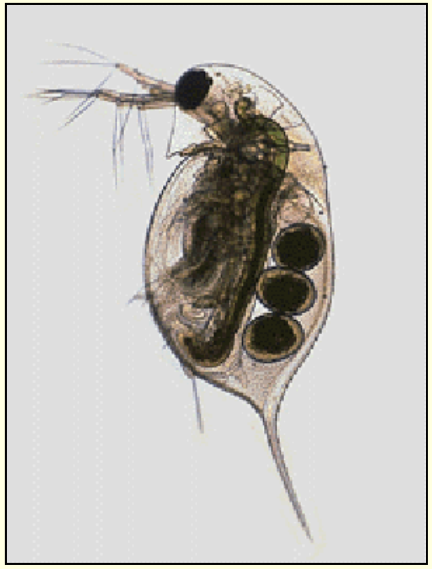
- Taxis- Planaria and light

- Kinesis- Daphnia and heart rate



E.3.3 Analyze data from invertebrate behavior experiments in terms of the effect on chances of survival and reproduction.

- Same as previous.

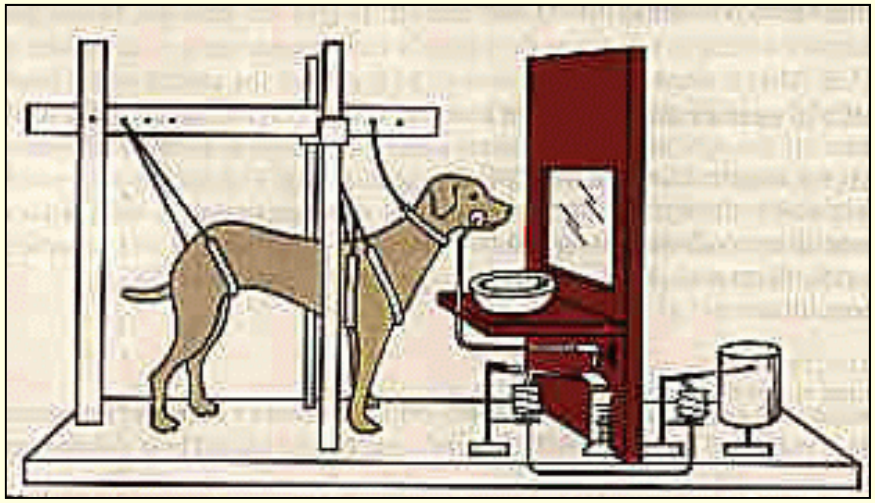


E.3.4 Discuss how the process of learning can improve the chance of survival.

- Innate behavior does not change, regardless of life experience. Learning on the other hand can be modified and refined based on life experience, which can help an organism adapt to its ever-changing environment.

E.3.5 Outline Pavlov's experiments into conditioning of dogs.

- Pavlov paired the ringing of a bell (unconditioned stimulus) with the presentation of food to a dog. After repeated exposures to the paired stimuli, the ringing of the bell became a conditioned stimulus, causing the dog salivate (conditioned response) even when food was not presented along with the ring. This is an illustration of classical conditioning.



E.3.6 Outline the role of inheritance and learning in the development of birdsong in young birds.

- Species specific bird songs are learned during a critical period in early development. In the zebra finch, this occurs approximately 20-35 days after hatching.
- During this critical window, the bird learns their song. After a certain point, the song remains relatively fixed and cannot be changed. Genetic programming helps determine the critical learning period for each species, as well as the degree of plasticity given to its development.

Zebra finch

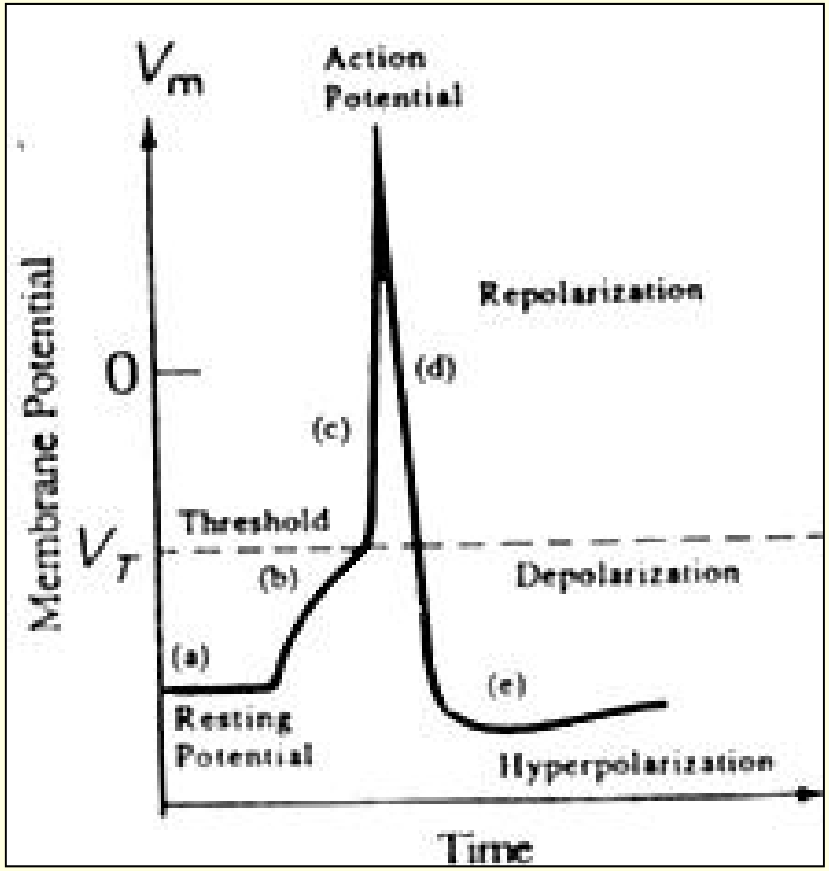
Courtesy of Larry Moore

Option E: Neurobiology and Behavior

Lesson E:4 Neurotransmitters and Synapses

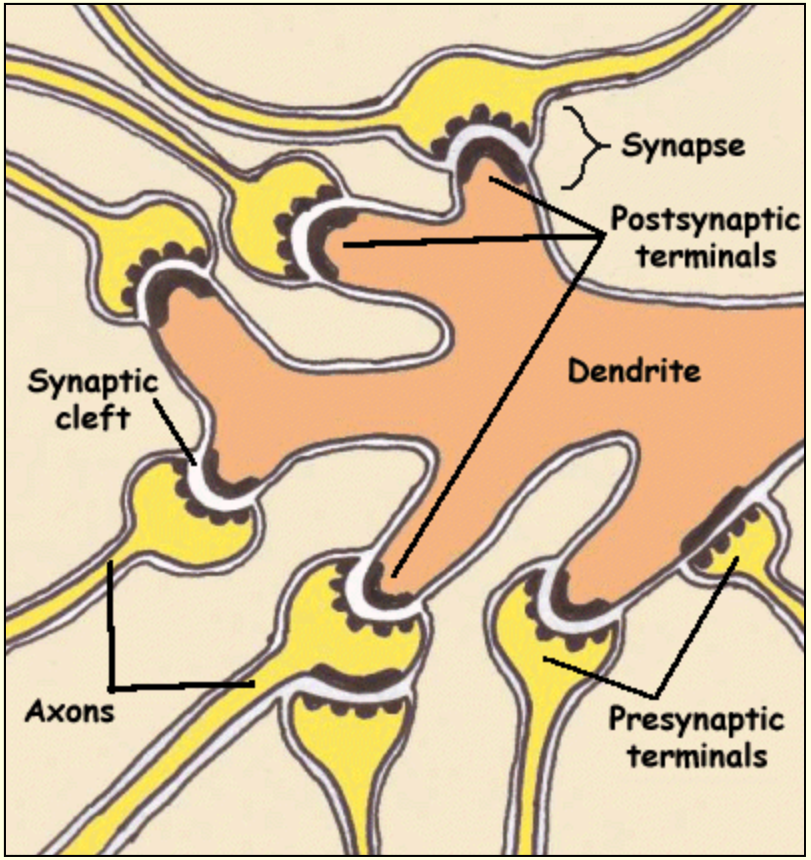
E.4.1 State that some presynaptic neurons excite post synaptic transmission while others inhibit post-synaptic transmission.

- Depolarization- encourages synaptic transmission.
- Hyperpolarization- discourages synaptic transmission.



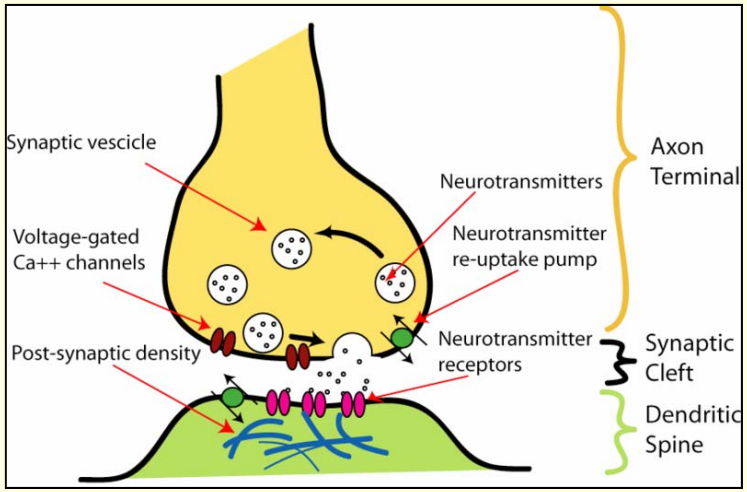
E.4.2 Explain how decision-making in the CNS can result from the interaction between the activities of excitatory and inhibitory presynaptic neurons at synapses.

- Each dendrite is connected to multiple presynaptic terminals. Some are excitatory in nature, others inhibitory. The sum of all these potentials, both positive and negative, ultimately determine whether an action potential will be generated.



E.4.3 Explain how psychoactive drugs affect the brain and personality by either increasing or decreasing postsynaptic transmission.

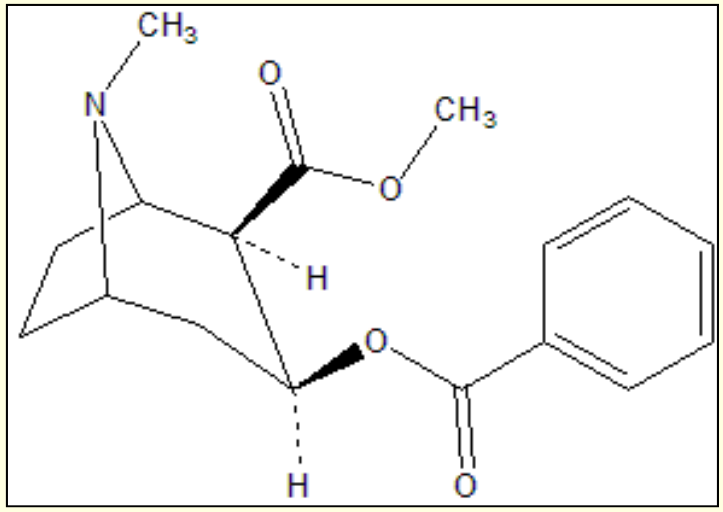
- Psychoactive drugs impact neural pathways by either increasing or decreasing the amount of neurotransmitter released into a synapse. Usually psychoactive drugs impact a specific neurotransmitter such as dopamine or seratonin.
- Personality traits like motivation and aggression can trace their origins to the activity of specific neurological pathways in the brain. Since psychoactive drugs affect the activity and resiliency of these pathways, they can directly affect personality.



E.4.4a List three examples of excitatory and three examples of inhibitory psychoactive drugs.

Excitatory

- Nicotine- stimulate alertness and memory, nausea and vomiting.
- Cocaine/crack- increases, heart rate, respiration, alertness
- Amphetamines/ecstasy- also a stimulant. Can cause anxiety and psychosis.

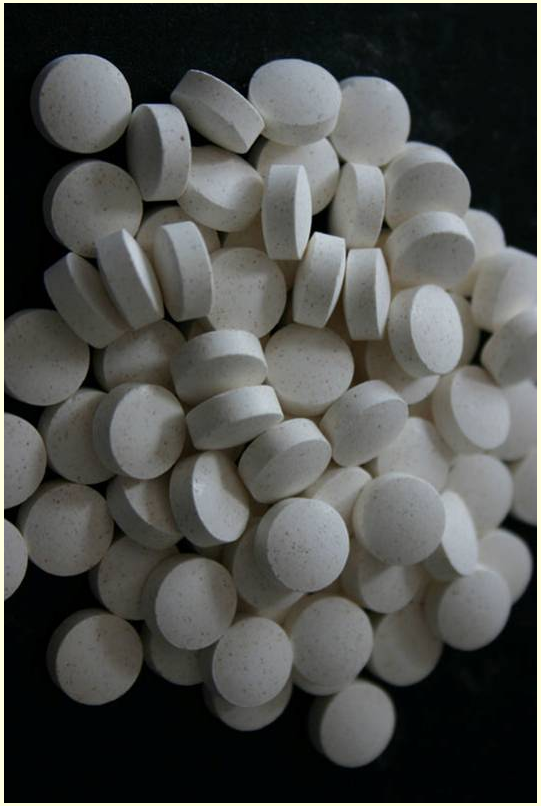


cocaine

E.4.4.b List three examples of excitatory and three examples of inhibitory psychoactive drugs.

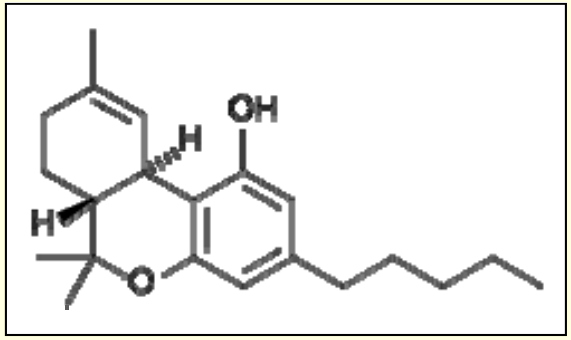
Inhibitory:

- Benzodiazepines- muscle relaxant, reduces anxiety.
- Cannabis- increases heart rate and appetite, causes euphoria.
- Alcohol- reduces heart rate and breathing and blood pressure.



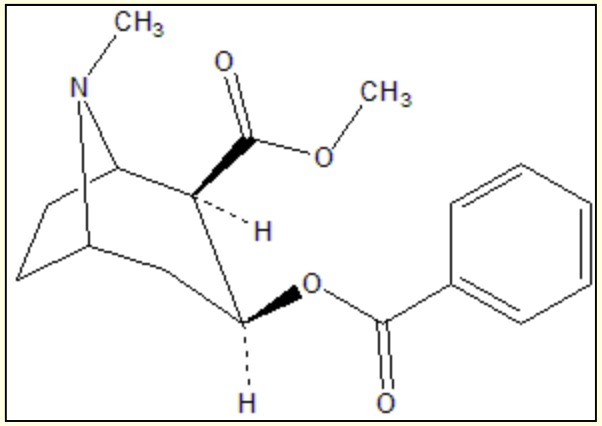
E.4.5 Explain the effects of THC and cocaine in terms of their action at synapses in the brain.

- THC (tetrahydrocannabinol)- increases the release of dopamine in the nuleus accumbens.



THC

- Cocaine- blocks the dopamine transporter protein, which inhibits reuptake.



cocaine

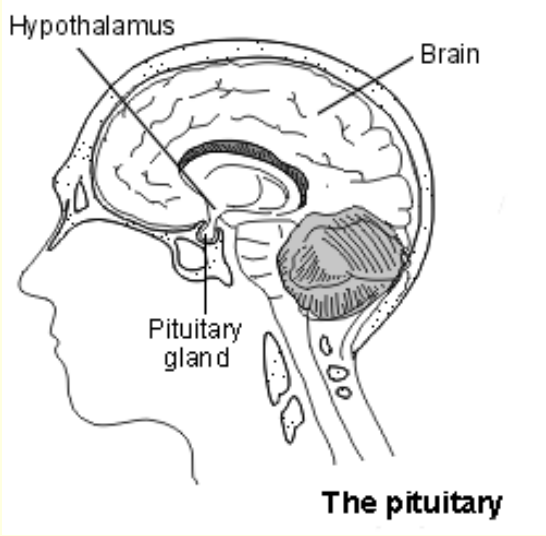
E.4.6 Discuss the causes of addiction, including genetic predisposition, social factors and dopamine secretion.

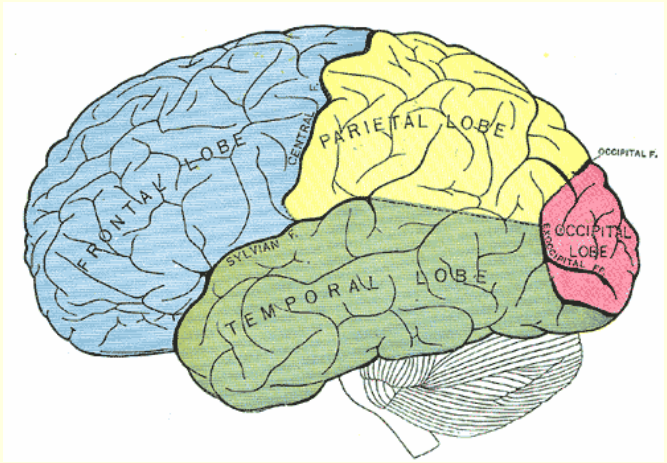
- Genetic predisposition- Pedigree studies show that addiction can run in families. Although a specific addiction gene has not been identified, most likely the genetic influence on addiction is due to the interaction of several genes.
- Social factors- social situations can reinforce a persons tendency to engage in addictive behavior.
- Dopamine secretion- Many addictive drugs increase dopamine secretion in the brains pleasure pathway.

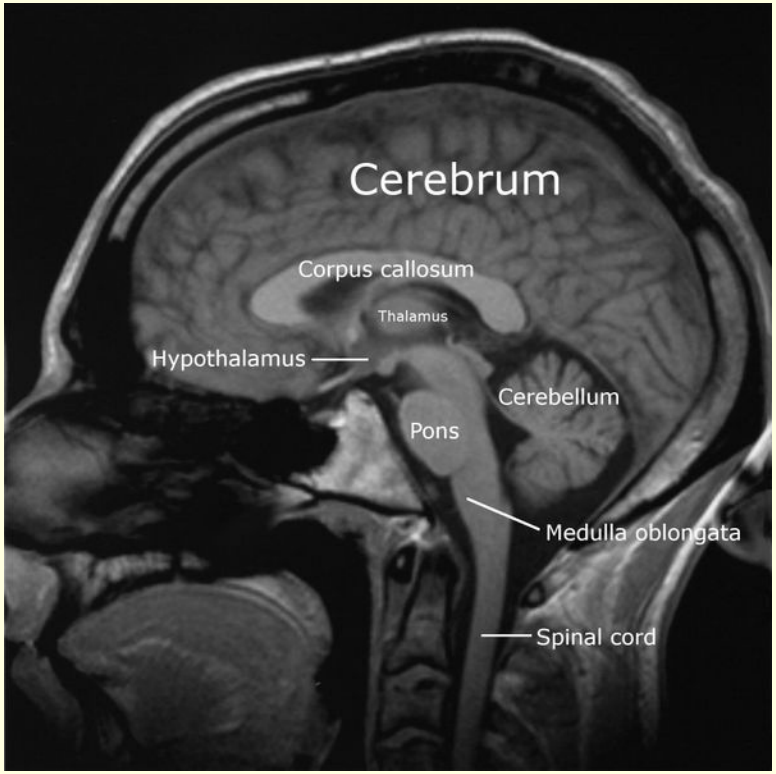
Option E: Neurobiology and Behavior

Lesson E.5 The Human Brain

E.5.1 Label, on a diagram of the brain, the medulla oblongata, cerebellum, hypothalamus, pituitary gland and cerebral hemishperes.







E.5.2 State one function for each of the parts of the brain in E.5.1.

Medulla oblongata- control center for automatic functions, e.g. heartbeat, breathing.

Cerebellum- motor function and coordination

Hypothalamus- helps coordinate autonomic nervous functions. Also involved in hunger and thirst.

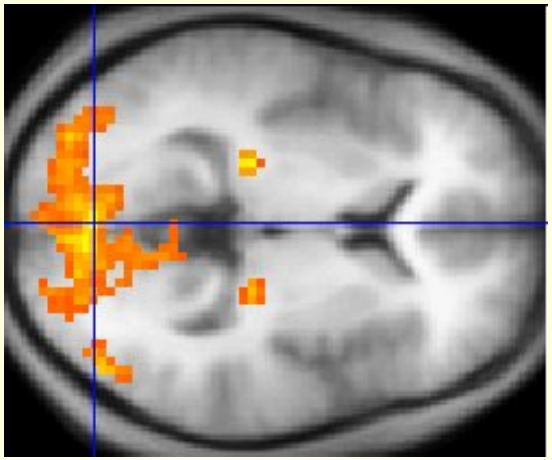
Pituitary gland- releases hormones involved in sexual function and the development of secondary sexual characteristics.

Cerebral hemispheres- center for speech, memory, emotion, and other conscious activities.

E.5.3 Explain how animal experiments, lesions and FMRI scanning can be used in the identification of brain parts involved in specific functions.

- Damaged brain tissue can result in lesions, which are visible on an MRI. The combination identifying lesion through brain imaging and external neurological testing can help identify the function of specific areas in the brain.

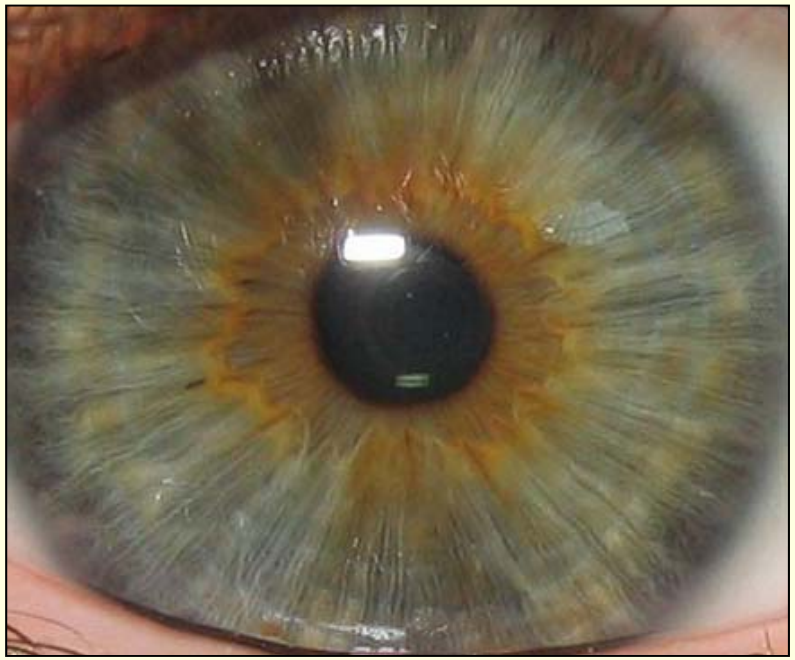
- In animal experiments, lesions can be induced in specific areas and the neurological impact studied. As always, there are ethical issues with such practices.



FMRI

E.5.4 Explain the sympathetic and parasympathetic control of the heart rate, movements of the iris and flow of blood to the gut.

Sympathetic and parasympathetic responses are largely antagonistic:



<u>Sympathetic Response:</u>

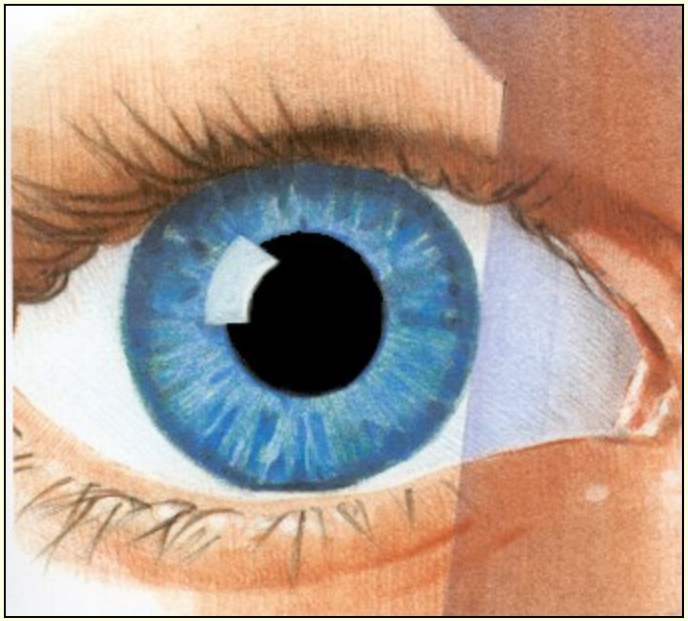
- Heart- speeds up
- Iris- dilates
- Blood flow to gut- decreases

<u>Parasympathetic Response:</u>

- Heart- slows down
- Iris- constricts
- Blood flow to gut- increases

E.5.5 Explain the pupil reflex.

- Pupil reflex- the size of the pupil will reduce in response to light. This reflex will affect both pupils, even if only one eye is stimulated.

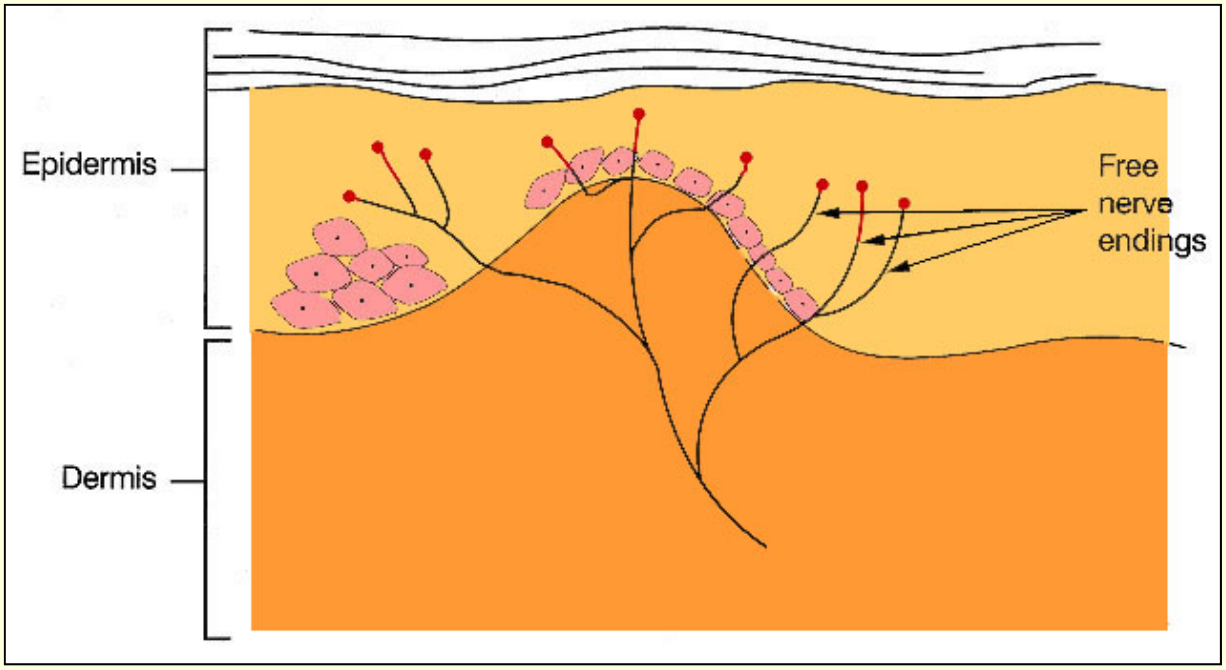


E.5.6 Discuss the concept of brain death and the use of the pupil reflex in testing for this.

- Brain stem (most primitive part of brain) needs to be functioning for pupil reflex to occur. Lack of this reflex may indicate brain death.

E.5.7 Outline how pain is perceived and how endorphins can act as painkillers.

- Pain receptors- sensory neurons located in the dermal tissue. Stimulation can trigger the release of endorphins, opiates which inhibit the transmission of the pain signal to the brain.



Option E: Neurobiology and Behavior

Lesson E.6 Further studies of Behavior

E.6.1 Describe the social organization of honey bee colonies and one other non-human example.

- Honeybees live in groups of 20,000 – 60,000.Three castes:
  - Queen: one female
  - Drones: fertile males
  - Workers: infertile females

- Ant colonies may have several queens who lay eggs, and thousands of workers. The underground chambers contain areas for mating, food storage, and raising young.

E.6.2 Outline how natural selection may act at the level of the colony in the case of social organisms.

- The survival of a colony depends on the contributions of all it's member, in the same way that the survival of an organism depends on the contributions of all its cells. In this sense, a colony could be acted upon as an individual "unit" during natural selection.

E.6.3 Discuss the evolution of altruistic behavior using two non-human examples.

- Monkeys will signal others with an alarm call if a predator is near.
- Wolves will bring food to pack members who were not present during a kill.
- Altruistic behavior helps social group survive, which in turn helps them pass more genes on to their offspring, including altruistic genes.

E.6.4 Outline two examples of how foraging behavior optimizes food intake, including bluegill fish foraging for Daphnia.

Optimal foraging behavior is species specific.

- Bluegill fish are risk neutral with regard to foraging behavior, even when availability of daphnia is varied.
- Raccoons, on the other hand, are more likely to engage in risk taking behavior if potential food is near, even is they pick up the scent of another predator.

E.6.5 Explain how mate selection can lead to exaggerated traits.

Courtesy of Thurner Hof

- Female peahens choose a male to mate with based on their perception of whom is the most fit. Male peacocks must compete with each other visually, which over time, has lead to exaggerated traits as individuals try to outshine each other.

E.6.6 State that animals show rhythmical variations in activity.

Courtesy of Mila Zinkova

E.6.7 Outline two examples illustrating the adaptive value of rhythmical behavior patterns.

- Isopods are more likely to move when they are in a moist environment, often during nighttime. As the forest floor dries during the day, they slow down, conserving metabolic energy, until the moisture returns.

- Human Infants engage in babbling behavior which helps them master verbal communication.