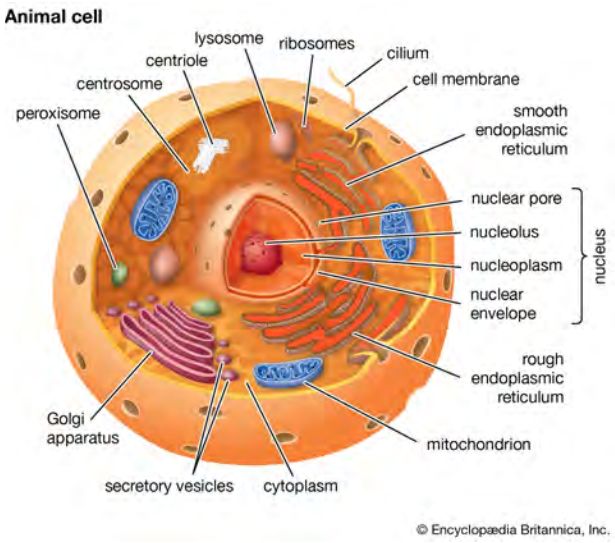
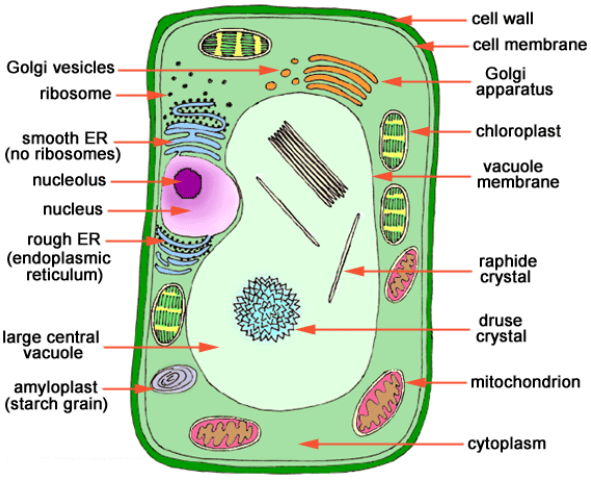
Structure of eukaryotic cells

Animal cells



Plant cells



- **Functions of organelles (5)**
  - Nucleus: Stores cell's chromosomes
  - Mitochondria: Provides ATP
  - Golgi apparatus: Site which packages and releases proteins
  - Rough ER: Synthesis and transportation of proteins
    - Ribosomes on RER synthesize proteins
    - Proteins from RER are used for the secretion
    - Golgi apparatus modifies proteins
    - Vesicles transport proteins from the Golgi apparatus to plasma membrane via exocytosis
  - Smooth ER: Site of lipid synthesis
  - Lysosomes: Contains digestive enzymes to break down cells
  - Free ribosomes: Site of protein synthesis
  - Plasma membrane: Controls entry and exit of material

Compare prokaryotic and eukaryotic cells… (5)

Prokaryotic cells	Eukaryotic cells
no nucleus	nucleus;
naked DNA	DNA associated with histone/protein;
loop of DNA	strands of DNA;
no mitochondria	mitochondria;
70S/ smaller ribosomes	80S/ larger ribosomes;
no/few internal membranes / no organelles	internal membranes/organelles/ Golgi/ER/lysosomes;
smaller in size (approx. 1-10μm)	larger in size (approx. 10-100μm);
cell wall (glycoprotein) present	sometimes present/not in animal cells;

- This debunked the **spontaneous generation theory**, stating that life spontaneously forms from non-living matter
    - Louis Pasteur and the swan neck experiment with broth
        - Broth boiled to kill existing microbes
        - Broke the neck of flask, broth became cloudy as microbes from the atmosphere entered

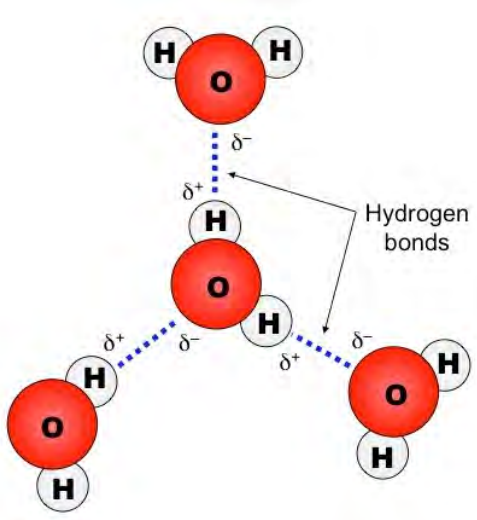
Unit two:

Water structure

- Two hydrogen atoms **covalently** bonded to an oxygen atom
- Polarity
    - Oxygen (-) attracts electrons more strongly, whereas hydrogen is more positive
- **Polarity** allows water molecules bind to each other with hydrogen bonds
    - Negative oxygen attracts positive hydrogen of other water molecules

Properties of water

- **Thermal**: Can absorb heat before changing state
    - Due to extensive hydrogen bonding
    - Comparison to methane (CH4): Good basis due to similarities in size, weight and valence
        - Methane is nonpolar and only can form weak bonds, thus changes shape more easily
- **Cohesive/Adhesive**
    - Cohesion: Ability to stick to like molecules
        - Water to water
    - Adhesion: Ability to stick to dissimilar molecules
- **Solvent**: Dissolves polar and ionic substances
    - Weakens intramolecular forces due to large attraction between water
    - Hydrophilic: Polar ions which readily dissolve
    - Hydrophobic: Large, non-polar molecules (Eg. Fats and oils)
- Metabolic activities of cells all take place in aqueous solutions



Importance of water to living organisms (6)

- Coolant in sweet and transpiration
- Universal solvent and dissolves many substances due to the polarity
- Has high thermal capacities: Temperature of water changes slowly
    - Oceans do not freeze, stable habitat
- Medium for transport in blood, the xylem and phloem, and metabolism
    - Cohesive properties allows for capillary action and transpiration stream
- Surface tension due to cohesion allows organisms to live on water surfaces
- Solvent makes it a medium for metabolic reactions

- Following glycolysis, pyruvate undergoes fermentation
- Produces lactate in humans and ethanol in yeast
    - Lactate: Needs to be broken down by oxygen (Oxygen debt)
    - Yeast: Addition of yeast in bread
        - Yeast respires using oxygen trapped in dough, CO_2 gets stuck, and when baked, the bread rises

Cell respiration: The process in which organic substances are broken down and used to make ATP

- Oxygen + glucose > Carbon dioxide + Water + Energy
- Phosphorylation: The addition of a phosphate group to ADP, realising **30.7kJ**
    - ATP > ADP + D
    - ATPase is the enzyme which controls this process
- Begins in the cytoplasm
- **Glycolysis (6)**
    - Occurs in the cytoplasm
    - Phosphorylation > Lysis > Oxidation
    - Substrate is glucose
        - **Phosphorylation** of glucose to form **glucose 6-phosphate**
        - Requires ATP
    - Glucose 6-phosphate is converted and **split** into **pyruvates**
    - **Oxidation** produces x2 NADH + H+, two pyruvate and net gain of 2 ATP
    - **Glucose > x2 pyruvate, x2 NADH + H+, net x2 ATP**
- Moves to the mitochondrion
- **Link reaction**
    - Pyruvate is converted to **acetyl coenzyme A**
    - CO_2 is released via **decarboxylation** and NAD is **reduced** to NADH + H+
    - Pyruvate > x2 CO_2, x2 NADH + H+ and Acetyl CoA
- **Krebs cycle**
    - Acetyl CoA combines with **4C oxaloacetate** to make a **C6 citric molecule**
    - **Decarboxylation** of 6C to **4C** releases 2CO_2 per molecule of pyruvate
    - Also **reduces** x3 NAD and x1 FAD to produce x3 NADH + H+ and x1 $FADH_2$
    - Substrate level phosphorylation produces x1 ATP
- **Electron transport chain**
    - Occurs in the inner mitochondrial membrane
    - **NADH + H+ and $FADH_2$** bring **electrons** to the ETC by being oxidised
        - Reduced in glycolysis and the krebs cycle
    - Allows **H+** to accumulate in the **intermembrane space** to generate a **proton gradient**
    - H+ diffuse back into the matrix through proton pumps in the inner mitochondrial membrane
        - **Chemiosmosis** is facilitated by the transmembrane enzyme ATP synthase
        - H+ moves through **ATP synthase** in the inner mitochondrial membrane, producing ATP
            - **Oxidative phosphorylation of ADP to ATP**
    - O_2 acts as the final electron acceptor, producing water with H+
    - **Produces x34 ATP**

How energy is generated by the ETC (8)

- **NAD and FAD carriers** are **reduced** by gaining hydrogen ions
    - NADH + H+ and $FADH_2$ is produced in glycolysis and the krebs cycle

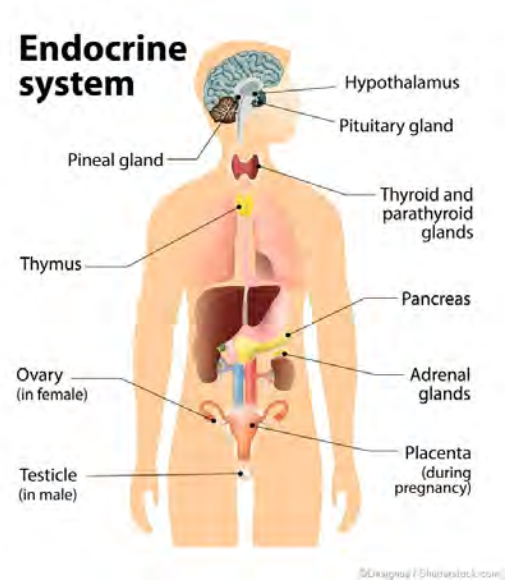
- Therapeutic cloning: Involves producing embryos from which embryonic stem cells can be harvested for medical use
- In favour…
    - Procedure which can reduce pain and suffering can be ethically justified
    - Can be used to replace organs that has been damaged
        - Pain and suffering can be reduced and improve the quality of life
    - Cells are removed at a stage where the embryo can feel no pain
    - Cells can be removed from embryos that have stopped developing and would have died
- Argument against...
    - Embryonic stem cells are no longer needed as adult stem cells can be used instead
    - Danger of embryonic cells that are not yet known
    - Human embryos can be potential humans that have the right to develop
    - More embryos may be produced that can be used
        - On purpose killing

Unit five:

Homeostasis (4)

- Process of ensuring that the body's internal environment maintains a constant state, regardless of the changes in the external environment
- Internal environment would be kept within narrow limits
- We utilise negative feedback mechanisms involving hormones and the nervous system
    - **Negative feedback**: Reverses the change detected by using the product of a process to inhibit the process
        - Change is detected by a receptor, activating the effector to induce the opposite effect, promoting equilibrium
- Eg. Body temperature, body pH, oxygen etc.

Hormones: Chemical messengers produced by the endocrine glands carried in the blood to a target organ



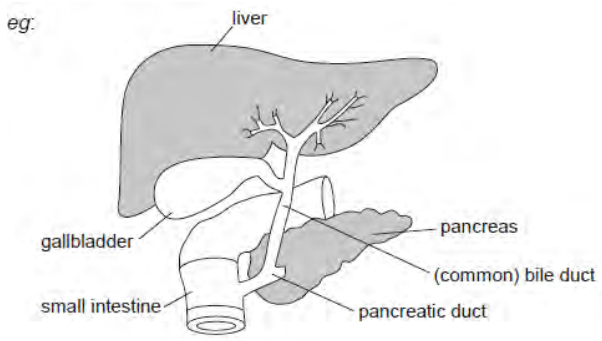
Control of blood glucose concentration

- Controlled by **glucagon and insulin**
    - Antagonistic hormones, produced by the islets of Langerhanns in the **pancreas**
        - Detects low/high blood glucose levels
- Negative feedback mechanism
- **Glucagon** increases blood glucose levels, converting glycogen into glucose
    - Released by **a** cells
- **Insulin** decreases blood glucose levels, promoting glucose reuptake and glucose breakdown into fatty acids
    - Released by **b** cells
- Glucose levels would be low due to exercise and high after eating

Diabetes mellitus: Metabolic disorder resulting from a high blood glucose concentration over a prolonged period

- Epithelium forms a barrier

5) **Accessory organs**
   - **Liver**: Products of digestion are broken down and fats are emulsified by **bile**
     - Produces bile
     - Detoxifies and neutralizes
     - Products are absorbed into the submucosa wall, to the blood
   - **Gallbladder**: Stores bile produced by the liver, which is released into the small intestine
   - **Pancreas**: Produces a broad spectrum of enzymes, released into the small intestine



How the small intestine moves, digests and absorbs food (8)

- Contraction of muscles via **peristalsis** helps move food
  - Circular muscle contraction prevents backward movement of food, longitudinal muscle contraction moves food along the gut
- **Peristalsis** mix food with enzymes, which digest large insoluble molecules into smaller soluble molecules
  - Eg. Amylase digests starch into glucose, lipases digest lipids into fatty acids and glycerol etc.
- **Bile** is secreted into the small intestine by the to emulsify fat and create a good pH environment
- Mucosa layer of the small intestine contain villi, which are finger-like projections which increase surface area
  - Absorb products of digestion
    - Glucose and amino acids > Blood
    - Lipids > Lacteals
  - Absorption involves active transport and diffusion, where different nutrients are absorbed by different mechanisms

Digestion, absorption and assimilation of proteins (6)

- **Digestion** consists of the breakdown of large insoluble molecule into small soluble molecule
- In the stomach, requiring pH 2 to function
  - Pepsin > Proteins into polypeptides
- In the small intestine, requiring a basic pH
  - Trypsin > Polypeptides into amino acids
- **Absorption** occurs in the villus of the small intestine
  - Absorbed into capillaries
- Blood carries amino acids throughout the body
  - Diffuse into cells by active transport, where amino acids are used to build proteins
- **Assimilation** is the process of amino acids becoming part of a cell

Digestion of food in the human digestive system (6)

- Mechanical digestion of food beginning in the mouth by chewing
  - Increases the surface area of food
  - Starch digestion begins in the mouth by salivary amylase
- Digestion of proteins in the stomach
  - Stomach provides the optimum pH for enzymes, being very acidic
  - Stomach muscle contractions also causes mechanical digestion
- Enzymes in the small intestine complete digestion

- **Endocrine** system uses nerves to transmits messages to pacemaker
    - To increase/decrease the rate of the pacemaker
    - Controlled by the **medulla of the brain**
        - **Accelatory nerve**: Epinephrine to increase rate, produced by the adrenal gland
        - **Vagus nerve**: Acetylcholine to decrease rate

Type of pathogens

- Virus: Inert and acelular which mutates quickly
- Bacteria: Unicellular prokaryotic cells which divide by binary fission
- Fungi: Attacks the body's surface
- Protozoa: Parasite

Surface barriers: The first line defense

- **Skin**: Physical barrier which protects external structures
    - Sebaceous glands which secretes lactic acid, lowering the skin's acidity
        - Acidity prevents growth of pathogens
    - Non-pathogenic bacteria also crowds bacteria out of skin
- **Mucous**: Softer membrane which protects internal membrane
    - Traps pathogens to be removed by cilia
    - Contains lysosomes which causes cell lysis and kill bacteria

Blood clotting

- Clotting factors are proteins which initiate the clotting cascade
- Fibrin is a protein which permits the blood to clot
- Once clotting factors are activated, it triggers the conversion of **prothrombin to thrombin**
- Thrombin converts **fibrinogen to fibrin**
- Fibrin forms a mesh to trap platelets and prevents the entry of pathogens

Coronary thrombosis: The formation of a clot within the blood vessels that supply and sustain the heart tissue

- A blockage in the coronary artery would deprive the muscle of a supply of oxygen and nutrients
- Fibrillation: Uncoordinated and irregular contractions, resulting the shrivelling of heart muscles
- Atherosclerosis: Areas of the artery become damaged, and cholesterol builds up and forms plaque. The artery loses elasticity.

Antibiotics (4): Components that kill or inhibit the growth of microorganisms by targeting and blocking prokaryotic processes. Protects humans against bacteria

- Only blocks prokaryotic processes, but not in eukaryotic cells
- Blocks the **metabolic pathways** (DNA replication, transcription, translation etc.) in prokaryotes
- Antibiotics do not protect against viruses as they have no metabolism
- Can be used in humans as antibiotics do not affect eukaryotic cells
- Spectrum: The diversity of the bacteria
- Selective toxicity: The degree of harmfulness of the antibiotic

Types of leukocytes

- Phagocytes: Second line
- Lymphocytes: Third line
- Leukocytes defend the body (6)
    - Can recognize pathogens as each pathogen has specific antigens

        - High blood pressure due to a larger afferent than the efferent
        - Capillaries with fenestrations of the glomerulus
        - Basement membrane: Molecular sieve
            - Large blood proteins do not pass
        - Epithelial cells: Podocytes wrap around the glomerulus
2. **Osmoregulation/Selective reabsorption**
    - The filtrate passes through the proximal convoluted tubule for selective reabsorption
        - Tubule cells are specialised
            - Microvilli for a large surface area
            - Mitochondria for ATP during active transport
            - Basal infoldings increase surface area
    - **Reuptake of glucose, amino acids, sodium, chloride and water**
        - Na and Cl: **Actively transported** into the tubule, diffuses to the basal end, actively transported into the tissue, diffuses into the blood
        - Glucose and amino acids: **Cotransported** with sodium
        - Water: Follows **ions** via osmosis
        - Urea: 50% follows water
3. **Loop of Henle**
    - Creates a solute gradient in the medulla
        - Descending limb is more permeable to water
        - Ascending limb is more permeable to salts
    - Water is reabsorbed in the descending limb
    - Sodium is actively transported out the ascending limb
    - Filtrate becomes more concentrated as salt and water leaves
4. **Collecting duct**
    - Antidiuretic hormone (ADH) increases the permeability of the duct, increasing the number of aquaporins
        - Secreted by the pituitary gland, controlled by the hypothalamus
            - Hypothalamus detects the solute concentration
        - ADH is released when the individual is dehydrated
    - Water is more easily reabsorbed, urine becomes more concentrated
    - Negative feedback
5. **Substances not absorbed are eliminated as urine**

Structure of the nephron in altering blood solute concentrations (9)

- The kidney carries out the osmoregulation of blood solute concentrations
- Ultrafiltration occurs in the glomerulus
    - **Capillary walls with fenestrations** are more permeable to smaller molecules
    - Bowman's capsule has a **basement membrane** and epithelial cells with which act as a filter
    - High blood pressure due to a larger afferent than the efferent
- Reabsorption of useful substances in the proximal convoluted tubule
    - Tubule cells are specialised
        - Microvilli provide a large surface area
- Loop of henle
    - Descending limb more permeable to water
    - Ascending limb more permeable to salts
    - Creates a solute gradient for water and sodium to be reabsorbed
        - **Water by osmosis**

- Auxins increase the **flexibility of cell walls**
    - Enables **cell elongation** on the side to cause growth towards the light
- Proton pumps are activated in the plasma membrane
- Secretion of **H+** ions into the cell wall
    - **Decreases the pH**
    - **Breaks bonds** between the cell walls using **expansin enzymes** that were activated
- Cellulose fibres within the cell wall loosens
    - Influx of **water** causes the cell to increase in size
        - Enhances ion uptake, causing increased turgor
- Auxin also causes **gene expression** to promote cell growth
    - Produces proteins, which repress or activate the expression of other genes

Role of auxin in phototropism (8)

- Auxin is a plant hormone which is produced at the shoot tip
- Auxins increase the flexibility of cell walls
    - Enables cell elongation on the side to cause growth towards the light
- Proton pumps are activated in the plasma membrane
- **Secretion of H+ ions** into the cell wall
    - Decreases the pH
    - Breaks bonds between the cell walls using **expansin enzymes** that were activated
- Cellulose fibres within the cell wall loosens
    - **Influx of water** causes the cell to increase in size
        - Enhances ion uptake, causing increased turgor
- Auxin also causes gene expression to promote cell growth
    - Produces proteins, which repress or activate the expression of other genes
- Phototropism is growth towards light
- Shoot tip senses the direction of light, moving to the side of the shoot with the least light
    - Causes cells on the darker side to elongate, growing towards the light

Micropropagation: Method to produce a large number of identical plants from a selected stock plant

- Used for rapid multiplication of important plants with superior genotypes
- Can reproduce asexually from meristems (Totipotent)
- Economical on time and space
- Labour intensive and expensive, no variation, requires a set environment
- **The process of micropropagation**
    - Selected plant tissues are cut (Explant)
    - Explants are sterilised using solutions
    - Transferred to a culture vessel to be incubated
    - New shoots that develop are removed and placed on a new culture medium

Substances transported in flowering plants

- Nutrients (CO_2 and H_2O) required for photosynthesis
    - Water is absorbed into the root hair cell by osmosis
- Oxygen for photosynthesis
- Food in sugar
- Plant growth substances (Eg. Auxin)
- Mineral ions (Eg. Magnesium, calcium and iron)
    - Calcium ions for cell wall, iron as a cofactor of many ions
    - Transported via mass-flow with water by diffusion

Chordata	Pinophyta
Mammalia	Phinosbida
Carnivora	Pinales
Canidae	Cupressaceae
Canis	Sequoia
Canis lupus	S. Semporrirens
Golden retriever	California redwood

Types of classification schemes

- **Artificial**: Arbitrarily selecting unifying characteristics first, then grouping accordingly
    - Easy to develop
    - Does not show evolutionary relationships
- **Natural**: Grouping organisms based on similarities, then identifying shared characteristics
    - Groups based on evolution
    - Predict characteristics shared by a species
    - Changes as new information is discovered
- **Phylogenetic**: Grouping based on homology in DNA and similarities in amino acid sequences

Divisions of the plant kingdom (9)

- Bryophyta
    - Non vascular
    - No leaves, roots or stems, only has rhizoids
    - Produces spores
- Filicinophyta
    - Have leaves, roots and stems
    - Pinnate leaves
    - Produces spores
- Coniferophyta
    - Needle-like and waxy leaves
    - Produce seeds in cones
- Angiospermophyta
    - Has ovules and ovaries
    - Has flowers
    - Covered seeds

Invertebrate classes

- Porifera: Eg. Sponge
- Cnidaria: Has tentacles, radicle symmetry, one opening, sac-like body, eg. Jellyfish
- Platyhelminthes: One opening to their digestive tracts
- Annelida: Has a mouth and anus, segmentation, eg. Worm
- Mollusca: Has a muscular foot, two openings, eg. Snail
- Arthropoda: Exoskeleton, jointed appendages and segmented bodies, eg. Crabs

Vertebrate classes

- Occurs in the inner mitochondrial membrane
- **NADH + H+ and FADH2** bring **electrons** to the ETC by being oxidised
    - Reduced in glycolysis and the krebs cycle
- Allows **H+** to accumulate in the **intermembrane space** to generate a **proton gradient**
- H+ diffuse back into the matrix through proton pumps in the inner mitochondrial membrane
    - **Chemiosmosis** is facilitated by the transmembrane enzyme ATP synthase
    - H+ moves through **ATP synthase** in the inner mitochondrial membrane, producing ATP
        - **Oxidative phosphorylation of ADP to ATP**
- O2 acts as the final electron acceptor, producing water with H+
- **Produces x34 ATP**

How energy is generated by the ETC (8)

- **NAD and FAD carriers** are **reduced** by gaining hydrogen ions
    - NADH + H+ and FADH2 is produced in glycolysis and the krebs cycle
- ETC is in the mitochondrial inner membrane
- Electrons release energy as they flow along the chain
- Proteins in the inner mitochondrial membrane act as proton pumps
    - Has ATP synthase
- As H+ accumulates in the intermembrane space, it generates a **proton gradient**
- Chemiosmosis occurs as H+ ions diffuses through the proton pumps with **ATP synthase**
    - **Oxidative phosphorylation occurs, converting ADP to ATP**

Overview of photosynthesis

1. **Light dependent reaction** (Thylakoid membrane) (8)
    - *Photoactivation in Photosystem II*
        - Pigments absorb light energy
            - Boosts electrons to become 'excited', increasing the energy level
        - Excited electrons accepted by a carrier protein molecule within the thylakoid membrane
    - *Photolysis*
        - Lost electrons are replaced by the splitting of water
            - Split into electrons, protons (Hydrogen ions - used to reduce NADP+) and oxygen
            - Oxygen is a waste-product
    - *Photophosphorylation*
        - Excited electrons are transferred to Photosystem I via ETC
        - Protons (H+) are pumped into the thylakoid membrane
            - Builds the concentration gradient
        - Protons flow through large channel proteins which contain ATP synthase
            - Chemiosmosis
        - Results in the formation of ATP (ADP + Pi > ATP)
    - *Reduction of NADP+*
        - Absorption of light energy causes photoactivation in Photosystem I
            - Boosts more electrons to become 'excited'
            - Replaces those lost in Photosystem II
        - Electrons combine with protons in the hydrogen carrier NADP+
            - Form NADPH+H+