Topic 5 – Energy transfers between organisms

Key words

Photoionization – the use of light to remove electrons
Chemiosmotic theory – the diffusion of H^+ ions across a membrane through an ATP synthase to phosphorylate ADP into ATP.
Substrate-level phosphorylation – is the transfer of phosphate from one organic molecule to ADP to form ATP
Oxidative phosphorylation – the process of generating ATP as a result of transferring electrons from NADH or $FADH_2$ to O_2 through a series of electron carriers.
Gross primary production (GPP)- is the chemical energy stored in plant biomass, in a given area in a given time.
Net primary production (NPP) – is the chemical energy store in plant biomass after respiratory losses to the environment.
Saprobionts – organisms that use extracellular digestion, they secrete digestive enzymes into detritus (dead material) and absorb soluble products.
Ammonification – is the conversion of organic nitrogen into ammonia
Nitrification – nitrifying bacteria convert ammonium in to nitrite and nitrate.
Denitrification – bacteria that convert nitrates in the soil into nitrogen gas

1) There are two parts to photosynthesis
    a. **Light -dependent reactions**
    b. **Light – independent reactions**
2) **During the light dependent reaction:**
    a. Chlorophyll absorbs light which causes **photoionization** of chlorophyll
    b. First a pair of electrons are excited from photosystem II
    c. The pair of electrons leave the chlorophyll and are passed along a series of proton carriers. This is called an electron transport chain
    d. As the electrons get passed along the carrier protons (H^+) are passed into the inner membrane space.
    e. As the protons (H^+) move back down the concentration gradient they pass through an ATP synthase embedded in the membrane which generates ATP from ADP and Pi (phosphate)
    f. The electrons are passed to photosystem I.
    g. The chlorophyll in photosystem I absorbs light which causes photoionization of the chlorophyll.
    h. The electrons are then excited and join with a proton (H^+) and $NADP^+$ to from NADPH
    i. The proton has been created from the photolysis of water
        i. Light is used to split water into – protons (H^+), electrons (e^-) and oxygen (O).
3) During the **light-independent** reaction the **ATP** and the **NADPH** form the light dependent reactions are used.
4) The light-independent reactions are also known as the **Calvin cycle**

a. **Rubisco** (an enzyme) catalyses the reaction between Carbon dioxide and ribulose bisphosphate (RuBP) to form two molecules of glycerate 3-phosphate
b. 1 ATP and 1 NADPH (from the light dependent reaction) are used to reduce each GP into triosephosphate (TP)
    i. GP and TP both have 3 carbons
c. 5 out of the 6 carbon molecules are used to regenerate RuBP the other carbon is used to be converted to organic substances.
    i. RuBP consists of 5 carbons

5) During **aerobic** respiration there are 4 stages
    a. Glycolysis
    b. The link reaction
    c. Krebs cycle
    d. Electron transport chain

6) Glycolysis
a. Glucose is phosphorylates to phosphorylated glucose by 2 ATP molecules transferring Pi to glucose.
b. Glucose phosphate a 6-carbon molecule is converted into 2, 3 carbon molecules of triosephosphate (TP)
c. 2 x Triosephosphate (TP) molecules are oxidised to 2 x pyruvate molecules by 2 NAD^+ being reduced to NADH and 4 molecules of ADP being converted to ATP.

7) Pyruvate is moved into the mitochondria by active transport.

8) The link reaction
a. Pyruvate is oxidised to acetate producing NADH in the process.
b. Pyruvate also loses a Carbon molecule as CO_2
c. Acetate (a 2-carbon molecule) combines with coenzyme A to produce acetyl coenzyme A.

9) The Krebs cycles
a. Acetyl coenzyme A reacts with a 4-carbon molecule releasing coenzyme A to produce a 6-carbon molecule.
b. The 6-carbon molecule is oxidised to a 5-carbon molecule, a molecule of carbon is lost as CO_2 and NADH is produced.
c. The 5-carbon molecule is oxidised to a 4-carbon molecule, a molecule of carbon is lost as CO_2 and NADH is produced.
d. The 4-carbon compound is oxidised into oxaloacetate. ATP Is created from ADP and Pi, FADH and NADH are reduced

10) Electron transport chain
a. NADH and FADH transfer electrons the electron transport chain and release a proton (H^+).
b. As the electrons are passed down the electron transport chain the protons pass into the inner mitochondrial membrane.
c. Protons move back down the electrochemical gradient through ATP synthase generating APT from ADP and Pi.
d. Oxygen is the final electron acceptor as the electrons combine with oxygen and protons to form water.

11) During **anaerobic** respiration only glycolysis takes place.
a. Pyruvate is then converted to ethanol and carbon dioxide in
b. Pyruvate is converted to lactate in mammals
c. This is so the NADH can be oxidised to NAD so it can be reused in glycolysis.
d. If glycolysis can continue creating a net of 2 ATP per glucose.

12) Lipids and amino acids can enter the Krebs cycle to generate ATP.

13) Plants produce glucose from photosynthesis. Most of the glucose produced is used for respiration, the rest is used to for biomass.
14) **Biomass** can be measured by looking at the mass of carbon
15) **Biomass** can also be measured as the dry mass of tissue per given area per given time.
16) **Biomass** can be measured by heating the sample to remove the water, keep measuring the mass of the biomass until a constant mass is reached.
17) The chemical energy in dry biomass can be estimated using calorimetry
    a. A dry sample is weighed and burnt in pure oxygen within a sealed chamber, the temperature increased of the fixed volume of water is used to calculate the energy released.
18) The **net primary production** of producers can be measured with the equation:
19) $NPP = GPP - R$
    a. GPP - gross primary productivity and
    b. R- respiratory losses
20) The net primary production is available for plant growth and reproduction. The net primary production is also available for the next trophic level in the ecosystem.
21) The **net production** of consumers can be measured with the equation:
22) $N = I - (F + R)$
    a. I - the chemical energy stored in ingested food
    b. F - the chemical energy lost to then environment in faeces and urine
    c. R – the respiratory losses to the environment
23) **Farms** want to **increase** the net primary production of livestock to increase the biomass for consumption. The do this by
    a. Reducing respiratory losses by restricting movement and keeping livestock in a warm environment
    b. Providing livestock with a high protein diet
24) It is important that **nitrogen** is recycled within the ecosystem (nitrogen is important for DNA, RNA, amino acids and proteins)
    a. Nitrogen from the air enters the soli by
        i. Lightning
        ii. Nitrogen-fixing bacteria in the soil
        iii. Mycorrhizae live in the root nodules of legumes – this is a symbiotic relationship where nitrogen gas to ammonium
    b. Nitrogen enters the soil from dead material by saprobionts that decompose protein into ammonium
    c. Ammonium containing molecules are broken down into ammonium ions by ammonification
    d. Ammonia is then converted to nitrite by nitrification
    e. Nitrite is converted to nitrate by nitrification.
    f. Nitrate can then be taken up by plants.
    g. Nitrates can be removed by the soil by denitrifying bacteria – this happens in anaerobic conditions.
25) **Phosphorous** is important for DNA, RNA and ATP
    a. Phosphate in rocks is eroded and dissolved in lakes and soil
    b. Phosphorous ions from guano, bones and shells are eroded into and dissolved into the lakes and soil.
    c. Plants absorb the phosphate and animals feed on the plants to take in phosphate ions.
26) Farmers us natural and artificial fertiliser to replace the phosphate and nitrates lost by harvesting plants and grazing livestock.

27) Using too much fertiliser can cause **eutrophication**.
    a. Fertiliser is washed into rivers and ponds.
    b. Fertiliser causes an algae bloom on the surface of the water
    c. This blocks sunlight to the photosynthesising organisms underneath
    d. Plants die and decomposers break down the deed material.
    e. Decomposers respire aerobically and use up the oxygen in the water
    f. This means the water becomes deoxygenated so other organisms in the lake die.