Unit 4 Summary Notes

1. **Populations:**
   a. ***Definitions:***
      i. Ecosystem: all the biotic and abiotic factors that make up a habitat
      ii. Population: the total number of one species in a habitat
      iii. Community: the total number of all species in a habitat
      iv. Niche: the role of an organism in a habitat – what it feeds on, its interactions etc.
   b. ***Random Sampling:***
      i. Need a large enough number of quadrats
      ii. Use calculator to generate random numbers to use as coordinates
      iii. Set up a grid eg using tapes
      iv. Either count individuals – these need to be accurately identified
      v. Or estimate percentage cover – quick, useful with very abundant species
      vi. Keep a running mean and when mean values stay the same, no further quadrats are needed
   c. ***Systematic sampling***
      i. To measure changes across a habitat; to build a profile
      ii. Eg down a shore, across a path
      iii. Use a transect:
         1. Belt transect – quadrats laid along a tape across the profile
         2. Interrupted belt transect – quadrats at regular intervals along tape
         3. Line transect – place a tape and count all the organisms touching it
   d. ***Mark-release-recapture***
      i. The ratio of the number caught and marked in the first sample to the whole population is the same as the ratio of marked animals in the second sample to the total number caught in the second sample
      ii. Assume organisms caught first time distribute evenly through the whole population
      iii. Assume that the population is constant with no immigration or emigration and that there is a fixed boundary
      iv. The survey needs to be ethical: the marking should be inconspicuous so as not to make the animal more likely to be preyed upon or to make it more vulnerable in any way
   e. ***Analysing data***
      i. Carry out a statistical test to make sure that results are not due to chance alone but that they are statistically significant
      ii. Chose the appropriate statistical test and justify your choice:
         1. Chi squared – 1 set of data; difference between observed and expected results
         2. Spearman rank correlation – 2 sets of data; to see if there is a relationship between two sets of data
         3. Standard error – means of 2 sets of data; to see if there is a significant difference between 2 sets of data

2. **Variations in population size**
   a. ***Lag, log, stationary phases of growth:*** - growth of a new population starts slowly (lag) then increases exponentially (log) then, with small fluctuations, stays the same (stationary)
   b. ***Each environment has a carrying capacity*** – a maximum number of one type of organism that it can support ie there are limiting factors to population size.

i. Limiting factors can be:
1. Biotic eg disease, predation – these depend on the density of the population: the greater the population, the greater the effect of the factor
2. Abiotic – these are absolute and do not depend on the density of the population eg light intensity, aspect etc

c. ***Competition:*** occurs when two or more individuals share a resource
i. Interspecific competition: between organisms of different species. If two organisms compete for all resources ie they compete for the place in a single niche, then competition will continue until one species is eradicated in that niche. Note the example of Paramecium
ii. Intraspecific competition: between organisms of the same species eg for food, water, mates etc

d. ***Predation:***
i. The predator population lags that of the prey population and is lower in number

e. ***Human populations***
i. Still in the log phase of growth
ii. Improved living conditions – hygiene, agriculture, medicine etc – mean that the population continues to grow
iii. Factors that affect population size:
1. Birth rate
2. Death rate
3. If birth rate exceeds death rate, the population is growing
4. Immigration & emigration

iv. Population growth = (births + immigration) –(deaths + emigration)
v. Factors affecting birth rate:
1. Economic conditions
2. Birth control
3. Social and political factors

vi. Factors affecting death rates
1. Life expectancy at birth
2. Age profile
3. Sanitation, hygiene & safe drinking water
4. War
5. Natural disasters

vii. Population structure
1. Stable: where birth rate = death rate
2. Increasing: where birth rate > death rate
3. Decreasing: birth rate < death rate

viii. Demographics: the study of population distribution – size, density, etc

3. **Energy & ATP**

a. ***ATP***
i. Is a phosphorylated nucleotide
ii. Can easily lose a phosphate group: phosphorylating another substance raises its free energy (potential energy available for a reaction)
iii. Is easily hydrolysed
iv. Is used for work eg:
1. Active transport
2. Muscle contraction
3. Cilia movement

4. Exocytosis
5. Raising the free energy of a compound by phosphorylation

v. Key definitions:

1. Substrate level phosphorylation: when phosphorylation occurs directly without use of an electron transport chain
2. Photophosphorylation: phosphorylation using energy from light. Can be cyclic or non-cyclic
3. Oxidative phosphorylation: phosphorylation where oxygen acts as the final electron acceptor
4. Dehydrogenation: removal of hydrogen from a compound which becomes oxidised and its addition to an electron carrier which becomes reduced
5. Decarboxylation: removal of carbon dioxide from the carboxyl group of an organic acid

b. ***Photosynthesis:***

i. Leaf adaptations:

1. Thin – short diffusion distance
2. Large surface area
3. Transparent cuticle and upper epidermis so that light easily reaches chloroplasts in the palisade mesophyll
4. Large number of chloroplasts
5. Many stomata for gas exchange
6. Network of xylem vessels to bring water and minerals (revise transpiration!)

ii. Light dependent reaction

1. Cyclic:
   a. PSI only
   b. Light energy excites two electrons from chlorophyll to new energy level – chlorophyll oxidised
   c. Electrons pass down electron transport chain in thylakoid membrane
   d. Energy used to pump H^+ ions into thylakoid space
   e. H^+ diffuse out – chemisosmosis – and ATP made
   f. Electrons return to PSI
2. Non-cyclic
   a. Light hits PSII
   b. Two electrons excited and chlorophyll oxidised
   c. Photolysis of water: $H_2O = 2H^+ + 2e^- + \frac{1}{2} O_2$
   d. Electrons from photolysis used to replace those lost from chlorophyll
   e. Electrons pass down first ETC to PSI
   f. ATP made
   g. Light hits PS1 and electrons excited
   h. Pass down second ETC
   i. Electrons plus hydrogen ions from photolysis join to electron acceptor NADP which becomes reduced
   j. Oxygen given off as waste product
   k. ATP and reduced NADP move to Calvin Cycle

iii. Light independent reaction

1. Carbon dioxide joins to 5C RuBP using enzyme rubisco
2. Unstable 6C compound breaks down into two glycerate-3-phosphate

3. ATP and reduced NADP used to convert GP to two molecules of triose phosphate
4. Some of this used to make glucose
5. Remainder recycled using ATP to regenerate RuBP

iv. Limiting factors
1. Main limiting factors are:
    a. Light intensity
    b. Carbon dioxide concentration
    c. Temperature
2. Even if all these not limiting, other factors will always limit rate eg number of chloroplasts etc
3. Point where rate of respiration = rate of p/s is called compensation point
4. Below this – rate resp >rate p/s therefore CO_2 given out
5. Above this rate p/s > rate resp therefore CO_2 taken in

c. ***Respiration***

i. Glycolysis – occurs in the cytoplasm
1. Glucose phosphorylated to hexose bisphosphate using 2ATP
2. These broken to two triose phosphate
3. These dehydrogenated to 2 pyruvate
4. 2 NAD reduced
5. 4 ATP made by substrate level phosphorylation
6. Net – 2 ATP made

ii. Link reaction – links cytoplasm to mitochondria
1. Pyruvate decarboxylated and dehydrogenated to make acetyl coenzyme A
2. CO_2 made
3. NAD reduced

iii. Kreb's Cycle – in the matrix of the mitochondrion
1. 2C Acetyl CoA added to 4C oxaloacetate to make 6C citrate
2. 2 decarboxylations – 2 CO_2 made
3. 3 reduced NAD made
4. 1 reduced FAD made
5. 1 ATP by substrate level phosphorylation

iv. Electron transport chain – on inner membrane of mitochondrion
1. Electrons brought by reduced NAD and reduced FAD pass down a series of electron carriers at successively lower energy levels
2. Energy used to pump H^+ into intermembrane space
3. HH++$^{=++++}$ diffuse out through stalked particles – chemiosmosis
4. eneEEEEnergy from diffusion enables ADP and P_i to combine with enzyme ATPase to make ATP
5. H^+ and electrons and oxygen combine to make water: oxygen is the final electron acceptor

v. Net production – 32 ATP

vi. If no oxygen available, ETC stops, NAD not regenerated therefore no Krebs possible

d. ***Anaerobic respiration*** – in cytoplasm only

i. Glycolysis makes pyruvate

ii. Pyruvate receives hydrogen atoms from reduced NAD

iii. Lactate made; NAD regenerated

iv. Net production – 2 ATP

v. Lactate broken down in aerobic respiration: converted to pyruvate and acetyl CoA
vi. Note: anaerobic respiration in yeast makes ethanol: pyruvate is decarboxylated

e. ***Mitochondria:***
i. Inner membrane folded into cristae to increase surface area
ii. Inner membrane holds ETC in a logical sequence
iii. Matrix contains respiratory enzymes
iv. Membranes impermeable to H^+ ions
v. Double membrane – can have different pH from matrix and from cytoplasm
vi. Stalked particles contain proton channels and the enzyme ATPase
vii. Carrier proteins used to pump HHH^+ ions into intermembrane space

4. **Energy and ecosystems**
a. ***Definitions***
b. ***Producers:*** make own food by autotrophic nutrition (photosynthesis)
i. Consumers: obtain nutrients be feeding on other organisms
ii. Decomposes: secrete enzymes to breakdown complex organic molecules in dead material into simple soluble ones that can be absorbed. These are saprobiontic bacteria and fungi, and detritivores – small animals such as earthworms

c. ***Food chains:***
i. Arrows show the direction of energy flow
ii. The original source of energy is the sun
iii. Energy is lost between each trophic level due to:
1. Respiration
2. Heat generated by movement
3. Not all organism is eaten
4. Incomplete digestion
5. Energy lost as faeces and urine

iv. GPP = NPP + R
v. Units are $Kgm^{-2}y^{-1}$
vi. Not all sunlight reaching earth used in photosynthesis:
1. Some reflected
2. Not all wavelengths used
3. Not all light reaches chloroplasts
4. Some light energy used to heat molecules

vii. Energy transfer = $\frac{\text{energy available after transfer}}{\text{Energy available before transfer}} \times 100$
viii. Energy efficiency = $\frac{\text{useful energy out}}{\text{Total energy in}} \times 100$

d. ***Ecological pyramids***
i. Pyramids of numbers: =not always pyramid-shaped eg there might be a single tree at the first trophic level
ii. Pyramids of biomass – usually correct shape
iii. Pyramids of energy – most accurate

e. ***Agricultural systems***
i. Are deflected climaxes
ii. There is reduced biological diversity
iii. There is less genetic diversity
iv. Natural cycling of nutrients enhanced with man-made activities
v. Energy input is from fossil fuels and food

vi. Productivity is higher than in the natural environment
vii. Agricultural practices are aimed at increasing productivity
1. Maximising rate of photosynthesis eg in glass houses
2. Use food that is more easily digested and absorbed
3. Reduce movement of farm animals
4. Reduce stress
5. Etc

viii. Controlling pests:
1. Pests reduce productivity:
   a. Weeds compete for resources
   b. Insects may damage leaves or suck plant sap so that growth is reduced
   c. Some pests may compete directly with humans
   d. Monoculture increases spread of pests particularly insects and fungi
2. Chemical pest control - pesticides
   a. Insecticides – chemicals that kill insects
   b. Fungicides
   c. Herbicides
3. Natural pest control – aka biological pest control relies on using natural predators such as ladybirds; pest levels reduced but not eliminated
4. Integrated pest management – uses both chemical and biological methods for maximum efficiency

ix. Intensive rearing of animals
1. Aim for efficient energy conversion
2. Uses less space but uses more energy eg for heating
3. High density populations spread disease within the population but can be protected from external sources of infection
4. Use of antibiotics is increasing antibiotic resistance
5. Ethics – animal welfare issues arise
6. Increase likelihood of pollution
7. Decreased genetic diversity through selective breeding

x. Intensive crop production
1. Hedgerows removed to make mechanisation easier therefore diversity reduced
2. Reduced genetic diversity
3. Increased use of pesticides: health issues and increased risk of pollution
4. Poor soil structure due to lack of crop rotation – some crops such as wheat are very demanding on the soil. Nutrients are replaced by using fertilisers but there is little organic matter added to maintain soil quality. Also, use of machines damages soil.

5. **Nutrient Cycles**

a. ***Carbon cycle***

i. Plants (producers)fix atmospheric carbon dioxide in photosynthesis
ii. Respiration returns carbon dioxide
iii. Carbon compounds as organic molecules move through the food chain by feeding
iv. Decomposers return carbon dioxide to the air by respiration

b. ***Carbon cycle and the enhanced greenhouse effect***

i. Carbon sinks tie up carbon dioxide for many years:
    1. Forests – as organic molecules
    2. The sea – dissolves carbon dioxde
    3. Shells of sea animals contain carbonates
    4. Polar ice caps contain frozen methane (CH_4)

ii. Greenhouse gases include carbon dioxide, methane, water vapour and CFCs

iii. Greenhouse gases absorb solar radiation and re-emit it as infra-red radiation

iv. Increased levels of greenhouse gases mean that more heat than usual is being absorbed rather than reflected back into space

v. This is leading to a warmer atmosphere and therefore global warming

vi. Consequences include:
    1. Melting polar ice caps:
        a. Flooding and rising sea levels
        b. Loss of habitat
        c. Increased levels of fresh water entering oceans
        d. Diversion of existing ocean currents
    2. Changes to food chains as organisms that are better adapted become prevalent – consequently, many species lost, reduced biodiversity etc
    3. Greater rainfall in some areas while others become hotter and drier
    4. Increased risk of famine and food shortage
    5. Changes to lifecycles eg of insect pests

c. ***The nitrogen cycle***

i. Nitrogen fixation:
    1. By lightning
    2. By nitrogen-fixing bacteria: convert nitrogen gas to ammonium compounds which can be converted to amino acids:
        a. In root nodules of leguminous plants (peas, beans, clover)
        b. Free-living in the soil

ii. Ammonificaton: conversion of proteins and amino acids in dead and waste materials to ammonium compounds by ammonifiying (putrefying) bacteria

iii. Nitrification: conversion of ammonium to nitrites then nitrates by nitrifying bacteria

iv. Denitrification: conversion of nitrates to nitrogen gas by denitrifying bacteria living in water-logged, anaerobic conditions

v. Nitrate-based artificial fertilisers can be leached into lakes and rivers and cause eutrophication

vi. Increase in nitrates causes algae to grow

vii. Algae block light to plants underneath

viii. Plants die and are decayed by bacteria

ix. Bacteria use up oxygen

x. Fish die

xi. Manure can be used – benefits as adds organic matter to soil to improve soil texture and it is broken down slowly giving a steady release of nutrients; disadvantage is that nitrates can leach and cause eutrophication

d. ***Water cycle main stages:***

i. Precipitation - rain

ii. Absorption by plant roots

iii. Transpiration from leaves

iv. Respiration

v. Evaporation from rivers and seas into the air

vi. Condensation forms clouds

6. **Succession**
   a. ***Primary sere*** – has never been colonised
   b. ***Secondary sere*** – previously colonised but then cleared eg by fire, quarrying etc
   c. ***Stages:***
      i. Pioneer species adapted to harsh conditions of little water, few nutrients etc colonise the land. Their seeds are wind-dispersed and germinate rapidly
      ii. Succession occurs: rock starts to break down and form soil or sand is fixed by the presence of roots and organic matter. Nutrient content increases and water retention increases. Diversity increases as the number of niches increases, resulting in more complex food webs; total biomass increases
      iii. Succession continues until a **climatic climax community** is reached: these are stable communities that continue in dynamic equilibrium with the climate.
      iv. A deflected community is one where, due to interference by man such as grazing, coppicing etc, a difference climax is reached. Examples include grazed grassland, mown grassland, land cleared by fire, agriculture etc.
   d. ***Conservation of habitats***
      i. To maintain biodiversity
      ii. Ethical issues: most extinction and endangerment is due to man's activities
      iii. To maintain the gene pool: useful alleles are being lost all of the time, making species more vulnerable to extinction
      iv. Species as yet undiscovered or not investigated may be useful for medicines
      v. Economic considerations
      vi. Cultural considerations: many cultures are based around the environment of the indigenous people
      vii. Aesthetic considerations
7. **Inheritance**
   a. ***A gene*** is a sequence of DNA that codes for a polypeptide
   b. ***An allele*** is a different form of a single gene
   c. ***Genotype*** – the combination of alleles
   d. ***Phenotype*** – the observable characteristic produced
   e. ***Chromosomes*** are in homologous pairs – one maternal and one paternal
   f. ***Each gene therefore has two copies***:
      i. Homozygous – two alleles the same
      ii. Heterozygous – two different alleles
   g. ***Dominant:*** if present it shows in the phenotype
   h. ***Recessive:*** only shows if no dominant allele present
   i. ***Co-dominant***: two dominant alleles that both manifest in the phenotype
   j. ***Multiple alleles***: when there are more than two alleles for a single gene
   k. ***Polygenic***: a characteristic that is determined by more than one gene
   l. ***Monohybrid inheritance***: inheritance of a single characteristic
      i. RR x rr gives 1: 0
      ii. Rr x Rr gives 3:1
      iii. Rr x rr gives 1:1
   m. ***Blood groups*** – show multiple alleles (A, B, O) and codominance (A & B)
   n. ***Sex inheritance*** – whole chromosomes: XX – female; XY - male
   o. ***Sex-linkage***: genes that are found on the unmatched portion of the X chromosome eg haemophilia
   p. ***Pedigree charts*** show phenotypes for a characteristic through different generations of

a family

q. ***Epistasis:*** one gene masks the presence of another (also called a dominance hierarchy)
   - i. E.g. Gene A →Gene B → Gene C
   - ii. Dominant epistasis: presence of a dominant allele in the first gene (A) in the sequence means that no further genes in the sequence have any effect – B and C do not affect the phenotype
   - iii. If the first gene is homozygous recessive, then B has an effect. If there is no dominant allele in B then C has an effect on the phenotype.

r. ***Allele frequencies***
   - i. Hardy-Weinberg:
     1. $p + q = 1$
     2. $p^2 + 2pq + q^2 = 1$
     3. Assumptions are:
        a. Large stable population with no selection
        b. No immigration or emigration
        c. No mutations
        d. Mating is random
   - ii. Founder effect: a small population breaks off and colonises a new area
     1. Allele frequencies may change
     2. Mutations may arise that are not present in the parent population
     3. Over time new species may form – different selection pressures etc
   - iii. Genetic bottlenecks: an environmental disaster causes changes in allele frequencies; some alleles may disappear

s. ***Selection***
   - i. Speciation types:
     1. Directional – shift in allele frequencies
     2. Stabilising – extremes of alleles disappear
     3. Disruptive – extremes are selected for
   - ii. Natural selection
     1. There is variation
     2. There is over production
     3. There is a struggle for survival
     4. The best adapted survive and pass their characteristics on to the next generation
     5. Over time this may lead to evolution: ie formation of a new species
     6. Species become reproductively isolated
   - iii. Allopatric speciation is due to geographical isolation
     1. Different areas have different selection pressures
     2. Different alleles selected for
     3. Over time populations become reproductively isolated