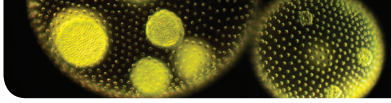


Topic 1 - data-based questions

Page 6–7

1. a) *magnification = size of image / actual size of the specimen;* size of the image (scale bar) = 20 mm; actual size = 0.2 mm; magnification 20 / 0.2 = 100 ×;

b) width of thiomargarita in the image (image size) = 26 mm; magnification = 100 × actual size = 26 / 100 = 0.26 mm;

2. a) *magnification = length mitochondrion in the image (63 mm = 63,000 μm) / actual size of the specimen (8 μm)* = 63,000 / 8 = 7875×;

b) scale bar 5 μm × 7875 = 39 375 μm = 39.375 mm (approx 40 mm)

c) width on the image 23 mm / magnification 7875 = 0.0029 mm (2.9 μm)

3. a) 20 μm × 2000 (magnification) = 40,000 μm; (or 40mm scale bar)

b) actual size of specimen 34 mm / 2000 = 0.017 mm = 17 μm

4. a) hens egg is 7 mm wide in diagram; ostrich egg is 22 mm long in diagram; real hen egg is about 50 mm wide; ostrich egg: $\frac{(50 \times 22)}{7}$ = 157 mm approx

b) *magnification = size of image of egg / actual size of the egg;* hens egg : $\frac{7\text{mm}}{50\text{mm}} = 0.14\times$

Page 28

1. a central white/light area; sandwiched between two darker layers;

2. proteins appear dark in electron micrographs (page 27 of the text); phospholipids appear light; reasonable support for the Davson-Danielli model;

3. proteins stain darkly; the dark pattern is the distribution of proteins; possible explanation is that they are enzymes/cytoskeleton elements/protein bound vesicles;

4. *magnification = size image / actual size of the specimen* 1 mm/10 nm = 1×10^{-3} m/$(10 \times 10^{-9}$ m) = 0.1×10^{6} = 100 000 × magnification

Page 29 (Membranes in freeze-etched electron micrographs)

1. a) membrane proteins; that are transmembrane / straddle the membrane;

b) the Davson-Danielli model had proteins on the outside; provided evidence that there were proteins in the centre of the membrane; falsified the Davson-Danielli model of membrane structure;

2. inner membrane; outer membrame visible to the right / outer membrane would not be as regular in appearance;

3. mitochondria can be recognised by their rounded shape and cristae in these positions: lower right; middle right; to the left of the mitochondrion middle right;

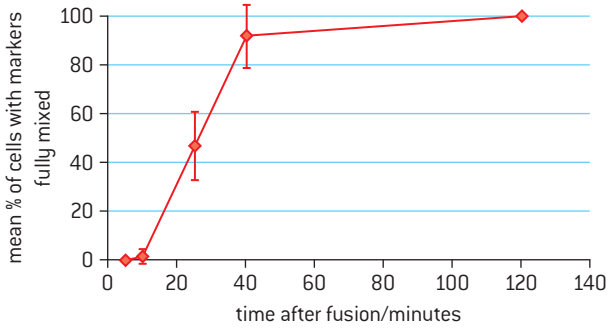
4. Golgi apparatus visible; with cisternae and many vesicles;

Page 29–30 (Diffusion of proteins in membranes)

1.

Time (min)	Mean
5	0
10	1.5
25	47
40	92
120	100

2.



3. as time progresses, an increasing number of cells have markers fully mixed

4. it supports the Singer-Nicholson model; membrane proteins can move; suggesting membrane is fluid;

5. range bars are a measure of variability of data; the more variable, the less reliable the conclusions based on the data;

6. human body temperature (normal temperature for human cells);

7. the movement of markers increases with temperature, because the molecules move faster with higher temperatures, then it levels off;

8. at lower temperatures the membrane proteins hardly move, therefore the markers are hardly mixed; phospholipids in membrane not fully liquid / semi-solid;

9. ATP is required for active transport; the movement of membrane proteins is passive/it does not require ATP/energy;

10. a rise in marker movement can be expected at lower incubation temperatures, since these animals are adapted to a colder environment; have phospholipids with a lower melting point;

Page 36

1. 1 mm = 1000 μm; 400 μm × 1 mm / 1000 μm = 0.4 mm

2. **a)** decreasing with distance; sharply at first but then decreasing more gradually;

b) used by cornea cells for aerobic respiration; diffusion from the air is slow; no blood supply to bring oxygen; no cells / no respiration in aqueous humour / oxygen supplied by blood capillaries in iris;

3. **a)** higher than the inner cornea; lower than the inner cornea;

b) concentration is lower in the cornea; there would not be (net) diffusion from the aqueous humour;

4. levels quickly fall off over a distance of 100 μm; making it an ineffective mechanism of transport over larger distances;

5. **a)** increase in the distance O_2 has to move; / decreasing concentration at the inner cornea;

b) increase moisture / increase O_2 permeability of the lens;

6. an indication of the variability of the data; provides an indication of the reliability of the data;

Page 39

1. reduction in oxygen concentration below 21% reduces phosphate absorption; from 21% to 2.1%, the reduction is very small / not significant; large / significant reductions below 0.9% / from 0.9 to 0.1%;

2. phosphate absorbed by active transport; ATP required for active transport; ATP produced by aerobic respiration in roots; aerobic respiration requires oxygen;

3. phosphate absorbed mainly by active transport; when DNP blocks production of ATP by aerobic respiration, phosphate absorption drops to a low level;

4. still some phosphate absorption when DNP has blocked ATP production by aerobic respiration; some ATP might be produced by anaerobic respiration; active transport probably not the only method of phosphate absorption; aerobic respiration fully blocked at 6 mmol dm^{-3} DNP, as phosphate absorption does not drop any lower above this concentration;

Page 42

1. **a)** it moved into the tissues

   b) out of the tissues

2. the cactus had the lowest concentration; where the graph crosses the x-axis is isotonic; lowest isotonic value seen for the cactus;

3. cactus tissue might act as a water store, so has low solute concentration; pine kernel might have dried out to become dormant, so has a high solute concentration; pine / butternut squash / sweet potato might be adapted to habitat with higher solute concentrations in the soil; butternut squash / sweet potato / pine kernel might contain large quantities of sugar / stored foods so have a high solute concentration;

4. the starting masses might have been different in different tissue samples; percentage change is a better measure of relative change;

Page 54

1. late anaphase; chromosomes have been separated into chromatids; chromatids are moving toward/ have arrived at the pole;

2. **a)** counting centromeres should give the number of chromosomes, thought it is difficult to discern individual centromeres as they can appear as double dots; counting telomere dots and dividing by two can yield a count but these can appear as single dots; reasonable estimate is 14 chromosomes;

   b) union of gametes regardless of whether they are odd or even would yield an even number;

   c) this is the same pattern that exists in anaphase; the pattern set up in interphase persists throughout interphase;

   d) shortening of telomeres ultimately might get to coding regions; death of the cell/limit to the number of times a cell can divide;

Page 59

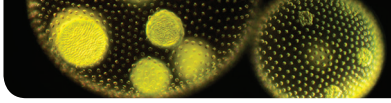
1. positive correlation between smoking and most diseases; respiratory, circulatory, stomach and duodenal ulcers and cirrhosis of liver; no correlation with Parkinson's disease;

2. respiratory diseases increased by a greater factor; over four times as high compared with less than twice as high for circulatory with more than 25 cigarettes; number of deaths increased more by circulatory; over 900 more deaths with circulatory and only 364 more with circulatory with more than 25 cigarettes;

3. even a small number shows a doubling in respiratory diseases; and 1.5 times as much for circulatory diseases; big difference between 1 cigarette a day and 14 cigarettes a day;

4. if a person was a smoker, they might have had other health limiting behaviours; such as drinking (cirrhosis); or inactivity;

5. mouth cancer; lung cancer; esophageal cancer; stomach cancer; throat cancer.



Topic 1 - end of topic questions

1. a) (i) eukaryotic because there is a nucleus;

(ii) root tip because it has a cell wall;

(iii) interphase because chromosomes are not visible;

b) (i) length of image is 44mm; 44mm = 44000 μm; actual size = 44000 / 2500 μm = 17.6 μm;

(ii) 125 μm × 2500 = 12500 μm = 12.5 mm

c) water lost from cell by osmosis; volume of cytoplasm reduced; plasma membrane pulled away from cell wall;

2. a) 98 130 μm^2

b) $\frac{\text{(plasma membrane area)}}{\text{total area}} \times 100 = 1.8\%$

c) outer membrane is smooth/not folded; inner membrane is invaginated; extra surface of inner membrane needed for respiration;

d) protein synthesis as there is much rough ER; ATP production as there is much mitochondrial membrane;

3. a) (i) active transport

(ii) facilitated diffusion

(iii) osmosis

b) contains secreted proteins; not enough water dilutes the solutes/proteins; because not enough chloride ions in it; so not enough osmosis happens;

4. a) I-G_1 or end of mitosis; II-S; III-G_2 or beginning of mitosis;

b) (i) prophase–approximately 14 pg/nucleus

(ii) telophase–approximately 7 pg/nucleus

Topic 2 - data-based questions

Page 79

1. a) **(i)** wild birds 13.3 kg;

(ii) captive birds 16.2 kg;

b) both groups lose most of their lipid; captive birds lose more of their lipids than wild ones; 11.2 versus 9.6 kg/93% lost versus 81%/other valid figures comparing the change;

c) insulation/source of waste heat when metabolized/source of metabolic water;

Page 81

1. a) BMI 34;

b) obese;

2. a) 100 kg;

b) BMI is 24, so status is normal weight;

3. a) current weight is 104 kg; needs to reach 57 kg; 104−57 kg = 47 kg;

b) increased exercise; reduced energy intake;

4. as height increases, BMI decreases; at an increasing rate/exponential rate;

Page 85–86

1. gender differences in fat deposition patterns controlled for;

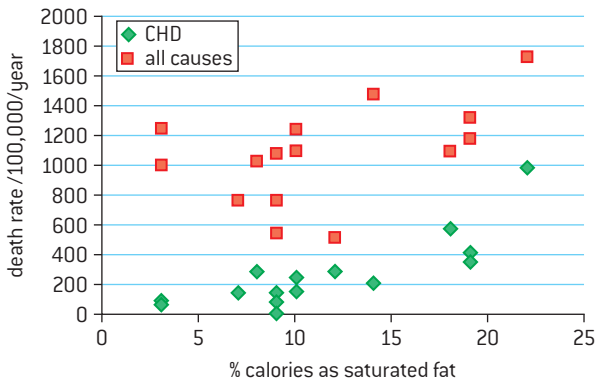
2. moderate/weak positive correlation;

3. age is a factor in the onset of CHD symptoms; hormonal changes with age may impact CHD; physical activity varies with age;

4. 100% − 99% = 1%;

Page 86 (Saturated fats and coronary heart disease)

1. a)



b) positive correlation with % saturated fat and CHD, especially at higher percentages; relationship is less clear with % saturated fat and all causes;

2. a) similar % saturated fat, but CHD much higher in E. Finland than W. Finland;

b) same % saturated fat, but much higher CHD in Montegiorgio than in Crete;

3. data suggests that saturated fat intake is a risk factor for CHD; because the graph shows a positive correlation; but some countries with similar/same saturated fat intake have different CHD rates; showing that other factors must also affect CHD rates;

Page 90

1. **a)** hypothesis 1 not supported as it isn't known whether these were the 20 amino acids on pre-biotic Earth; hypothesis 1 not supported as simulation experiments / comets suggest other amino acids were present; hypothesis 2 not supported as it isn't known whether other amino acids would have been useful; hypothesis 2 not supported as some other amino acids are used in protein by modification of one of the 20 amino acids; hypothesis 3 is supported as there is other evidence for the common origin of life; hypothesis 3 is supported as all organisms use the same genetic code / use D glucose/L amino acids;

b) simulate conditions on pre-biotic Earth to find which amino acids could have been present; find another planet where life has evolved and see which amino acids are used; look for organisms on Earth that do not use the same 20 amino acids;

2. not a significant discrepancy; oligopeptides aren't polypeptides; amino acids in peptidoglycan are not linked together by ribosomes; linked together by a simpler process catalysed by enzymes; does not involve the use of the genetic code; evolved separately from the genetic code and translation on ribosomes;

Page 97

1. one enzyme catalyses the formation of 1,4 bonds; the other enzyme catalyses the formation of 1,6 bonds;

2. once the 1,6 bond is formed, then this starts a new chain that can be extended by the enzyme that makes 1,4 bonds; in other words the substrate for this enzyme is doubled;

3. heat-treatment denatures enzyme; curve A shows no enzyme activity/no enzyme mediated conversion;

4. **a)** increasing rate of conversion earlier/until 35 minutes; rate of conversion levels off;

b) every bond formed can either be creating a new glycogen molecule or adding to an existing one; the former leads to an exponential increase in number of glycogen molecules/substrate molecules; until growth in new glycogen molecules slows and available enzyme becomes limiting;

Page 100–101

1. **a)** no; method is subjective and not quantified so can't express as a rate;

b) yes; the faster the rate of reaction, the darker the colour;

c) yes; the faster the rate of reaction, the larger the change in mass; will need to measure mass of cubes before starting;

2. finding the mass altogether; will control for variability; **or** finding the masses individually; allows the reliability of the mass changes to be assessed;

3. **a)** not precise enough to detect changes;

b) yes, it will be precise enough to detect changes;

c) yes, it will be precise enough to detect changes (but it may be more precise than is justified);

4. to remove the immersion solution from the surface; to reduce errors in mass measurements;

5. results for pH 2 to 6 are reliable; results for pH 7 to 9 are not reliable, as the third result in each case is much lower;

6. **a)** final column, pH 7, 8 and 9;

b) freshness of pineapple; older pineapple has degraded tissue and less functional enzyme;

7. x-axis legend is pH; y-axis legend is mass decrease (mg);
mean results plotted; all points plotted correctly; straight lines joining point to point;

8. optimum pH 6; activity decreases above and below pH 6; activity greater at basic pH as compared to acidic pH values;

9. precise value is between 5 and 7; more active at 6 than 5 or 7; but not clear if fractional pH doesn't give a higher rate;

Page 103

1. **a)** temperature (other variables could be investigated); varied using a thermostatically controlled water bath;

   b) degrees Celsius;

   c) 20 to 80 °C at 10 °C intervals;

2. **a)** use an electronic timer; compare the colour in the tube to another tube containing only milk, which will show when the phenolphthalein has turned colourless;

   b) seconds;

   c) to assess the reliability of the results; to avoid relying on one result which might be atypical/ anomalous;

3. **a)** volume and concentration of lipase; volume of milk; pH of reaction mixture;

   b) use the same sample of lipase solution for the whole experiment; measure the milk with an accurate syringe/pipette; put the same volume and concentration of sodium carbonate into each tube;

   c) 1 ml of 1% lipase; 5 ml of milk; pH 8;

4. **a)** the fat is in small droplets with a large total surface area;

   b) the larger volume will take longer to reach the target temperature than the small volume;

   c) a smaller proportion of the liquid will be left behind on the sides of the tube/there will be better mixing of the liquids;

5. sketch graph should show a steeper and steeper rise to a peak at about 50 °C; followed by a steep drop to zero at higher temperatures;

6. human pancreas because it is adapted to work at 37 °C, while the lipase from castor oil seeds will be adapted to work at lower temperatures;

Page 107

1. the quantities of the four bases are reasonably similar across all of the eukaryotes: the relative quantities of bases in *Mycobacterium* are distinct from eukaryotes; *Mycobacterium* has less adenine and thymine but more guanine and cytosine; the amount of adenine approximately equal to the amount of thymine in both; the amount of guanine is approximately equal to the amount of cytosine in both groups;

2. 1.00 in both cases;

3. within experimental error the data supports the hypothesis; differences in amounts of G/C and A/T are too small to be significant;

4. complementary base pairing between A and T would mean that they would need to be present in equal quantities – same argument for C and G;

5. Polio virus may be single stranded/may be RNA virus; (need uracil data to know); bacteriophage T2 may be double stranded;

Page 109

1. all other bases contain oxygen;

2. it is used for the linkage between the base and the deoxyribose; base is linked to C1 of the deoxyribose;

3. both have two rings of atoms on their molecule; both have one six-membered and one five-membered ring; the nitrogen and carbon atoms are in the same places in the rings; both are purine bases;

4. both have one six-membered ring with carbons and nitrogens in the same positions; both have an oxygen linked to a carbon in the ring; both are pyrimidines;

5. distinctive shape needed for complementary base pairing; each base only pairs with one other; A to T and G to C; hydrogen bonds formed between complementary bases; allows accurate replication of DNA; essential for producing genetically identical cells/organisms/ needed for inheritance; allows gene regulators to recognise specific sequences of bases;

Page 113–114

1. DNA was produced containing ^{14}N, rather than ^{15}N in the organic bases; ^{14}N has a lower mass than ^{15}N;

2. **a)** 1.717 g cm^{-3}

b) falsifies conservative replication because that method would give two bands of DNA with densities of 1.710 and 1.724 g cm^{-3}; dispersive unlikely to give a band half way between the higher and lower densities;

3. **a)** two bands; density 1.717 and 1.710 g cm^{-3}; equal amounts of the two bands;

b) falsifies the dispersive mechanism; there would only be one band; all the DNA would be partly 1.710 and partly 1.724 g cm^{-3};

4. less and less 1.717 g cm^{-3} DNA; because all new strands are 1.710 g cm^{-3}; and when these strands are replicated the DNA produced is 1.714 g cm^{-3};

5. semi-conservative redrawn; next generation has two red-green molecules and two all green ones; generation after has two red-green molecules and six all green ones;

6. three bands with 1.710, 1.717 and 1.724 g cm^{-3} density;

Page 118

1. left picture: translation (polysomes / ribosomes are visible); middle picture: DNA replication (replication bubble is shown / two replication forks are visible); right picture: transcription (possibly coupled with translation; increasing lengths of mRNA are visible);

2. **a)** DNA

b) DNA

c) mRNA with ribosomes attached

d) DNA

e) mRNA

Page 125

1. (560-544) g; 15/16 g total mass loss divided by 13 days; 1.2 g per day;

2. anaerobic cell respiration / alcoholic fermentation; CO_2 is a waste product; release of CO_2 leads to loss of mass from the solution;

3. population growth of yeast/more yeast respiring; positive feedback/increasing amounts of CO_2 from higher population leads to lower solubility/higher rate of release; waste heat decreases CO_2 solubility;

4. substrate has run out; death of yeast (from high alcohol);

Page 128

1. **a)** respiration rate increases;

b) all cells/tissues in the larva are respiring; so respiration rate increases as number of respiring cells/mass of respiring tissue increases;

2. **a)** slight increase in 3rd and 4th instar larvae as larval weight increases; slight decrease/no significant change in 5th instar larvae; changes may not be statistically significant;

b) oxygen consumption is proportional to the mass of respiring tissue below critical weight; above critical weight the supply of oxygen by the tracheal system reaches a maximum because tracheae are part of the exoskeleton and cannot grow;

3. lower maximum rate of oxygen supply by the tracheal system; oxygen supply to the larva becomes insufficient at a lower mass; the insect has to moult and develop a larger tracheal system at a lower mass;

Page 134

1. wavelength on the x axis and leaf area and height on two y axes; suitable scales on the x axis and the two y axes; appropriate legends on each axis stating what the variable is; units stated on each axis; all points plotted correctly; all points joined with straight lines between the points;
2. inverse correlation/larger leaf area with lower height;
3. red only makes the seedlings very tall so plants might need more support/height to grow; orange only gives the lowest leaf area which might reduce photosynthesis rate; blue only gives the largest leaf area which might increase photosynthesis rate; red, green and blue combined gives the lowest height and second highest leaf area; data does not indicate photosynthesis rates with the different wavelengths; data does not indicate crop yields with the different wavelengths.

Topic 2 - end of topic questions

1. substrate is triglyceride; product is glycerol; and fatty acids; which lower pH when generated;

2. a) (i) no effect due to temperature between 20°C and 40°C; rate of activity falls above 40°C

(ii) higher temperature causes changes to enzyme structure; active site no longer fits the substrate; denaturation;

b) (i) also becomes less active at higher temperatures; activity is higher than soluble papain at temperatures above 40°C;

(ii) immobilized papain is more heat stable; binding to a solid surface makes the enzyme molecule more stable;

(iii) maltase; in the cell membrane / microvilli of epithelium cells lining the small intestine;

3. a) (i) dm^3;

(ii) g and kg;

b) (i) $\frac{18.25 \text{ kg ATP}}{134.4 \text{ dm}^3} = 0.1358 \text{ kg dm}^{-3}$;

(ii)

Length of race/m	Volume of oxygen/dm^3	Mass of ATP produced/kg
1500	36	4.888
10,000	150	20.37
42,300	700	95.06

c) ATP produced in a cyclic process; synthesis of ATP only involves addition of phosphate to pre-existing ADP; same ADP molecules phosphorylated many times during the race; cycle of rephosphorylation only takes seconds; mass of ATP produced as a result of oxidation of glucose is much larger than the mass of glucose;

d) 0.5 dm^3 of oxygen consumption would allow production of only 69 g of ATP; sprints must involve a degree of anaerobic cell respiration;

4. a) (i) light intensity;

(ii) carbon dioxide concentration;

(iii) temperature;

(iv) light intensity or carbon dioxide concentration or photosynthetic capacity;

b) because carbon dioxide concentration is the limiting factor; they are at the same carbon dioxide concentration; the light intensity is not affecting the rate of photosynthesis;

c) rate of photosynthesis is very low because of low light intensity; carbon dioxide is released in respiration; rate of respiration is greater than rate of photosynthesis;

5. a) with increasing wavelength there is limited effect up until about 680 nm; then there is a significant decrease in yield as wavelength increases;

b) supplementary light has limited effect up to about 680 nm; above 680nm supplementary light increases oxygen yield/rate of photosynthesis;

c) the error bars show the variability of the data; where the error bars overlap up to 680 nm. Suggest that there is no significant difference; up to 680 nm;

d) $\frac{1 \text{ photon}}{0.125 \text{ molecules}} = 8 \text{ photons/molecule}$

e) eight photons produce one oxygen molecule; eight electrons are excited per oxygen molecule; eight electrons are excited per four electrons produced by photolysis; so each electron must be excited twice.

Topic 3 - data-based questions

Page 145

1. (Non-smokers without the cancer are controls in this study as they do not have the risk factor of smoking, or the cancer.)
A is more common; as the percentage with A and G or A and A is much higher than the percentage with G and G (the Hardy Weinberg equation could be used to predict the base frequencies: frequency of G is $\sqrt{0.126} = 0.355$; frequency of A is $1 - 0.355 = 0.645$);

2. **a)** patients with cancer = 43.7 + 9.8 = 54%; without cancer = 35.6 + 9.4 = 45%;

b) a higher percentage of those with the cancer were smokers than those who did not have the cancer, suggesting that smoking increases the risk of the cancer / gastric adenocarcinoma;

3. the base A is associated with a higher risk; 19.3% GG total for those with the cancer versus 22.0% for those without the cancer; 83.7% AG plus AA total for those with cancer versus 78% for those without cancer;

4. increased more in smokers who have the A allele; proportion of smokers with AG or AA is $\frac{43.7}{(43.7 + 9.8)} = 0.82$; proportion of non-smokers with AG or AA is $\frac{35.6}{(35.6 + 9.4)} = 0.79$;

Page 153

1. 20 in mice (or 21 if the X and Y chromosomes are considered to be separate types); 23 in humans (or 24 if the X and Y chromosomes are considered to be separate types);

2. X, 1, 14;

3. 1 and 13;

4. common evolutionary history / common mammal ancestor; evolutionary divergence was relatively recent; rate of mutation / change is low; conserved function / roles of genes;

5. duplication of some chromosomes; fission of some chromosomes; fusion of some chromosomes; translocation of parts of chromosomes to a different chromosome;

Page 156

1. such an organism would be sterile; meiosis requires synapsis/chromosome splitting; odd number means meiosis;

2. not supported when considering plants; meaning of complex needs to be established as all are multicellular; no difference in complexity of cat and dog yet dog has more chromosomes etc; threadworm is least complex so possible; would need to see chromosome number of prokaryotes etc;

3. some chromosomes may be long/fused;

4. chimpanzee and human have different chromosome numbers (48 versus 46); chimpanzee and human have a common ancestor so either chimp number increased by fission / duplication or human number decreased by fusion of chromosomes;

Page 159

1. **a)** chromosome 1;

b) chromosome 21;

2. **a)** chromosome 2 is longer; chromosome 2 has the centromere nearer the middle of the chromosome; banding pattern is different suggesting differences in structure;

b) the X chromosome is significantly longer; the banding pattern differs; the centromere of the X chromosome is nearer to the middle of the chromosome and is toward one end in the Y chromosome;

3. male; has an X and Y chromosome;

4. it has three chromosomes #21; the child will have Down's syndrome;

Page 161

1. similarities between the life cycle of a moss and of a human include:
both have haploid sperm and egg; both have an 'n' stage; both have a '2n' stage; both have mitosis, meiosis and fertilization; both have a zygote stage;

2. in humans the zygote gives rise to either male or female in individuals but in moss, the zygote gives rise to sporophyte; in moss sporophyte gives rise to spores whereas diploid human gives rise to gametes; eggs and sperm created by mitosis in moss but meiosis in humans; moss plant can give rise to male or female, but separate genders create gametes in humans; in moss, there is a gametophyte and a sporophyte, but we don't have this in humans; meiosis gives rise to gametes in humans, but to spores in moss;

Page 167

1. limited change in incidence until mid-30s; exponential increase after mid-30s;

2. **a)** 1% +/− 0.5%;

b) 1.7−1.0; 0.7%;

3. chromosome 21 is one of the smallest of the human chromosomes; trisomies of other chromosomes have more serious effects; causing death of the zygote / embryo / fetus before birth; missing chromosomes / chromosome mutations also too harmful for the individual to survive;

4. data doesn't discuss risk of advanced age of father; before age of 40, risk of non-disjunction is still relatively small; other possible complications besides chromosomal abnormalities; risk might be balanced by other benefits of postponed parenthood;

Page 173–174

1. 198 grey: 72 albino; 2.75 grey: 1 albino;

2. albino is recessive; the presence of the albino is masked by the grey allele; in a cross of heterozygotes, approximately 25% are albino;

3. GG / homozygous dominant is grey; Gg / heterozygous is grey; gg / homozygous recessive is albino;

4. the parental phenotypes are grey and albino; the parental genotypes are GG and gg; the alleles in the gametes are G and g; the hybrid phenotype is grey; the hybrid genotype is Gg; the alleles in the gametes are G and g;

	G	g
G	GG	Gg
g	Gg	gg

5. white fur and red eyes due to lack of the same pigment / melanin; due to a single mutation in gene for an enzyme needed to make the pigment;

Page 174

1. both typical and annulata have black and red colouration; both have spots; annulata has more black pigmentation;

2. in both cases, they are pure breeding strains; homozygous for the gene influencing coloration;

3. larger black spots than typica; black in more parts of the wing cases than typica; less black than annulata; do not have the rear black strip crossing from left to right side that annulata has;

4. **a)** key to alleles with A^T as allele for typical and A^A as allele for annulata (or other suitable symbols); F_1 genotypes are A^TA^A ; gametes produced by F_1 are A^T and A^A ; F_2 genotypes are A^TA^T, A^TA^A , A^AA^T, A^AA^A; corresponding phenotypes are typical, hybrid, hybrid, annulata; Punnett grid used as the genetic diagram;

b) 1: 2: 1; typical: hybrid: annulata;

Page 176

1. a) Bb × Bb;

	B	b
B	BB	Bb
B	Bb	Bb

prediction is: 3 bilateral: 1 radial; observed is: 2.38 bilateral: 1 radial;

b) fewer bilateral than expected, but close enough to support the prediction;

c) lack of success in pollination/attracting pollinators; reducing the number of recessive alleles;

2. a) LL' × LL';

	L	L'
L	LL	LL'
L'	LL'	L'L'

b) predict ratio of 1 light: 2 bluff: 1 ringed; actual observed 1.1: 2.1: 1.0; within sampling error, these results are close to predicted results;

3. a) do not fit Mendelian ratio; different results from wild type × poky crosses are different depending on which the female parent is; wild type × wild type gives some poky offspring, but not 3 : 1 ratio;

b) due to a mutation in a mitochondrial gene; mitochondria are inherited from female parent;

c) mutations to produce the poky allele of the mitochondrial gene;

Page 183

1. it is recessive as unaffected parents in generation I produce affected children;

2. a) 100% that they will be homozygous recessive;

b) 0%;

c) 0%;

3. a) Dd; the mother is dd;

b) Dd or DD; most likely DD as condition is rare and person is marrying into family with history of disease;

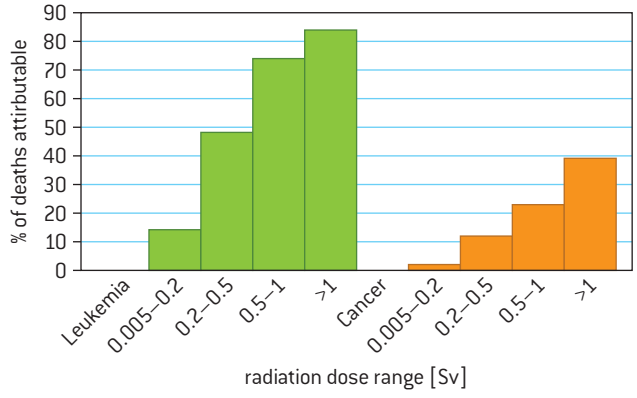
4. cystic fibrosis; sickle cell anemia; other example of autosomal genetic disease caused by a recessive allele;

Page 186

1. a) 10/70*100% = 14.3%

b) 47/56*100% = 83.9%

2.



3. higher doses increase deaths in both cases; more deaths due to leukemia than cancer; nearly quadruple at 0.5–1/double at >1;
4. less than 0.0005 Sv; as this level gives 14% increase in leukemia; and 2% increase in cancer; which is unacceptably high;

Page 188–189

1. 7;
2. data suggests Neanderthals more closely related to humans; because of the fewer differences in bases between humans and Neanderthals; minimum difference in human-Neanderthal exceeds maximum human-human difference, therefore humans and Neanderthals not the same species;
3. based on the bones of a single Neanderthal/limited support;

Page 195

1. **a)** type of leaf; equal misting; all in same type of tube; same method of applying pollen; same number of larvae on each leaf; same length of time of monitoring; time at which larvae were weighed;

   b) to ensure that the only variable was genetic modification; so the effects of this variable could be isolated from other variables;
2. **a)** 5 larvae per leaf x 5 replicates x 3 treatment groups = 75 larvae;

   b) to be able to identify anomalous results; to assess the reliability / variability of the results; to ensure that differences are not due to sampling error / variability between larvae;
3. error bars provide an indication of variability of data; if error bars overlap, likely to be no difference if difference in means exist;
4. mortality is only seen in group where leaves were dusted with GMO pollen; difference is significant suggesting an effect of GM pollen;
5. larvae may find leaves dusted with pollen unpalatable; pollen may provide nutrients and reduce the need for consumption of leaves; consumption of pollen/GM pollen may affect the health of larvae and reduce appetite;
6. 0.26 (g) / mid-way between other treatment groups; because leaf consumption is mid-way between them;
7. whether the larvae would consume leaves dusted in pollen; leaves still connected to plants in wild; density of caterpillars on one leaf affecting how much of one leaf they eat; whether mortality rates in the wild are normally this high.

Topic 3 - end of topic questions

1. a) the long arm of the chimp chromosome #12 and the short arm of the human chromosome appear to be identical; the entire length of the chimp chromosome #13 appears to be found on the long arm of the human chromosome; the final band on the end of the short arm of chimp chromosome #13 does not appear in the human chromosome; the human chromosome is longer than either of the chimp chromosomes;

b) near the centromere on the long arm of the human chromosome, you would find a number of repeats that were more characteristic of telomeres than sequences normally found near the centromere;

2. a) AB individuals are all I^AI^B; O individuals are ii; A individuals are all I^Ai; B individuals are all I^Bi except II 1 which may be I^BI^B;

b) A or B or O or AB; 25% chance of each;

c) (i) 100% blood group O;

(ii) 50% group A, 25% AB and 25% B;

3. a) zero cheetahs; thirteen domestic cats;

b) one allele in cheetahs; three alleles in domestic cats;

c) three alleles.

Topic 4 - data-based questions

Page 204

1. venus fly trap is autotrophic; Euglena is autotrophic; both fix carbon compounds by photosynthesis; though both also feed on other organisms;
2. ghost orchid is heterotrophic; ghost orchid does not carry out photosynthesis despite being a plant; dodder is heterotrophic; feeds parasitically on autotrophs;
3. ghost orchid is saprotrophic; feeds on dead organic matter underground; dodder isn't a detritivore or a saprotroph as it feeds on living plants; dodder is a parasite / not a typical consumer / does not ingest living organisms;

Page 209

1. observed values:

	Heather Present	Heather Absent	Row Total
Moss Present	57	7	64
Moss Absent	9	27	36
Column Total	66	34	100

2. expected values:

based on the row totals, moss should be present 64% of the time and absent 36% of the time; this should hold in all four cell; based on the column totals, heather should be present 66% of the time and absent 34% of the time;

	Heather Present	Heather Absent	Row Total
Moss Present	$(64 \times 66)/100 = 42.2$	$(64 \times 34)/100 = 21.8$	64
Moss Absent	$(36 \times 66)/100 = 23.8$	$(36 \times 34)/100 = 12.2$	36
Column Total	66	34	100

3. degrees of freedom $= (m - 1)(n - 1) = (2 - 1)(2 - 1)$; degrees of freedom $= 1$;
4. the critical region (obtained from a table of chi-squared values) is 3.83 or larger;
5. $(57 - 42.2)^2 / 42.2 + (7 - 21.8)^2 / 21.8 + (9 - 23.8)^2 / 23.8 + (27 - 12.2)^2 / 12.2$ $= 5.1905 + 10.0477 + 9.2034 + 17.9541 = 42.3957$;
6. the calculated value of chi-squared is in the critical region, so there is evidence at the 5% level for an association between the two species; we can reject the null hypothesis H_0;
7. mosses are mostly confined to damp habitats; on this Shropshire hilltop, the moss *Rhytidiadelphus squarrosus* is associated with the heather because the heather provides shade, humidity and shelter from drying winds; neither species can tolerate trampling on the paths created by hill walkers on this site; in the photo, the heather appears purple-brown in colour and the paths are green;
8. a measuring tape was laid down along one edge of the area; random numbers were used to determine a distance along the tape and then another random number was used to determine a distance at right angles to the tape, where the quadrat was positioned; this procedure was repeated one hundred times;

Page 214

1. insolation decreases with increasing distance from the equator / inverse relationship;
2. **a)** 400 W/m^2

   b) 240-260 W/m^2
3. different levels of cloud cover / variations in the composition of the upper atmosphere that absorbs sunlight;
4. tropical rainforests are near equator so supported; rainforests in areas with high insolation, but not the highest in all areas; some high insolation areas are desert, such as Sahara/Atacama deserts; some tropical rainforests in areas of low insolation, like South East Asia;

Page 216

a) respiration rate increases with decreasing temperature below 12 °C; temperature changes between 12 °C and 33 °C have no effect on respiration rate; as temperature climbs above 33 °C respiration rate begins to increase (sharply);

b) bird is trying on maintain temperature; homeostasis; respiration generates waste heat; rise in metabolic rate undertaken to preserve core temperature; bird may increase motion as well to preserve core temperature;

c) increase in metabolic rate linked to activities designed to keep cool; such as evaporative cooling through increased ventilation rate; becoming hyperthermic / body temperature higher than normal; faster metabolism / enzyme-catalysed reactions including cell respiration;

d) random/expermental error; variation in surface area of birds effects temperature homeostasis; variation in muscle contractions / some birds more physically active than others;

Page 219

1. both are top predators; both occupy more than one trophic level; both can be predator/prey of the other; *belastoma* has higher productivity;

2. *Ranatra* and *Belostama* both can be considered as secondary, tertiary and quartenary consumer;

3. a) *Metaphyton → Hyalella → Telebasis → Belostoma;*

b) telebasis;

4. first rung is sum of metaphyton and epiphyton energy values; first rung labelled as producers or with species name; Second rung is labelled primary consumers; second rung shown 5% as wide as first rung;

5. $\frac{\text{final-initial}}{\text{initial}} \times 100\% = -95.3\%$;

6. same organisms can occupy more than one trophic level at the same time; some organisms can occupy different trophic levels at different points in their life cycle; easier to define trophic level in a food chain rather than a food web;

7. determine the fraction of each organism's diet coming from each specific trophic level;

Page 221

1. it is in the spring;

2. a) higher in May than in October;

b) photosynthesis in Northern Hemisphere forests; depletes carbon dioxide in summer leading to lower concentrations in autumn;

3. a) much higher in Northern Hemisphere;

b) Southern Hemisphere at the end of summer, but Northern Hemisphere at beginning; photosynthesis reduces carbon dioxide concentrations in summer; greater burning of fossil in Northern Hemisphere (during Northern winter than in Southern summer); more ocean in Southern Hemisphere where carbon dioxide can dissolve; colder water in Southern Hemisphere so more carbon dioxide dissolves; more land area in Northern Hemisphere so higher total respiration rates;

4. a) the Equator;

b) less fluctuations due to absence of seasons; presence of tropical rainforests to absorb carbon dioxide;

Page 222

1. sharp rises and falls are due to artificial light being switched on and off by a timer; fluctuations when artificial light is on are due to variation in natural light / cloudy or sunny conditions;
2. six days;
3. **a)** pH rises in the light; becomes more alkaline / basic;
   b) absorption of carbon dioxide (which is acidic) from the water; by photosynthesis;
4. **a)** pH falls in darkness (mostly) / becomes more acidic;
   b) more cell respiration than photosynthesis; carbon dioxide released into the water;

Page 224

1. **a)** increasing the temperature increases the release of carbon; the effect is more significant in moist soils than waterlogged soils;
   b) higher temperature means higher rates of chemical reactions, including respiration which releases CO_2;
2. **a)** in both cases, carbon release increases with temperature; an increase in carbon release is much higher in moist rather than water logged soils;
   b) in water-logged soils, more anaerobic respiration in bacteria and fungus; only some have alcoholic fermentation; anaerobic respiration releases adding fertiliser increases release of carbon dioxide; in moist soils, but not in soils saturated with water; adding fertilizer impacts carbon release – in moist soils only;
3. amount of water in the soil has the greatest impact; differences between M and W greater than differences between 7 and 15 or TC and TF;

Page 227

1. approximately 210 days of decreasing versus approximately 160 days of increasing;
2. lowest on day 135 which is in April; highest on day 290 which is in October;
3. high rates of photosynthesis in summer due to high insolation and warm temperatures leads to high net ecosystem photosynthesis (NEP); low rates of photosynthesis with cellular respiration
4. annual carbon flux is 17.5 t CO_2 ha^{-1} because this is the value reached at the end of the cumulative curve;
5. they could capture more carbon dioxide and reduce the concentration in the atmosphere / reduce the greenhouse effect;

Page 233

1. direct and indirect measurements are very similar in the years when both data is available;
2. both rise between 1880 and 2008; both rise most steeply from 1970/80 onwards; temperature fluctuates more than carbon dioxide concentration;
3. $0.22 - (-0.19) = > 2000 - 1900 = 0.41$ C $0.41 - (-0.21) = > 2005 - 1905 = 0.62$ C
4. **a)** some possible explanations: natural variability / solar variability / variations in fossil fuel use; local conditions at monitoring stations vary; feedback systems from the earth triggered by warming;
   b) they suggest that CO_2 is not the only variable influencing temperature; strong correlation both in figure 5 and in the figure 6 + 7;

Page 234

1. **a)** 1990;
   b) 1970;
2. **a)** the higher the temperature, the earlier the opening of the chestnut leaves;
   b) over the final 10 year period, highest average temperatures occurred; pervious pattern appeared to be cyclical; supports claim of global worming;

Page 236

1. greater affluence in the US leading to more transportation; more use of air conditioning in the US; no winter so no heating use in Brazil; greater industrial activity in the US;
2. rapid growth in fossil fuel use in the four named countries; cheap oil in countries that produce it; large use of fossil fuel for air conditioning / water purification / construction / oil production;
3. forest fires; to clear land for farming; combustion releases carbon dioxide;
4. farming activities / cattle / sheep / ruminants release methane;

Page 237

1. AIFI;
2. minimum 1.1 °C; maximum 5.9 °C;
3. 1.8 °C;
4. 2.1 °C in the Arctic versus 1.8 °C global average; Arctic temperature rise is higher than global average;
5. whether positive feedback cycles will exacerbate the problem; such as melting of polar ice caps; or permafrost melting; or increase in cloud cover;
6. depends on whether data used by centres is the same or independently gathered; more centres means more validity; similar logic applies to positive impact of sample size on certainty in IA experiments;
7. according to precautionary principle strong action called for because consequences of inaction are potentially catastrophic; costs of mitigation should be borne equally; developing nations need assess to carbon production to achieve higher standard of living; will require greater reductions in developed world;
8. forces acting in support of avoiding economic risk are more powerful; some shifts in economic activity possible; local versus global economies; shift to greater degree of subsistence activities; fossil fuel shortage may aid shift.

Topic 4 - end of topic questions

1. a) respiration loss = gross production − net production = 1×10^2 kJ m^{-2} y^{-1}

b) answer presumes a student draws a pyramid of net production: base of pyramid is 50 units wide; second tier is 6 units wide; third tier is 0.6 units wide; (accept equivalent ratios) tiers labeled as producers, primary consumers, secondary consumers (accept equivalent terms);

2. a) greater fraction of incident light energy lost in desert; deserts are less productive/less vegetation to fix energy;

b) large amounts of energy pass to decomposers in dead plant matter; large amounts of energy accumulated in forests in wood;

3. a) the late 1960s and the 1990s;

b) (i) the number of years with an infestation is a longer stretch in the 1990s; the number of affected hectares is much higher in the 1990s;

(ii) increase in the number of cycles in one season; population explosion with limited predation due to global warming;

c) data suggests increased destruction of spruce trees in future; warmer temperatures will reduce life cycle to one year / increase reproduction rates; rates of destruction may remain stable / decrease; if there is an increase in predation of the spruce beetle;

4. a) all are in remote areas/areas uncontaminated by local pollution;

b) both increase over time; greater annual fluctuations at Alert than at Baring Head;

c) smaller annual fluctuations at Baring Head because it is in the southern hemisphere; less land mass / more ocean; so less photosynthesis and respiration / more storage and release of carbon dioxide in seawater;

5. a) (i) between 330 and 340 ppm;

(ii) 310 to 330 ppm;

b) (i) 0–7 hours;

(ii) carbon dioxide produced by cell respiration in the soil; furthest from leaves that reduce the carbon dioxide concentration by photosynthesis in the day; lower speeds of wind that cause mixing of air; carbon dioxide is a dense gas so it sinks;

c) 8.00 hours;

6. a) all organisms living above the surface of the soil (including plant shoots and animals);

b) equatorial forest;

c) little nitrogen stored in the soil; growth of crop plants will be limited by lack of nitrogen/ mineral nutrients in the soil; high rainfall leaches nitrogen/mineral nutrients out of the soil;

d) cell respiration;

e) low biomass of plants above ground / small maximum plant size / organic matter accumulates in the soil due to slow rates of decomposition;

f) melting of permafrost allowing diffusion of gases / carbon dioxide; faster rates of cell respiration in saprotrophs / bacteria / fungi; faster metabolism / enzyme activity.

Topic 5 - data-based questions

Page 243

1. length of image is 83 mm and magnification is 100 mm / 5.5 mm = 0.055x;
actual size is 83 mm / 0.055 = 1509 mm or approximately 1.5 metres;

2. similar skull bones; similar dentition; vertebrae / backbone; similar limb bones / pentadactyl limb;

3. maintenance of a stable body temperature / insulation;

4. forelimbs have to evolve into wings; protofeathers have to evolve into feathers; body size evolves to become smaller;

5. fossil record is incomplete; feathers not well preserved in most fossils; direct observation not possible; DNA / molecular evidence not available;

Page 244

1. $\frac{170 - 14}{14} \times 100\% = 1114\%$ increase in length;

2. $\frac{4100 - 150}{150} \times 100\% = 2633\%$ increase in yield;

3. seed texture; sweetness of seeds / kernels; texture / starchiness of seeds / kernels; number of seeds / kernels per cob; colour of seeds / kernels; disease resistance; frost hardiness; tolerance of drought;

4. loss of genetic diversity; less variation; purebred varieties developed; loss of hybrid vigour; inbreeding;

Page 249

1. a) more likely to be eaten on the exposed trunk than below a joint; higher percentage were eaten on exposed trunk for melanics and peppered moths in both New Forest and Stoke;

b) on the exposed trunk, it is easier for birds to detect the moths;

2. a) peppered have a higher mean survival rate in the New Forest than the melanic forms on both the exposed trunks and below the joints;

b) unpolluted air in New Forest, so tree trunks are clean and covered in lichens; peppered moths are better camouflaged / harder for the birds / predators to detect;

3. in Stoke the melanics have a higher survival rate than in the New Forest; in the New Forest, the peppered moths have a higher survival rate than in Stoke; overall survival is slightly higher in the New Forest; greater difference between Stoke and New Forest in below joint survival than exposed trunks;

4. less soot on tree trunks / cleaner tree trunks; more lichen on tree trunks; melanic variety less well camouflaged; increased predation of melanics; numbers of melanic form will be reduced; percentage of peppered form increased;

Page 253

1. hybrids have genetic variety but pure-bred varieties do not; genetic variety is needed for natural selection;

2. mean flowering date becomes later; variation in flowering dates reduced;

3. a) later flowering times in lower latitudes / further south;

b) shorter growing season further north / higher latitudes so plants that flower later will not have enough time to develop seeds and fruits;

4. a) less variation and stronger correlation between latitude and flowering time;

b) poor performance in the first year with some flowering too early and some too late; cross-breeding between the two varieties produces plants that flower at intermediate time; in following years the intermediate flowering plants become dominant;

Page 255–256

1. a) increases to a peak of 300 birds in 2003; decline after 2003 to very low population size;

b) both have population peak in 2003, followed by a decline; *G. fortis* reaches a much higher level of population; *G. fortis* pattern appears cyclical/has two instances of a peak and decline in the same period that *G. magnirostris* has one peak and decline;

2. minimum: presuming 100 birds per 0.34 km^2, the density is 294 birds per km^2;
maximum: 1,500 birds per 0.34 km^2, density is 4,411 birds per km^2;

3. **a)** *G. magnirostris* feeds on all three seeds with a preference for large seeds; *G. fortis* feeds on all three seeds with a preference for small seeds; *G. scandens* feeds on only small and medium seeds with a preference for small seeds;

b) *G. magnirostris* and *G. scandens* ate more medium sized seeds after the drought; *G. fortis* ate fewer large seeds;

4. **a)** 1977 to 1978 and 2004 to 2005;

b) less food, so more deaths during a drought; selection can be more intense; distribution of seed sizes different from non-drought periods, so different individuals have a selective advantage;

c) shortage of small seeds during the first drought; so selection favours birds with larger beaks; *G. magnirostris* also present during the second drought; competition for larger seeds so *G. fortis* beak size did not increase;

5. small population size / small island size; large fluctuations in abiotic factors due to El Nino and La Nina; high death rates during droughts; geographic isolation, so little immigration or emigration; short generation time in birds;

6. long studies can reveal smaller / more gradual evolutionary trends; funding for scientific research often favours short projects with fast results; scientists may not want / be able to continue with long term research; methods / research priorities change over time;

Page 257

1. **a)** negative correlation / lower resistance with greater distance from the pen;

b) antibiotic in faeces of pigs treated with antibiotic; soil contaminated with antibiotic near to the pen where manure has spread; decreasing soil antibiotic concentration at increasing distances from the pen; more intense selection for antibiotic resistance with higher antibiotic concentrations;

2. *either* lower resistance; because soil concentration of antibiotic will be lower; so there will be less selection for antibiotic resistance; *or* same resistance; resistance already very low at 100 metres; some antibiotic resistance in bacterial populations is natural;

3. should not be used because they increase the problem of antibiotic resistance; may be needed to increase production of pork needed to feed the human population; should not involve use of antibiotics that are important for controlling human / livestock diseases;

Page 262

1. animal;

2. **a)** the four rays (middle left, middle centre, lower left and lower right);

b) **(i)** different species; they show large differences in their structure;

(ii) same family as same genus;

c) eyes on top of head; flat body; pectoral fins are wing-like;

3. fish at 3 o'clock / middle right is in its own order; fish at 11 / upper left, 1 / upper right and 6 / lower middle are in the same order as they are similar;

Page 273

1. they are more closely related to the short-tailed opossum; because there are fewer differences;

2. $6 + 3 = 9$;

3. the evidence suggests that painted turtles and lizards are a clade; only four differences in their microRNA genes; more closely related to each other than to alligators / some other reptiles; they share a clade that excludes birds and mammals;

4. alligators are classified conventionally as reptiles; but this evidence suggests they are more closely related to birds than some other reptiles; suggests that birds and reptiles are not separate clades / should not be classified separately;

Topic 5 - end of topic questions

1. d

2. a

3. d

4. d

5. **a)** 34

b) 24 to 30 are in one of the two genera; 31 to 33 are in the other genus in the family;

c) 1 to 7 are in one of the families; 8 to 23 are in the other family in the order;

d) 1 to 23 are in one of the orders; 24 to 33 and 34 are in the other two orders in the class;

e) more closely related to species 16; because 8 and 16 are in the same family, but 6 is in a different family;

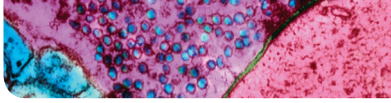
f) due its different characteristics species 34 is classified by itself; in its own genus, family and order;

6. **a)** minimum is 0%; maximum is 100%;

b) more melanics than peppered in east / in central and northern England; more peppered in west and far north / in Ireland, Wales and south-west England;

c) wing colour / pattern affects visibility of roosting moths to predators; differential predation / how many individuals of a variety are killed / survive; differential reproduction / how many offspring are produced; more offspring produced with wing colour / pattern that provides better camouflage; individuals with better camouflage increase in number / proportion in the population;

d) more melanics in areas polluted by industry; including areas down-wind of industrial areas; melanic forms are better camouflaged against tree trunks covered in black soot / with no lichens; more peppered moths in areas with clean air; peppered forms are bettered camouflaged against tree trucks covered in lichens.



Topic 6 - data-based questions

Page 301

1. blood is pumped from atria to ventricles 0 seconds to 0.1 seconds (N.B the slight rise in atrial pressure at 0.15 seconds is probably due to the AV valve bulging back into the atria as ventricular systole starts;)

2. ventricles start to contract at 0.10 seconds;

3. AV valve closes at 0.1 seconds (atrial pressure falls below ventricular pressure);

4. SL valve opens at 0.15 seconds (ventricular pressure rises above arterial pressure);

5. SL valve closes at 0.4 seconds (ventricular pressure falls below arterial pressure);

6. blood is pumped from the ventricle to the artery from 0.15 to 0.4 seconds;

7. **a)** blood in the ventricle is at a maximum at 0.1 seconds (just before the SL valve opens);

b) blood in the ventricle is at a minimum at 0.4 seconds (at the end of ventricular systole);

Page 310

1. **a)** increasing to peak in 1993; decreasing to 1996; increasing to a peak in 1998; declines to lowest level in 2002;

b) pattern appears to be cyclical;

2. $\frac{(5.2 - 16.0)}{16.0} \times 100\% = -67.5\%$;

3. lowest levels of resistance occurred after programme implementation; therefore same success; peak in 1998 suggests programme not fully effective;

Page 312

1. inhaled air mixes with air in alveolus which has a lower oxygen concentration / is stale air; some oxygen has diffused into capillaries that surround the alveoli due to low partial pressure of oxygen in those capillaries;

2. **a)** $\frac{105 - 40}{40} \times 100\% = 163\%$; the partial pressure of oxygen is 163% higher in the alveolus;

b) diffusion;

c) **(i)** $\frac{3 - 27}{3} \times 100\% = 800\%$; 800% increase in CO_2 concentration between inhaled and exhaled air;

(ii) CO_2 produced by cell respiration; CO_2 enters blood as it flows through tissues of the body; CO_2 has diffused out of the blood into the alveolus raising the CO_2 concentration in the alveolus;

d) nitrogen concentration in blood is already as high as in the atmosphere; nitrogen not used by tissues of the body; no concentration difference between blood and air in alveolus; as many carbon dioxide molecules move from blood to air as from air to blood / no net movement;

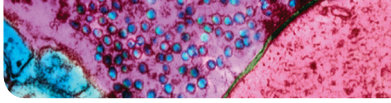
Page 318

1. **a)** *typical results:* healthy lung 8 times; lung with emphysema 4 times; units are number of gas exchange surfaces per 60 mm of micrograph; (if the magnification of the micrograph is known, the units could be converted to per micrometre of lung);

b) as a result to emphysema, the mean number of gas exchange surfaces decreases; by about half; the volume of the alveolus increase; decreasing surface area to volume ratio; decreasing total gas exchange per unit time;

2. total gas exchange per unit time decreases; lower levels of oxygen in blood; lower availability of ATP for energy requiring activities;

3. greater resistance to blood flow in the lungs because of decreased numbers of capillaries; leads to increase in blood pressure;



Page 324

1. −72 mV;

2. −30mV; because the membrane potential starts to rise very steeply on the trace when this potential is reached;

3. depolarisation takes approximately 2 ms according to the graph; repolarisation takes approximately 2 to 3 ms; depolarisation and repolarisation together take 4 to 5 ms;

4. more than 65 ms because the graphs shows that the resting potential has not been reached after than time; estimates between 80 and 500 ms are reasonable;

5. assuming a refractory period of 60 ms after the action potential during which impulses cannot be initiated, there could be one action potential per 80 ms; 1000 / 80 impulses per second = 12 action potentials per second;

6. pulse of current that was given to stimulate impulses has not yet finished and causes the membrane potential to rise briefly after the repolarisation;

Page 325–326

1. a) precursor to L-Dopa so increases dopamine production in existing neurons;

b) prevents dopamine breakdown, prolonging dopamine effects;

c) favours dopamine production pathway by blocking alternative pathway;

d) an agonist either mimics or promotes the activity of a chemical such as dopamine;

e) causes dopamine concentration to increase / remain high in the synapse;

2. a) stem cells cultured and develop into neurons; dopamine-secreting neurons / cells produced; transplanted into brain to replace dopamine-secreting neurons;

b) insert functional copy of gene to replace mutant gene; insert into vector such as a virus; inject large numbers of transgenic viruses into patient;

Page 331

In person with diabetes:

a) higher concentration of glucose at time zero;

b) longer time to return to baseline (hasn't occurred after 5 hours);

c) much higher maximum glucose;

d) delay in time before glucose begins to fall;

Page 338

1. a) the more menstrual cycles, the higher the bone mineral density; significant increase in bone density once the number of cycles surpasses 10; effect on bone density is not uniform across the bone;

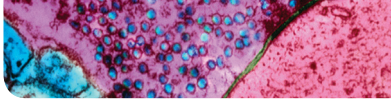
b) as few as 1–3 has clear effect on entire bone but 4–10 has a different effect depending on the part of the bone; neck of femur has lower density when number is between 4–10; trochanter has higher density when number is between 11–13; lowest density reached in neck/highest density reached in trochanter; both show the relationship that the more menstrual cycles, the higher the bone mineral density;

2. a) may have better diets; may have more moderate running regimes;

b) lower bone density might be caused by caused by insufficient nutrient intake; lower bone density might be caused by low estrogen levels; older runners might be over-represented in this category; high energy consumption might forestall bone maintenance;

3. a) preserving resources for demanding exercise regime; reduced estrogen impacts uterine and ovarian hormone cycles;

b) reduced appetite/exercise regime is part of weight loss strategy.



Topic 6 - end of topic questions

1. a) success rate increases as age of mother increases; success rate much lower above age 39; success rates slightly lower below 30 than 30–34;

b) success rates increase as more embryos are transferred; but rate with two/three is not double/triple rate with one; rate with three embryos only slightly greater than rate with two;

c) restricting the number of embryos transferred reduces chance of multiple birth; multiple births increase the health risks for mother/child; restricting number of embryos to two would prevent (almost all) triplets; older mothers at less risk of multiple births so more embryos could be transferred;

2. a) glucose is stored in liver as glycogen when blood sugar is high; when blood sugar is low, glucose is released from liver stores; daily fluctuations in glycogen levels is linked to daily fluctuations in blood glucose; caused by eating; and activity;

b) homeostasis is maintenance of variables at or near a set point; blood sugar regulated by the hormones insulin and glucagons; these hormones whether glucose is stored as glycogen; or released from glycogen stores; considerable daily variation is glycogen stores enables blood sugar homeostasis;

3. a) (i) airways become blocked so ventilation stops; oxygen concentration of alveoli falls so saturation drops;

(ii) reduced oxygen saturation wakes the sleeper; airways reopened by moving the soft palate;

(iii) 55 cycles in one hour; 65 seconds per cycle;

b) 65%; 5 hours 40 minutes;

c) normal sleep initially; then apnoea for rest of night apart from two periods of normal sleep;

4 and 5

a) (i) the magnitude of the depolarization is lower; and it takes longer to reach;

(ii) the action potential has a longer duration; highest value takes longer to reach; re-polarization takes longer;

b) with reduced extra-cellular Na^+ the magnitude of depolarization will be lower, as the concentration difference is lower and the electrochemical gradient is lower;

c) membrane potential does not rise as far during depolarisation / does not rise above 0 mV; fewer potassium channels open; potassium ions diffuse out of axon at slower rate;

d) the magnitude of the action potential is lower in the mutants; the rate of depolarization is approximately equal; the rate of re-polarization is much longer in the mutant; as a result the duration of the action potential is longer in the mutant; final resting potential is the same in both;

e) K^+ channels faulty / don't all open / don't open for as long so slower diffusion of K^+ ions explaining the slower repolarisation; K^+ channels might open early preventing maximum depolarisation.

Topic 7 – data-based questions

Page 344–345

a) after spinning, the solid mass which is at the bottom is referred to as a pellet and the liquid and the smaller molecules/particles that remain suspended in the liquid above the pellet is referred to as the supernatant;

b) the viruses, being much lighter would remain in the supernatant; in order to transform the cells, the genetic material would need to be found in the cells; since the cells are heavier, the material that transformed the cells would be in the pellet;

c) 80% of the ^{35}S remains in the pellet;

d) ^{32}P is found in DNA, but not proteins; because the cells / pellet contained the radioactive ^{32}P the DNA must have been involved in the transformation of the cells; because the cells / pellet did not contain radioactive ^{35}S, the sulphur is not responsible for transforming the cells;

Page 349

1. **(i)** 250 bp / the smallest fragment / the fragment furthest from the origin;

(ii) 500 bp/ the second smallest fragment;

(iii) 750 bp;

2. 250 bp;

3. there would only be a fragment that was 250 bp long and it would be brighter;

Page 353

a) starting with the fragment at the bottom: 123, 246, 369, 492, 615, 738, 861

b) assuming the top of the image is the origin

Distance moved[mm]	Fragment size [bp]
0.35	861
0.79	738
1.28	615
1.82	492
2.50	369
3.25	246
4.20	123

&)

Individual	Distance moved [mm]	Estimated fragment size [bp]
#1	2.4	420
	2.7	370
#2	1.7	550
	3.5	220
#3	1.4	610
	2.8	340
#4	1.1	680
	1.8	550
#5	1.2	660
	3.1	290
#6	1.6	580
	1.8	540

e)

Estimated length [bp]	Estimated number of repeats
420	26
370	23
550	34
220	14
610	38
340	21
680	43
550	34
660	41
290	18
580	36
540	34

f) run the gel for longer;

Page 356

a) approximately 40%;

b) identical twins have the same combination of paternal and maternal chromosomes; their genotypes are the same for all genes; having a higher probability of both having the disease than siblings/ fraternal twins suggests genetic component to the condition;

c) height has the highest contribution coming from genetics, but not entirely; there is still an environmental component; rheumatoid arthritis has lowest genetic contribution, but still some component; diabetes has significant increase in probability with genetics, but still relatively low overall probability; alcoholism has a genetic component;

Page 358

1. green mixes with red to produce yellow; if both are methylated in the same places then green will always mix with red to produce yellow;

2. all show differences between the two twins with chromosome 1 and 17 showing some similarities;

3. chromosome 3 has the least yellow;

4. differences in methylation represent differences in regulation of gene expression; twins exposed to different conditions that effect gene expression tesulting in methylation at different locations;

5. as they grow from 3 years old to 50 years old, they will become different from one another in those areas where gene expression is influenced by environmental factors;

Page 369

the alpha chain: is missing a (his) at residue #2 / has had a deletion at residue #2; the alpha chain has an (ala) where the beta chain has a (glu); (glu) is more polar than (ala) and will affect protein folding; the beta chain has more residues; the alpha chain and beta chain both begin with a non-polar aa (val); the alpha chain has more deletions;

Page 371

a) epsilon and zeta globin;

b) gamma is expressed in the first 10 weeks while beta is not; while gamma declines, beta increases: gamma is not expressed at six months while beta is significant fraction of hemoglobin at six months; both are expressed in approximately equal amounts at 24 days;

c) at 10 weeks, hemoglobin is composed of equal amounts of alpha and gamma globin; at 6 months, hemoglobin is primarily composed of alpha globin and beta globin with smaller amounts of delta globin;

d) maternal blood;

e) fetal blood and maternal blood will differ in affinity for oxygen; (difference in hemoglobin structure gives) fetal blood greater affinity so oxygen will move from mother to fetus; change (with development) necessary so fetus can prepare for independent gas exchange/transition from placental to pulmonary gas exchange.

Topic 7 – end of topic questions

Page 372

1. a) more radioactive fragments of all sizes at 30 seconds; increase in ratio of larger fragments to smaller fragments at 30 seconds/2 peaks at 30 seconds versus one peak at 10 seconds;

b) two peaks suggests two different sizes of molecules predominate; higher peak represents large number of small fragments/lagging strands; smaller peak represents a number of longer fragments/leading strands;

c) if lagging strands are joined together by DNA ligase, then the number of initial small molecules would decrease and the number of larger molecules would increase. This is what is observed so the hypothesis is supported;

2. a) phosphate

b) H-bond

c) covalent bod

d) sugar

e) base

3 a) deoxyribose

b) DNA

c) III and V

d) III

Topic 8 - data-based questions

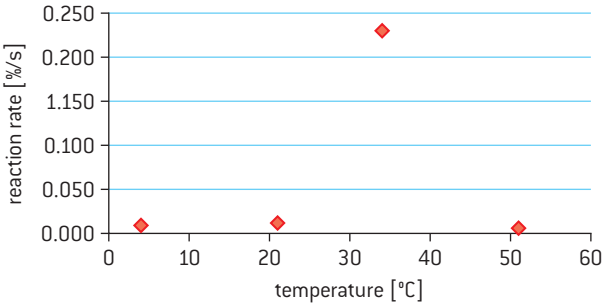
Page 378

1. OMP decarboxylase has the slowest uncatalysed rate;
2. OMP decarboxylase has the highest catalysed rate;
3. ketosteroid isomerase 3.8×10^{11}; nuclease 5.6×10^{20}; OMP decarboxylase 1.4×10^{24};
4. OMP decarboxylase is the most effective as it is the slowest reaction without a catalyst and the most rapid reaction with a catalyst;
5. the substrate binds to the active site of the enzyme; the binding leads to a conformational change in the enzyme that strains bonds within the substrate making it more reaction; or it makes collisions between substrates more effective in terms of promoting a reaction;

Page 379

1. appears to be independent of temperature therefore must be part of the uncertainty of the measuring device;
2.

Temperature [˚C]	Reaction rate [%/s]
4	0.01
21	0.013
34	0.23
51	0.007

3. 

Page 385

1. pyruvate is a substrate for aerobic respiration; pyruvate is broken down in the link reaction which will not occur in absence of oxygen; oxygen is consumed during oxidative phosphorylation which requires reduced molecules produced from pyruvate breakdown;
2. ADP needed to be added so that Krebs cycle could occur; as ADP is raw material for Krebs cycle; no Krebs cycle, no electron transport chain; no electron transport chain, no oxygen consumption;
3. oxygen level would not have declined any lower; as no Krebs cycle would occur and therefore no electron transport chain would occur;
4. all pyruvate has been used up; no more Krebs cycle occurring; so no oxygen consumption in the electron transport chain; so ADP is no longer rate limiting;

Page 390

1. multiple fracture layers are visible;
2. integral proteins are embedded in both halves of a bilayer; the bilayer fractures down the middle, but the proteins remain embedded in one half giving the studded appearance;
3. 10^6
4. other membranes that might be visible are stroma lamellae, inner membrane and outer membrane / membranes of other organelles in the cell;

Page 394

1. **a)** the higher the pH of ADP solution, the more rapid is the rate of ATP production. This is a direct relationship at lower pH but rate of increase increases with pH;

   b) because the magnitude of concentration gradient between inside and outside is being increased;

2. the lower the incubation pH, the higher the yield of ATP. This also increases the magnitude of the concentration gradient/difference in concentration;

3. ATP production powered by movement of H^+ down concentration gradient. Once movement occurs, concentration, difference is lowered so less ATP production;

4. in the presence of light, photolysis occurs, which generates H^+ and therefore affects concentration gradient;

Page 396

1. the dark period causes the concentration of glycerate 3-phosphate to rise. The dark period causes the concentration of ribulose bisphosphate to fall;

2. **a&b)** in the light reactions energy for Calvin cycle is produced; in the dark, RuBP is converted to glycerate-3–phosphate; glyerate-3–phosphate cannot be converted to RuBP; some of the glycerate-3–phosphate is converted to carbohydrate;

3. RuBP concentration would rise and glycerate-3–phosphate levels would fall;

4. **a)** lower concentration of glycerate-3–phosphate;

   b) lower concentration of RuBP;

Page 398

2. bundle sheath chloroplasts are larger; bundle sheath chloroplasts lack grana; bundle sheath chloroplasts have more starch granules; mesophyll chloroplasts have more higher density of thylakoid membrane;

3. **a)** mesophyll chloroplast because of higher density of thylakoid membrane;

   b) bundle sheath chloroplasts because of the presence of the starch granules;

   c) mesophyll because of the higher density of thylakoid membrane.

Topic 8 - end of topic questions

1. a) chain or cycle of reaction; enzyme catalyse;

b) (i) pyr; **(ii)** FDP; **(iii)** PEP;

c) (i) pyruvate is accumulating; pyruvate is the product of the pathway;

(ii) enzyme that converts F6P to FDP; F6P accumulates; FDP concentration is lower;

2. a) (i) zero light intensity then sudden/instantaneous rise; slower rise to a maximum then these changes in reverse;

(ii) sudden rises and falls when light switches on or off; slower rise to a maximum and fall due to natural light changes;

b) (i) same maximum/1200 lux/maximum beyond range of meter;

(ii) daily maximum falls; falls rapidly at first then more slowly;

(iii) no significant change in maximum intensity; fluctuation from day to day (due to natural light variation);

c) *Chlorella* culture has multiplied/more cells per unit volume; more chlorophyll per unit volume; light absorbed by the chlorophyll/Chlorella cells;

d) *Chlorella* culture has reached a maximum density; nutrients in water are used up; light intensity/carbon dioxide concentration is restricting growth;

3. a) (i) increasing fructose 6-phosphate concentration (initially) causes an increase in activity; activity levels out/remains constant as (substrate) concentration continues to rise;

(ii) more collisions with active site as concentration rises; at high substrate levels all active sites are occupied so no further increase in rate/enzyme working at maximum rate;

b) (i) decreases activity; at all fructose 6-phosphate concentrations; most effect at intermediate fructose 6-phosphate concentrations/little differenceat high fructose 6-phosphate concentrations; ATP acts as an inhibitor;

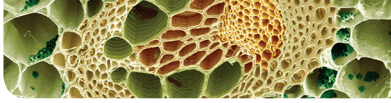
(ii) end-product inhibition; respiration rate decreased if ATP already available;

4. a) between 1.5 and 3.5 hours (or number between these figures) after feeding mealworm RQ values are higher than for millet; no difference in RQ values between 3.5 hours and 6 hours; between 0.5 and 1.5 hours (or number between these figures) millet RQ values much higher than for mealworm; between 2 and 3 hours mealworm RQ values areslightly higher than for millet;

b) millet is not composed entirely of carbohydrates; millet contains more carbohydrates; mealworms contain more lipids/proteins;

c) (i) using carbohydrate (from millet as a respiratory substrate)

(ii) reverting to other substrates / carbohydrates (from millet) used up



Topic 9 – data-based questions

Page 407

1. the rate of water uptake decreases from 17 $cm^3\ hr^{-1}$ to 0;

2. cutting the top of the shoot resulted in a decrease from 10 $cm^3\ hr^{-1}$ to 4 $cm^3\ hr^{-1}$;

3. 10 $cm^3\ hr^{-1}$ to −5 $cm^3\ hr^{-1}$ to = 5 $cm^3\ hr^{-1}$;

4. the pressure generated in the xylem by the leaves on the shoot resulted in a greater uptake of water than that of the vacuum (18 $cm^3\ hr^{-1}$ vs 5 $cm^3\ hr^{-1}$);

Page 408

1. a) addition of the fungus has an effect on both shoot dry mass and root dry mass, but a greater effect is observed on shoot dry mass; different species have different effects; *paxiliis* has the greatest effect; *pisolithus* has least effect;

b) increases surface area of roots; allowing greater mineral absorption and greater water absorption; promoting plant growth;

2. a) as root dry mass increases, shoot dry mass also increases – the relationship is direct;

b) more roots can support greater shoot mass;

c) the two species of *Laccaria* and the two species of *Thelophora* all have a significant effect. Conclusion is supported by *Thelophora* less so by *Laccaria*;

Page 415

assume labels: A C

B D

1. C has more negative solute potential which will draw water

2. water is under positive pressure because of solute having drawn the water there; forced downward due to positive pressure;

3. as solute is withdrawn, pressure difference causes water to move down from C to D

4. pressure potential differences lead water to move from D to B;

Page 418

1. a) (i) active transport of sugar

(ii) create high solute concentration; water drawn in by osmosis;

b) (i) no oligosaccharides at sucrose concentration below 0.25 mol dm^{-3}; oligosaccharides concentration rises between 0.25 and 0.50 mol dm^{-3}; no further increase above 0.50 mol dm^{-3};

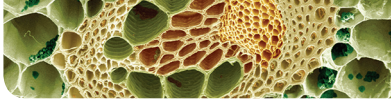
(ii) to reduce water loss from aphid/gut cells by osmosis;

c) (i) poor source of amino acids, with many (especially essential amino acids) at a lower percentage in phloem sap that aphid proteins;

(ii) plants synthesize amino acids for making plant proteins; plant and aphid proteins have different amino acid composition;

d) (i) feed aphids on phloem sap containing antibiotics; test aphid growth rates/protein synthesis rates/amino acid contents;

(ii) physiological problems have to be overcome; problem of phloem sap dehydrating cells by osmosis; problem of lack of essential amino acids;



Page 419

a) direct relationship; as photosynthesis rate climbs, translocation climbs;

b) **(i)** the higher the light intensity, the greater the translocation rate;

(ii) greater light intensity should lead to greater rates of photosynthesis which will lead to more sugar production which would lead to greater rates of translocation so it is a cause and effect relationship;

c) 5: 245 = 0.02;
3: 131 = 0.02;

d) it is a growing leaf as net photosynthesis rate is far in excess of what is being translocated; sugar must be used for storage in leaf or leaf development;

Page 420

(i) leaves 1 and 6;

(ii) on the same side as the source leaf; above the source leaf; youngest leaves (though this is less relevant to location);

(iii) drawing is not clear so difficult to conclude; 4 and 3 appear to be lateral rather than above or below; pruning causes re-routing: hypothesis unsupported; photosynthate appears in leaves on the opposite side after pruning;

Page 424–425

a) IAA causes a lowering of pH, with large initial changes; the pH then stabilizes; IAA could trigger proton pumping;

b) at about 50 minutes;

c) once pH reaches its lowest level, the maximum increase in length occurs;

d) the rate of elongation is greater in pH 3 than in pH 7; elongation stops at pH 7, but not at pH 3;

e) IAA promotes elongation again at neutral pH;

f) addition of KCN prevents elongation;

g) hypothesis supported; figure 5 shows that IAA lowers pH; figure 6 shows that IAA promotes elongation even with neutral pH; figure 7 shows that IAA has no effect with the addition of proton pump blocker;

Page 430

1. for all planting dates there is an initial low rate of increase in the number of nodes; a linear increase in the number of nodes; all groups produce nodes at the same rate/slope of lines are approximately equal; all plants stop producing new nodes at the same time; the earliest plantings produce the greatest number of nodes;

2. **a)** approximately 20 August;

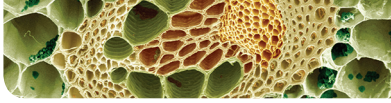
b) day length is a key factor; day (light) length grows shorter in late August; critical day length reached/soybeans are short day plants;

3. **a)** earlier planting yields more nodes; by flowering time more fruits produced per plant;

b) possible frost risk; possible drought risk; early flowering if day length is critical length early in season;

Page 432–433

1. the diameter of the pollen grain is likely to be the cause of both the mean growth of the pollen tube and the optimal sucrose concentration; these can be represented on a single graph or on two different graphs;

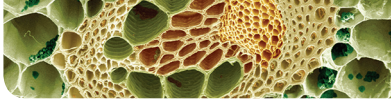


2. as the diameter of the pollen grain increases, mean growth of the pollen tube decreases, though this is a weak correlation; as the diameter increases, the optimal sucrose concentration decreases; this is a reasonably strong correlation; one possible explanation for a certain concentration of sucrose triggering germination may be that this concentration matches the concentration on the stigma of the species;
3. the experiment could have been improved by increasing the number of trials;

Page 436

1. 0.5 μm;
2. the dye appears only on the outside of the cuticle; it was able to penetrate through the testa but was not able to reach through to the embryo;
3. **a)** in the control seed, the stain is only on the surface of the cuticle; in the smoke treated seed, the stain has penetrated further (nearly to the embryo);

   b) fire damages/melts cuticle; allowing water to penetrate and promote germination; in the absence of fire seeds do not germinate because of the cuticle;
4. in climax ecosystem the plant can't compete – *Emmenannthe* is a colonizer species; after fire, more nutrients and more light are available.



Topic 9 – end of topic questions

1. a) as temperature increases, permeance also increases; at higher temperatures, rate of increase of permeance increases; Liriodendron shows this relationship in particular;

b) increases in permeance means more water loss; the plant will need an alternative strategy for preserving water;

c) **(i)** 1.3 μm;

(ii) 1.7 μm;

d) data is highly variable and the highest permeance values are at lower thickness; data does not support the hypothesis;

2. a) 2.9 (± 0.2) mm

b) cyclic light makes style grow almost immediately while with continuous light it takes longer to start to grow; (L16 / D8) starts growing in first hour while L24 style starts growing after 6 hours; growth is more gradual in L24; with continuous light the style grows less; continuous (L24) grows to 9.8 mm while cyclic (L16 / D8) grows to 10.2 mm / little difference after 28 hours; in both cases growth only starts with anthesis;

c) 47% / more fertilized ovules in cyclic light; filament grows more in cyclic light than continuous; pollen closer to stigma, so pollination more probable; in continuous light anthers do not become exposed;

d) standard deviation is a measure of variability, indicating the spread of values around the mean; continuous light data is more variable (because it has a higher standard deviation); helps to decide whether the difference between two means is significant; 68% of values are 1 SD from mean; difference between means is approximately 47, appears to be significantly different; light treatment makes a significant difference;

e) darkness promotes and white light inhibits because filaments shorter than in darkness; red light inhibits because filaments shorter than in darkness; auxins promote because filaments are longer than in control / in white and red light; gibberellic acid inhibits because filaments are shorter in continuous white light / darkness;

f) self-pollination reduces / does not promote variation / no new combination of alleles; no variation for natural selection; more susceptible to infectious diseases; more prone to genetic disease / (inbreeding) more likely to be homozygous for disease;

3. a) **(i)** 2 mM kg^{-1}

(ii) 180 %

b) cells in stem absorb water (by osmosis) providing turgidity / turgor pressure

c) maintain osmotic balance; help to maintain turgidity; assist active transport;

d) active transport means movement against a concentration gradient; there is no concentration gradient / concentration in xylem should be lower than stem (but it is not);

e) diffusion / facilitated diffusion.

Topic 10 – data-based questions

Page 452

1. coloured, starchy both dominant traits Cc; white, waxy recessive traits Ss; F_1 are all CcSs; so $F_1 \times F_1$; CcSs × CcSs produces typical dihybrid ratio of 9 coloured starchy: 3 coloured waxy: 3 white starchy: 1 white waxy in F_2;

2. the actual frequencies do not follow the 9:3:3:1 ratio and so the genes must be linked as they differ from the theoretical ratio for dihybrid crosses;

3. coloured, shrunken CCnn; white, non-shrinken ccNN; F_1 coloured, non-shrunken is CcNn are test-crossed with homozygous recessive: ccnn; CcNn × ccnn; typical ratio of 1 coloured non-shrunken: 1 coloured shrunken: 1 white non-shrunken: 1 white shrunken

4. actual frequencies frequencies differ from typical ratio of 1:1:1:1, so genes must be linked;

5. if starchy/waxy and non-shrunken/shrunken are both linked to colour, then they must also be linked to each other;

Page 454

1 and 2.

	White Crested	Non-white, Non crested	Non-white Crested	White Non-crested	Total
observed	337	337	34	46	754
expected	188.5	188.5	188.5	188.5	754

3. 3 degrees of freedom expected;

4. critical value for 3 df = 7.815;

5. $X^2 >> 7.815$;

6. H_o the traits are not linked and differences between observed and expected are due to sampling error; H_1 the traits are linked and differences between observed and expected are not due to sampling error; $X^2 >> 7.815$, therefore $p << 0.05$; reject H_o and accept H_1;

Page 456

a) negative correlation / mean length declining with time;

b) the longer the horns, the more likely the sheep will be shot; advantage to having short horns; long horns removed from reproductive pool; mean length becomes shorter with time; shorter horn alleles become more common in population with time; this is directional selection;

c) long horns more likely to win in courtship battles and become more common in reproductive pool; long horns more likely to be hunted and removed from the pool; the latter seems to be the most relevant factor;

Page 457

a) any value from 3.25 to 3.49 kg;

b) any value from 3.50 to 3.74 kg;

c) initially as birth mass increases up to 3.5 kg, survival increases, hencemortality decreases; then, as birth mass further increases beyond 3.5 kg, survival decreases andmortality increases; further from mode the higher the mortality, the highest survival and lowest mortality nearest to mode value;

d) birth mass shows variation; selection against very low / very high birth weights;

Page 458

a) **(i)** sneaking approximately 80 cm

(ii) fighting approximately 200 cm

b) **(i)** >60 cm body size for fighting

(ii) 25–29 for sneaking;

c) 45–49 / 40–44;

d) extreme size forms reproduce; intermediate size forms are selected against;

Page 459

1. *C. lucasina* has uniform loudness whereas the *C. mediterranea* grows louder and then softer; the *C. lucasina* song lasts longer; individual notes would be more audible in *C. lucasina*;

2. lacewings with certain songs will attract some mates, but not others; over time, gene pools become isolated within the population; this would lead to sympatric reproductive isolation;

3. **a)** allopatric speciation is reproductive isolation due to geographic barriers; founder populations may differ in allele frequencies; the source and founder populations are subjected to different selection pressures; leading to increasing differences between the two;

b) sympatric speciation is reproductive isolation within the same geographic area; it could be caused by behavioural or temporal isolation; variables prevent interbreeding of sub-populations; the same selection pressures present in the habitat may affect the two sub-populations differently.

Topic 10 – end of topic questions

1. anaphase I (figure 13) and telophase II (figure 14)

2. a) except for *S. arcticum* and *S. olafii*, the mass of DNA is similar between the varieties;

b) the ancestral species had 19 chromosomes; they are descended from a common ancestor;

c) (i) because they have double the mass; the 2n chromosome number is 38; a leaf cell will be 2n/will have 38 chromosomes;

(ii) more resources required to create a new cell;

d) mosses have alternation of generations in their life cycle; the gametophyte is dominant and is a haploid;

3. a) the *Polypodium* (species) are (completely) isolated in different parts of the continent **and** the *Pleopeltis* (species) much closer together, physically overlapping and sharing the same habitats; *Polypodium* grows in more northerly / temperate locations;

b) (i) *Polypodium* as it has lower similarity / genetic identity values / *Pleopeltis* has higher similarity / genetic identity values;

(ii) *Pl. polylepis* and *Pl. conzattii*;

c) geographic / ecological isolation / isolated by distance / by glacial periods / climatic changes; reproductive or genetic separation of gene pools (led to speciation) / adaptive radiation;

d) *Polypodium*, as more genetic difference between all three species than between the species of *Pleopeltis*; takes time to accumulate mutations / genetic changes; distance may have facilitated the process of reproduction isolation;

4. a) C c W w; all are coloured starchy;

b) gametes are C W, C w, c W, c w and c w; F_2 genotypes are CcWw, Ccww, ccWw and ccww; 1 coloured starchy: 1 coloured waxy: 1 colourless starchy: 1 colourless waxy;

c) chi-squared test;

d) (autosomal) linkage / genes are on the same chromosome / genes do not assort independently; coloured starchy and colourless waxy are parentals / coloured waxy and colourless starchy are the recombinants; recombinants produced by crossing over.

Topic 11 – data-based questions

Page 473

1. endemic: native to the area;
2. Afghanistan, Pakistan and Nigeria;
3. WPV1;
4. Pakistan is the only country where year to date comparison shows a total decline;
5. eradication programme appears to have led to a significant reduction in the total number of cases; only 650/350000 = 0.2% of the number of cases have been reported; worsening in two countries; disease is persistent / eradication has not been achieved;
6. lack of access to populations in remote areas; lack of trust between affected individuals and epidemiologists; lack of recognition of mild cases; mis-diagnosis; language barriers; death before identification;

Page 477

1. 26 flaps;
2. vigorous contractions during take off and landing, less vigorous contractions during fast flight; decreasingly vigorous contractions during take off and fast flight / increasingly during landing; fewer contractions per unit time in (later stages of) fast flight than other phases; most vigorous contractions during landing;
3. TB is used (mainly) for landing;
4. the upstroke of the wing;
5. similar frequency to the SB muscles / same number of contractions; the peaks of activity would be out of phase / alternate with those of the SB and TB;

Page 481

1. a longitudinal section is one that is cut along the long axis of a structure; a cross section would be one that is perpendicular to the long axis;
2. the light band, as it contains only actin;
3. the first and second have the same pattern of large dots; the first and the third have the same pattern of small dots; the first is heterogeneous while the second and the third are homogenous; the first is a combination of the second and the third;
4. the first diagram shows the region of the sarcomere where actin and myosin are both found the dark band), the second diagram shows myosin only (central part of dark band – sometimes called the H zone); the last diagram shows actin only (light band);

Page 486

1. 1.5 delta;
2. 0.7–1.2 delta;
3. it would have a similar shape to the line of isosmoticity over all concentrations;
4. below 0.7 and above 1.2 it is an osmoconformer, but between 0.7 and 1.2 it is an osmoregulator; likely that the natural habitat variation is between 0.7 and 1.2, it can be considered to an osmoregulator;

Page 488

1. the kidney has the highest blood flow rate of the tissues shown – five times more than the heart muscle and nearly 200 times resting skeletal muscle;
2. the kidney receives 420 mL per minute; in 2.38 minutes, 1 litre is delivered to 100 mg of tissue; in this time (84.0 × 2.38) = 200 mL of oxygen is delivered;

3. skin 14.6%
skeletal muscle 36%
heart muscle 41.4%
kidney 8%

4. blood flows to different organs for different reasons; all blood needs toxic waste products removed so must flow to kidney; some oxygen demand is variable depending on activity; such as by skeletal muscle during activity; some blood flow is variable such as thermoregulation and the skin;

5. selective re-absorption/active transport;

6. blood flow to the skin would change; to support thermoregulation;

Page 490–491

1. the larger the particle size, the lower the permeability to them of the filter unit;

2. **a)** all show a decline in permeability with an increase in size; neutral dextran shows the most direct relationship; dextran sulfate permeability declines most rapidly with an increase in size; DEAE permeability declines most slowly with an increase in particle size;

b) large particles of any type cannot pass easily through the membrane; electric charge has an impact on ultrafiltration with negatively charged particles decreasing ultrafiltration and positively charged particles increasing the rate of ultrafiltration;

3. regardless of charge, particles as large as 4.4 nm do not end up in the filtrate; the presence of such particles in the urine indicates kidney function disability because it has been able to pass through the glomerulus when it normally would not pass through;

Page 493–494

1. the drier the habitat, the more concentrated the urine; some variation evident;

3. **a)** the higher the RMT, the higher the MSC produced;

b) the length of the loop of Henle determines the solute concentration established in the medulla; the higher the RMT, the longer the loops of Henle;

Page 495

a) 5.3 ($\pm$ 0.3) pmol dm^{-3}(unit needed);

b) a positive correlation; no data below 280 mOsmol kg^{-1};

c) after drinking water, blood plasma / solute concentration decreases; plasma ADH concentration decreases; osmoreceptors in the hypothalamus monitor blood solute / blood plasma concentration; impulses passed to ADH neurosecretory cells to reduce / limit release of ADH; drop in ADH decreases the effect of this hormone on the kidneys; blood solute concentration returns to normal;

d) vomiting / diarrhea / blood loss; increased salt intake; drinking alcohol / coffee; taking certain drugs / morphine / nicotine / barbiturates; excess sweating / lack of water intake; diabetes as it increases glucose in blood;

Page 503

2. pattern is not clear; longer sperm tend to have higher cross sectional area;

3. scaling of all dimensions related to overall size of sperm; shearing stress in longer sperm; needs thicker cross-sectional area to support;

4. data is not supplied about relative sizes of rodents but in general no as humans and bulls are larger organisms with relatively small sperm;

Page 507

1. **a)** microvilli, coming in and out of the plane of the section;

b) active transport of glucose and other foods; osmosis for water absorption; facilitated diffusion of mineral ions or other substances; increased surface area; gas exchange;

2. progesterone is a steroid hormone; so the sER produces the hormones;

3. nucleus because it is adjacent to the ER; nucleus because it is a large organelle;

Page 508

a) the higher the concentration, the greater the number of oocytes in testes;

b) 31%;

Page 509

1. **a)** hCG is present throughout pregnancy; highest levels are at about 2 months declining sharply after that;

b) estrogen levels increase throughout pregnancy; estrogen falls sharply before parturition;

c) progesterone rises throughout pregnancy, falling sharply just before parturition;

2. hCG maintains the ovary's hormone production capacity; once the placenta takes over production, then the ovary's production does not have to be maintained;

3. miscarriage; endometrium would not be maintained;

Page 510

1. open dots are altricial species; as these have smaller body mass and shorter gestation;

2. the higher the adult body mass, the longer the gestation period;

3. large body mass organisms are more likely to be precocial; time taken for structures for more rapid independence are developing in utero; meeting nutrition requirements of large body mass offspring difficult for parent, so better if it can be independent earlier;

4. **(i)** top left quadrant of graph;

(ii) gestation period is longer than other organisms of similar adult body mass; longer period for neural development; human infants relatively helpless for longer compared to organisms of similar adult body mass.

Topic 11 – end of topic questions

1. a) skin pH of neonates is higher than adults / skin pH of neonates is neutral while pH of adults is acidic; skin pH varies over the body in both adults and neonates;

b) colonization by harmless bacteria that produce acid as a by-product of metabolism;

c) neonate skin is neutral; adding a base will raise pH to an irritating level;

d) normal skin flora adapted to certain pH; changing pH might favor pathogens; changing pH might affect competence of the skin;

2. a) declines after birth; sharpest decline over first six hours; ability eventually falls to zero;

b) the calf would be weaker so they can't nurse during the critical period when antibodies are more likely to be absorbed;

c) the concentration of antibodies would fall – production of antibodies would be wasteful of resources if they are not absorbed;

d) the mother would develop immunity / antibodies that could be transferred to lamb through colostrum;

e) active transport;

3. a) absorbed in PCT; part of selective reabsorption; co-transport with sodium / active transport; (once past the wall of PCT) diffusion into blood;

b) this is glycosuria; when concentration of glucose exceeds renal threshold / 160–180 mg dl^{-1}; excess glucose is not absorbed and appears in the urine as the PCT has a maximum rate of glucose reabsorption;

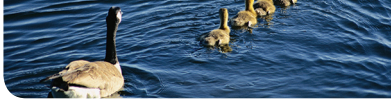
c) high glucose levels in blood detected as high solute concentration; leading to less ADH being released; collecting ducts remain impermeable to water; creating dilute urine;

4. a) control group showed initial slight decrease at two weeks but rose approximately 4% overall; in contrast, exercise group body mass remained stable until final two weeks and ended approximately 2% lower than initial body mass;

b) based on data shown, groups without exercise (both 1 and 2) had higher pectoralis mass than exercise group; claim is therefore supported;

c) determining percentage weight of pectoralis muscle as proportion to total body mass (from cadaver sample) could be used to determine live muscle mass;

d) specifically restricting movement of poultry for testing purposes raises ethical concerns in terms of subject pain and suffering, as well as general health and physical ailments of test subjects; concerns may also involve ultimate state of subjects once testing is complete.



Option A - data-based questions

Page 523

1. as the mass of the body increases, the mass of the brain increases, but not directly/body mass increases faster than brain mass;
2. the graph would have been flatter; a 10X increase in body mass would have been matched by a 10X increase in brain size;
3. largest brain mass is hump-backed whale; smallest brain mass is the shrew;
4. it has the greatest distance above the straight line; however, not all animals in the world are displayed; dolphin is close and could be statistically the same, depending on sample size;
5. hypothesis appears to be supported, as they all fall below the standard curve, though not all marsupials are shown, nor are all placentals;
6. the platypus and echidna are the only known monotremes;

Page 537

1. both sonogram I and II have a steady low pitch in the first part of the pattern; in the second part of the song, both sonogram I and II have a variable pitch pattern (a trill); in the third part of the song, sonogram I starts with a high pitched sound and quickly drops the pitch, but continues to lower the pitch gradually after the initial drop (this is a slur); for sonogram II, the third part oscillates in frequency more gradually than the second part of the song; sonogram I has a distinct fourth part of the song, while sonogram II does not;
2. **a)** the three patterns are similar, with sonograms II and III being more similar; all begin with a single, low pitched note; the second part is a trill in all three, with III being the noisiest; the third pattern involves a slower set of down slurs; sonogram I has a trill that ends the song, whereas the other two do not; the third pattern in I and III is more disrupted than in II;

   b) the song of the white-crowned sparrows is innate and learned; this can be said because of the similarities and differences in the birdsongs of isolated and non-isolated white-crowned sparrows; the song can be innate because despite isolation, the beginning single note of sonogram III is similar to sonograms I/II; external stimuli affected the pitch/timing of the birdsong causing the differentiation;
3. **a)** sonogram V birdsong opens with a single note whereas sonogram IV has a short momentary slur; both sonogram V and IV in the second portion of their songs have a trill though IV is noisier; both then have a set of closely spaced slurs that are initially at a steady pitch, but then get lower in pitch;

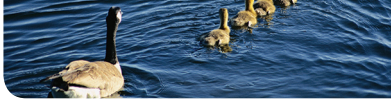
   b) both sonogram I/II and sonogram V open with a single note, though V declines in pitch slightly, while I varies more; sonogram I/II have three or four definitive portions to their birdsong, whereas sonogram V has two.

   c) songs attract mates and defend territory; imitation of other species would waste effort, if mating was not possible; it is not necessary to defend territory against other species, if they eat different foods; differences in vocalization structures may make imitation difficult;

   d) the beginning part of sonogram V suggests the birdsong is innate because of its similarities to sonograms I/II/III; the rest of the song is completely different from the sonograms I/II/III, which suggest that perhaps the isolated white-crowned sparrow (sonogram V) does in fact have a song that is also learned (external stimuli changed it).

Page 544

1. at the higher dosage level, dopamine levels rose rapidly, peaking at one hour after dosage, then falling more gradually; after three hours, the dopamine level has not fallen to the pre-dose level; there appears to be no effect at the lower dosage level;



2. both doses result in a rise in serotonin levels; for the higher dosage, the percentage rise is significantly higher/3 x as much as compared to the dopamine rise; for the lower dosage, there is nearly a 1000% increase in serotonin levels;

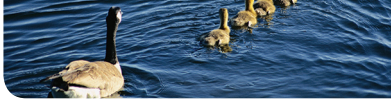
3. **a)** knocking out DAT, increases the serotonin levels above wild type after drug administration and lowers levels of dopamine compared to wild type after administration of the drug;

   b) as the increases are between 500 and 1000 times higher, the increases are significant;

4. knocking out SERT leads to an increase in dopamine release in response to the drug; knocking out DAT leads to an increase in serotonin levels in response to the drug;

5. MDMA acts on both transporters; knocking out one transporter results in more effect of MDMA on the other transporter; the difference suggests that MDMA probably has a higher affinity for the SERT transporter;

6. allows for exploration of a protein's function by investigating what happens when it isn't working.



Option A - end of topic questions

1. a) activity reduced, dropping from 100% to 75%;

b) (i) left hemisphere becomes less active than when both eyes are closed; left hemisphere is more active than when both eyes are open; right hemisphere remains more active than when both eyes are closed; right hemisphere becomes more active than the left hemisphere;

(ii) left hemisphere;

(iii) left eye to the right hemisphere and right eye to the left hemisphere;

c) seeing a predator before it attacks; using less energy/allows part of the brain to rest;

2. a) percentage of NGF in both areas is highest in AD patients; percentage of NGF is similar in both pre-AD patients and controls in both areas; less NGF in frontal than temporal in all three groups; controls slightly more than pre-AD patients in both areas; less difference between AD patients in both areas than other two groups; lowest value in both groups is the pre-AD patients;

b) 50%;

c) control to pre-AD has little change/slight drop in percentage of NGF; pre-AD to AD has a (large) increase in percentage of NGF; increase/percentage increase/progression is greater/more in frontal cortex;

3. a) 19:00 hours;

b) 2 m s^{-1};

c) at 17:00 hours less (calling) area/distance than at 18:00 hours; at 17:00 hours, the maximum calling distance is just over 6 km, whereas at 18:00 hours, the maximum calling distance is just under 10 km; both expand most in the direction of the wind / towards the south-west;

d) when there is no wind (at 19:00 hours) there is greatest calling area/distance more than 10 km; shape of the calling area is affected by the presence /direction of wind/when there is no wind the shape of the calling area is circular; when there is wind the calling area/distance is associated with wind direction/calls travel furthest in the direction of the wind; when there is wind there is no relationship between the wind speed and the distance travelled by the calls; stronger calls could result in greater calling areas/distances (so wind has less effect)/other factors affecting (such as mountains).

Option B - data-based questions

Page 573

1. 64;

2. 3 in 64;

3. stop codons should occur with a frequency of about 1 in 20 codons; their frequency would be lower in an open reading frame; the first reading frame has one stop codon, the second has two, but the third has none, so the third is possibly an open-reading frame; a much longer sequence is necessary to identify the open reading frame.

Option B - end of topic questions

1. a) 28 hours after untreated sewage added;

b) (i) sunlight reduces counts of fecal coliform bacteria significantly; fecal coliform bacteria fall below 1 count per 100 ml on day 2; no reduction during dark period; significant drop on day 1 as bacteria count drops from 10^5 per 100 ml to less than 10^2 per 100 ml;

(ii) sunlight causes small reduction of coliphage viruses; coliphage virus counts never fall below 10^2 counts per 100 ml; no reduction during dark period;

c) coliphage viruses, because they are less affected by the sun/numbers do not decrease much in two days;

2. a) 12 litres $\times$ 3 mg dm^{-3} = 36 mg;

b) inverse relationship; approximately the same rate for decrease in terephthalate concentration and increase in methane production; linear degradation of terephthalate and methane production; on day 12, methane production starts to level out/plateaus/terephthalate concentration is at zero;

c) anaerobic methanogenic bacteria/chemoheterotroph;

d) breakdown rate is (approximately) constant; terephthalate concentration decrease and methane concentration increase are linked; concentration of 3 mg dm^{-3} is non-lethal for these bacteria; breakdown is very efficient (100%), but slow (as it takes 12 days);

3. a) 400 million years ago;

b) 10 (events);

c) vertebrate hemoglobin and myoglobin are more closely related to each other because of a more recent split over evolutionary time / invertebrate hemoglobin more distantly related because of a more ancient (distant) split in evolutionary time;

d) animals have a higher metabolic rate / greater oxygen needs which requires transport of oxygen to cells / plants do not move thus have a lower metabolic rate / plants produce their own oxygen (through photosynthesis);

e) the genetic code is degenerate / more than one codon will code for an amino acid; so a mutation may result in the same amino acid being produced; some mutations are neutral; multiple point mutations for the same base (can obscure the mutation history).

Option C – data-based questions

Page 605–606

1. numbers of individuals would be counted; a standard would be developed for defining this number as abundant, common, frequent, occasional or rare; the graph is a symmetrical representation of these scale measurements;
2. *Sargassum muticum* is abundant across a large shore distance;
3. $45 \text{ mm} \times \frac{5 \text{ metres}}{2.9 \text{ mm}} =$ approximately 78 meters;
4. *Enteromorpha sp / Fucus spiralis / Arenicola marina;*
5. cannot tolerate desiccation; cannot tolerate high salt found in evaporating tidal pools; adapted to a particular type of wave action; upper tidal species are better adapted to variable conditions that persist in the upper tidal pools;
6. *Sargassum muticum* and *Anemonia viridis;*

Page 607 (NaCl as a limiting factor)

1. for *Suaeda*, the optimum range is between 190 and 390 mM; for *Eutrema*, the optimum range is between 200 and 300 mM;
2. for *Suaeda*, the starting value of the lower zone of stress should be lower than 190 mM, but is typically placed at 25% of the value of the optimum, which is difficult on the lower end so could be placed at 40mM; for *Eutrema*, the starting value of the lower zone of stress should be lower than 200 mM, but is reasonably placed at 40 mM;
3. would need more data at interim values; variability within population; some growth at even very high levels; appears to be able to survive in the absence of salt so no lower limit of tolerance;

Page 607 (Maintaining conditions for aquarium fish)

draw a graph that goes to 100%; graph the 50% population levels surviving; estimate the mid-point between the values to be the optimum; this would be the value that would be suggested to shippers; sketch a graph that is a reasonable copy of the curve in figure 4;

Page 609

1. in both the presence and the absence of competition, *T. angustifolia* does not grow beyond 110 cm; in both the presence and the absence of competition, it does not grow well out of water;
2. in the presence of competition, *T. angustifolia* narrows its fundamental niche to the realized niche of specializing at growth in greater depths than *T. latifolia;* its fundamental niche is to be found growing from about 20 cm above the water line to 110 cm below the water line; its realized niche is to grow between 18 cm and 110 cm;

Page 610

1. *S. xyloni*;
2. all graphs show between 0.65 and 0.75 mm to be a probable mandible size in all areas;
3. assuming mandible size is equivalent to seed size, then between 0.5 and 1.10 mm;
4. appears to be borne out, as the broadest niches occur with one competitor and the narrowest niches occurs with two; however the extremes in the one-competitor groups have very low frequencies;

Page 614

1. check its stomach contents; determine trophic level of organisms within the stomach;
2. **a)** both have been declining over the study period; rate of decline is faster in fresh water populations; rate of decline is more constant in marine/accelerating in freshwater;

   b) freshwater fisheries are more established/have been overfished for longer, freshwater populations smaller/more susceptible to disruption;

3. increasing age means increasing size; increasing size means broader range of prey including larger fish/higher trophic level fish;
4. age correlated with trophic level; lowering of trophic level means lowering of mean age;
5. greater biomass of lower trophic level means higher sustainable yield which allows higher trophic levels to recover;

Page 616

1. waste product of cellular respiration; from metabolism and decomposition; released by exothermic reactions;
2. 576 kJ m^{-2} $year^{-1}$
3. **a)** $2300 + 18 + 4 = 2322$ input

   input − heat loss = $2322 - 1746 = 576$ kJ m^{-2} $year^{-1}$

   b) 576 kJ m^{-2} $year^{-1}$

   $\frac{576}{2318} \times 100\% = 24.8\%$

Page 621

1. **a)** mean stem diameter increases with time, though data is highly variable;

   b) increased survivorship of trees; they increase in diameter as they age;
2. **a)** the number of species increases with time; sharp increase after 44 years;

   b) evenness improves with time;
3. organic content increases with spruce; moisture content increases with spruce; nitrogen increases with spruce; bulk density increases with spruce; pH decreases with spruce; conditions are similar for the other three species;

Page 622

1. 19 580 kJ m^{-2} yr^{-1};
2. autotrophs lose 55% of their gross products to heat compared with the heterotrophs which lose 96.3% (96) of their food energy/41% more of heterotrophs; 3 animals use a lot of energy to move/ maintenance of body temperature;

Page 623

1. conditions became altered as succession proceeded; new conditions not favourable to the species;
2. **a)** would increase;

   b) would increase;

   c) assuming closed ecosystem, mineral content is fixed but flux increases with succession;

   d) greater numbers of species 6, lower numbers of early colonizers;

Page 628

1. *G. tebygi* is a predator, as well as a parasite;
2. biological control;
3. *G. tebygi:* 27 days; *R. invadens:* 77 days;
4. 2.5 life cycles of the predator can be completed in one life cycle of the prey; increasing chance that individual would be preyed upon;
5. it may become invasive itself / may prey on species other than the mango mealy bug;

Page 629

a) damage increases as time passes (with some variability);

b) plant height decreases with time after release;

c) it appears to effectively cause damage to the plants and decrease growth height; as loosestrife is destroyed, it might cause *Gallerucella* to die off, leading to a boom and bust cycle alteration; *Gallerucella* might have to be continuously released;

Page 631 (Biomagnification of caesium)

1. a) lichens: producers/autotrophs/first trophic level;

b) Inuit: secondary consumer/third trophic level;

2. (relatively) constant/slight increase until June 1963; peak in June 1964; decrease until December 1964; rise and fall of Cs-137 happens within a year (1964); increase again, until 1965;

3. a) (i) in spring;

(ii) in June;

b) variation in the diet of caribou means that it sometimes eats plants without the caesium-137; variation in the diet of the Inuit, whereby they sometimes eat caribou and then eat other food without caesium-137;

4. data shows levels rising in lichens; data suggests biomagnification, but not bioaccumulation; if levels in lichens would fall, then they would ultimately fall higher in the food chain; no data to support that it would fall to zero;

Pages 631–632

1. 3.5;

2. because the fish participates in multiple food chains and occupies different trophic levels in the different food chains;

3. each trophic level results in a 10 fold increase in concentration;

4. in the marine fish food web;

5. the concentration is the same in the both trophic levels;

6. the toxin might store in tissues only found in mammals and not in fish; in both food webs, the pattern for salmon, cod, sculpin etc. is the same; the processes might be different (bioconcentration vs. biomagnification);

Page 635

1. 1965;

2. find number of turtles with plastic and divide by total number of turtles 37%;

3. might be confused as food and eaten directly; might be found on the food and eaten indirectly;

Page 640 (Island size and diversity)

a) 200;

b) a 10 × increase in area results in an approximate doubling in the number of species;

Page 640–641 (Forest size and songbird density)

a) (i) between 50% and 67%;

(ii) 0.62 × 20 = 12 times approximately, taking the red line as the probability or between 10 and 15 times;

b) red-eyed vireo is most likely; wood thrush is least likely;

c) 100 ha size minimum as that is when each curve begins to level off;

Page 646

a) **(i)** exponential growth in population/natality exceeds mortality during these years; population density sufficiently low that limiting factors are not as significant;

(ii) transition point reached; mortality increases as limiting factors begin to be significant due to increases in population density;

b) population would reach carrying capacity of the environment; population would stop growing/reach plateau phase;

Page 654

1. **a)** highest at outfall and falls off; drop-off occurs at greater rate with initial increase in distance;

b) declines sharply close to outfall but then steadily rises again;

c) declines to lowest value near outfall, climbs to a peak and then falls again as distance increases;

2. **a)** bacteria consume oxygen for metabolism; high nutrients promote metabolism and population growth;

b) nitrate is a growth limiting nutrient for plants; nutrient enrichment can promote algae growth/reproduction;

c) algae produce oxygen through photosynthesis; when they die, decay of dead cells by bacteria demands oxygen, hence lowering its concentration;

3. BOD will be high near outfall and will continue to be high in the vicinity of the algae blooms and then will fall once all nutrients have been dispersed.

Option C – end of topic questions

1. a) (i) asbestos cement; grows closest to city centre on asbestos cement roofs; only grows on asbestos cement roofs between concrete/cement and asbestos lines;

(ii) acid rain is neutralized by alkaline building materials;

b) gives a measure of acid rain levels/indicator species allow a variable to be measured; monitoring of environmental change/shows if conditions are getting worse or better; shows if pollution control/conservation projects are working; organisms are there all the time so give a longer-term measure/not just at an instant;

2. a) 30 (±1) squirrels hectare^{-1};

b) population decreases from 12 (±1) squirrels hectare^{-1} to 2 (±1) in food addition area; in food addition plus predator exclusion area, it decreases from 30 (±1) to 2 (±1); reaches same level as control (in 2 years);

c) addition of food and exclusion of predators results in more squirrels as conditions are ideal; squirrels can feed well and are not predated/higher reproduction rate; food addition alone also results in more squirrels; because food affects population growth more than predator exclusion (squirrels climb, hide); no additional food but predator excluded, so data does not confirm the hypothesis;

3. a) (i) 24(±2)mm;

(ii) Sheyma Island, as there are larger sea urchins found on the island;

b) sea urchin biomass is greater on Sheyma Island than Amchitka Island; sea urchin density is similar on both islands/slightly larger on Sheyma Island; Amchitka Island has no sea urchins bigger than 40 mm diameter, while Sheyma Island does/diameter range smaller on Amchitka Island than Sheyma Island;

c) herbivore/primary consumer;

d) sea otters feed on urchins; sea otters keep the sea urchin density/biomass at lower levels; Amchitka Island shows high numbers of small (diameter) sea urchins and no large ones due to presence of sea otters/vice versa on Sheyma Island;

4. a) 8 m;

b) as oxygen increases, egg development increases (up to 8 m); as temperature increases, egg development increases (up to 8 m); when the temperature is 27.6°C (±0.2) and oxygen is 3.5 ppm (±0.2), egg development is maximum; after 8 m there is a decrease in egg development despite little change in the oxygen concentration/temperature;

c) (i) optimal conditions for egg development found at 8 m; distance (> 8 m) starts having a negative effect on egg development despite (near) optimum levels of oxygen and temperature; distance from the high tide line is more important than both oxygen/temperature for egg development;

(ii) wave action; predators; human interaction; tides; humidity/dessication; salinity; pollution; nature of sand.

Option D – data-based questions

Page 662

1. **a)** Africa (4.00 YLD/1000);

   b) all-round malnutrition due to drought and food shortages; land unsuitable to support dairy farming; farming meat may be too expensive;

2. **a)** Africa = 4.00 YLD/1000 (+/−0.05), W. Europe = 0.10 YLD/1000 (+/−0.05);
   % difference = 4.00/0.10 * 100 = 4000% difference;

   b) increased food aid; supplies of milk; supplementation; financial aid for farming; reduce western demand for meat, which would lead to less pressure on land;

3. **a)** in all regions except Africa, there was a decrease in YLD/1000 between 1990 and 2000;

   b) biggest improvement in S. & C. America;

   c) possibly due to imported food products from the USA; increased economic stability; increase in agricultural production; 4 as the population grows, more demand is put on food supplies; possible reversal of the trend (or worsening) in Africa, China & E. Asia as demand outstrips supply; expect continued improvement in developed nations, though difference may be less apparent;

Page 666

1. **a)** left ventricle $\frac{38 - 47}{47} = 19\%$ decrease;

   b) $\frac{8 - 9}{9} = 11\%$ decrease;

   c) $\frac{26 - 29}{29} = 10\%$ decrease;

   d) $\frac{21 - 27}{27} = 22\%$ decrease;

2. the base of the aorta;

3. lower stroke volume; tiredness/lethargy/abnormal heart beat because of transmission of signal through aorta;

Page 674

1. **a)** microvilli;

   b) site of absorption; structure maximizes surface area to volume ratio;

   c) $\frac{20 \text{ mm image}}{0.85 \text{ mm}} = 23.5 \times \text{magnification}$;

2. **a)** purple structures;

   b) to provide ATP for active transport;

3. **a)** endocytosis;

   b) lipids;

4. **a)** tight junction;

   b) to hold tissues together/prevent passage of materials;

Page 677

1. 50%;

2. digestible matter increases mean residence time; reduced fibre reduces transit rate and extra water is reabsorbed in the colon;

Page 682

1. **a)** as the rate of bile salt secretion goes up, the rate of flow of bile increases;

   b) bile salts draw water into the narrow canaliculi (by osmosis) and this increase the flow rate;

2. after the consumption of a meal containing fat;

3. secretin causes an increase in the rate of bile flow; at all rates of bile salt release/increase caused is uniform; 4 when concentration of bile salt is zero, there is still flow of bile, indicating something else was drawing water into the tubes;

Page 683

1. **(i)** as percent triglycerides increases, density goes down;

   (ii) as percent protein increases, density increases;

   (iii) as percent cholesterol increases, density increases;

2. the % cholesterol is very similar in both;

3. because LDL contain higher levels of cholesterol which can contribute to plaque formation;

Page 688

1. 89 beats min^{-1};
2. $\frac{83 - 89}{89} \times 100\% = 6.7\%$ decline;
3. decline is small/data is variable; experiment limited: face or total exposure might have a more profound reduction/greater time of exposure might have an effect; data is inconclusive;

Page 692

1. $\frac{25}{10000}$;
2. as both increase, death rates increase; increases in systolic blood pressure have a larger effect;
3. $160 - 70 = 90$ mm Hg;
4. difference appears to be important only at very high systolic rates;

Page 693

1. high cholesterol rates in young people is correlated with high cholesterol rates in adults;
2. it increases/for every pair, adult level is higher;
3. in four states, the maximum is exceeded; in a number of other states, the mean is quite close to the maximum; suggests high rates of CHD in Mexico are likely.

Option D – end of topic questions

1. a) (i) 2.6 (±0.2) nmol mg^{-1} liver tissue;

(ii) 6.4 (±0.3) nmol mg^{-1} liver tissue;

b) injection reduces the total glutathione content in liver tissue by about 45%/2.4 nmol mg^{-1};
reduced glutathione content is reduced by about 41%/1.8 nmol mg^{-1}; smaller proportion of glutathione is oxidized;

c) pre-treatment with flaxseed increases glutathione content over control levels; cells exposed to tetrachloromethane with pre-treatment with flaxseed maintained higher glutathione levels than without pre-treatment, so cells would show less damage when exposed to free radicals;
hard to evaluate due to short period of investigation;

2 a) (blind) mole rats have a lower oxygen consumption than white rats *eg* white rats consume about twice as much oxygen as (blind) mole rats;

b) both graphs show greater speed correlated to greater consumption/positive correlation/directly proportional;
(overall) rate of increase is lower in white rats than (blind) mole rats;
(blind) mole rats consume less oxygen at lower speeds than white rats, but white rats consume less oxygen at higher speeds;
white rat oxygen uptake slows down/stops increasing/reaches plateau as treadmill;
speed increases but (blind) mole rat oxygen uptake keeps increasing;
(blind) mole rats reach a higher maximum oxygen consumption;

c) lowers oxygen consumption in both types of rats;
less effect on (blind) mole rats than on white rats;
plateau reached in white rats at lower speed;
(blind) mole rats have better ventilation systems / are better adapted than white rats;

d) greater lung volume increases amount of air/oxygen that can be breathed in/contained;
greater alveolar area increases surface area for gaseous exchange/allows more absorption/diffusion of oxygen;
greater capillary area means more contact/more exchange/larger rate of diffusion between capillaries and alveoli, so more oxygen can be carried away from lungs;
greater capillary area allows more oxygen absorption/gaseous exchange between lungs (alveoli) and blood;

e) rats with adaptations survive better in low oxygen conditions and are able to reproduce (more) (and vice versa);
adaptations are genetically determined/inherited by offspring;
leave more offspring to pass on genes/characteristics/traits;
the frequency of the allele in the genetic pool will tend to increase;
the characteristic of the species gradually changes;

3. a) Na^+ concentration is lower in saliva;
Cl^- concentration is lower in saliva;
HCO_3^- concentration is higher in saliva;
K^+ concentration is higher in saliva;

b) as the flow rate of saliva increases, the amount of Na^+ in saliva increases;
the increase is largest initially, but then levels off as flow rates increase;

c) Na^+ concentration (always) higher in blood plasma/moves against concentration gradient, so active transport must be used;

d) higher flow rate means Na^+ flows past without being re-absorbed/more difficult to be absorbed/less time of contact with cells;
pumping activity/transport of Na^+ can only occur at a fixed rate;
numbers of pumps limiting/reach saturation level.

Data-based question: Centromeres and telomeres (page 54)

The following images support the data-based question on page 54 of the IB Biology Course Companion (2014 edition).

They show micrographs of cells undergoing mitosis in which the DNA has been stained blue, the centromeres have been stained with a red fluorescent dye and the telomeres with a green fluorescent dye.

Images courtesy of dr. Glyn Jenkins (University of Aberystwyth)

1 Deduce the stage of mitosis that the cell was in (using the image below), giving reasons for your answer.

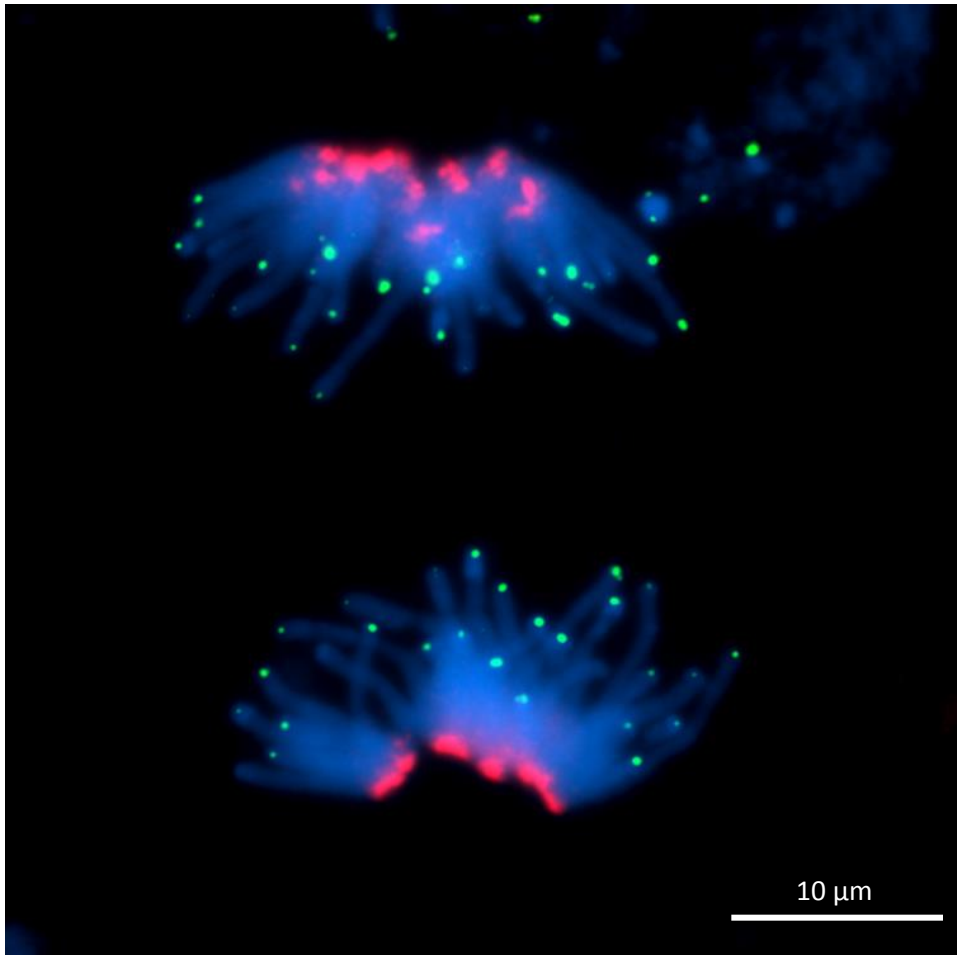


Figure 1 Cell in mitosis

(Same as Figure 3 on page 54 of the Course Companion)

2 The cell has an even number of chromosomes.

a) State how many chromosomes there are in this cell.

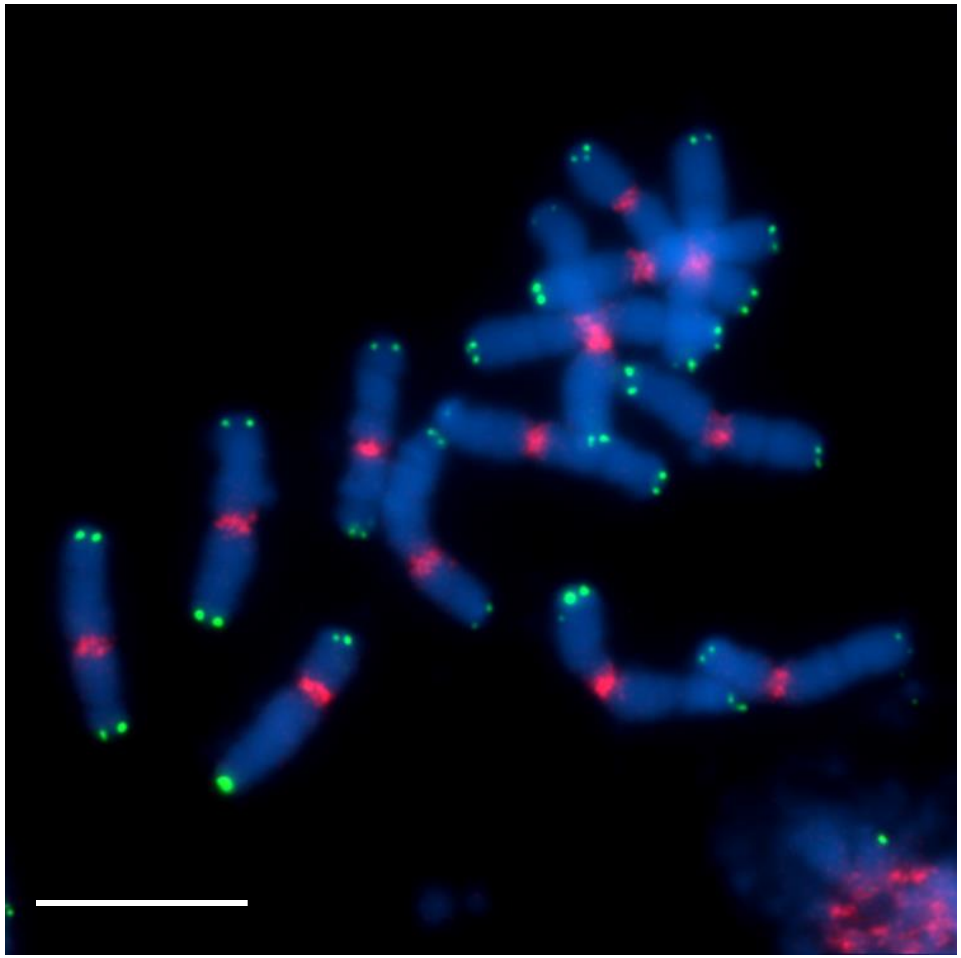


Figure 2 Cell in C-metaphase*

**C-metaphase is observed when cells are treated with colchicine, a drug which arrests mitosis in metaphase.*

2 c) In the micrograph of a cell in interphase, the centromeres are on one side of the nucleus and the telomeres on the other side. Suggest reasons for this.

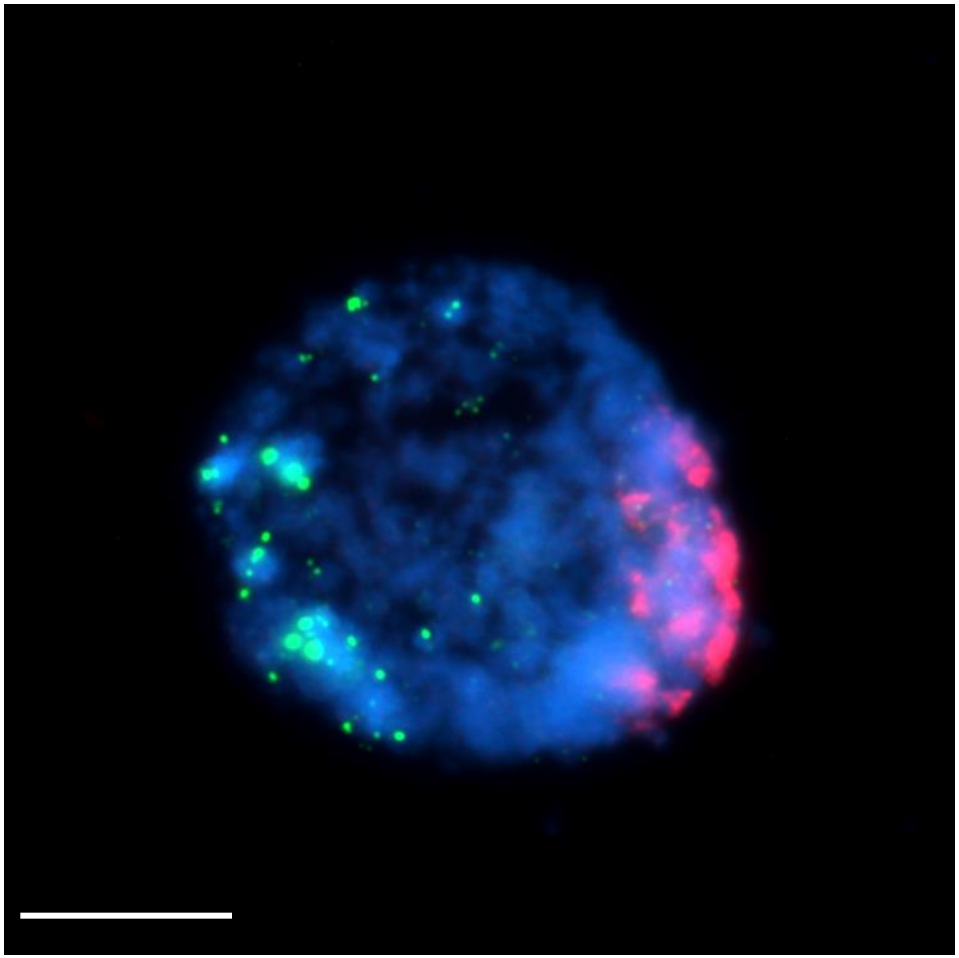
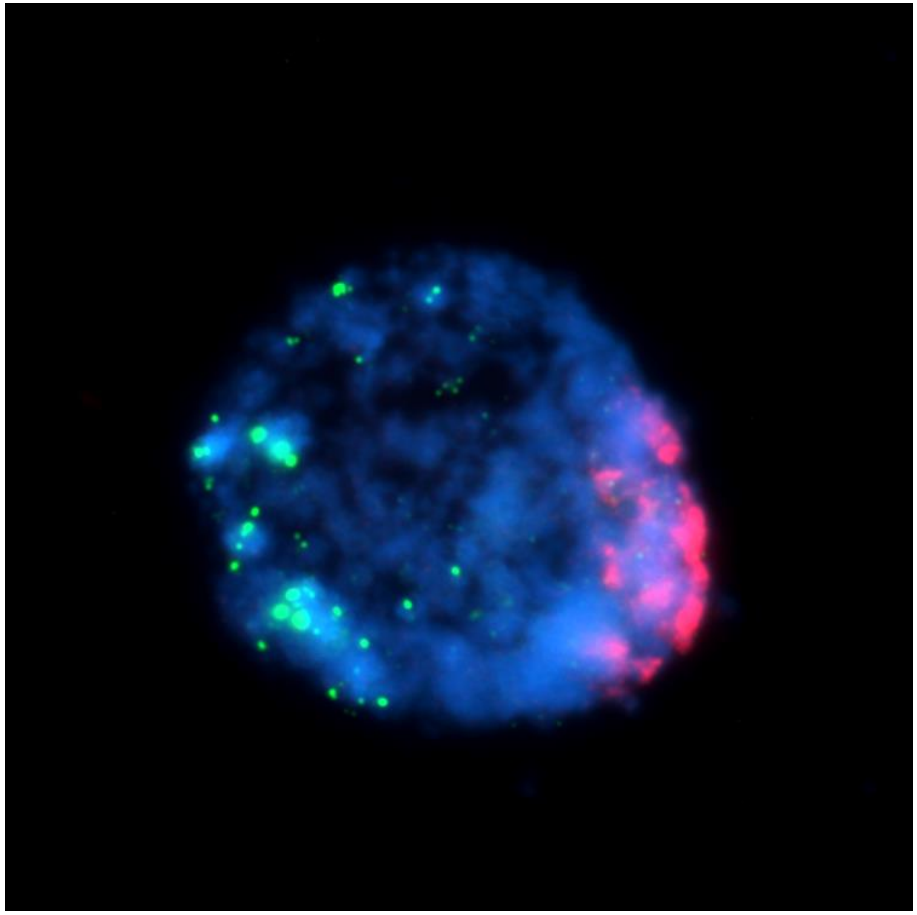
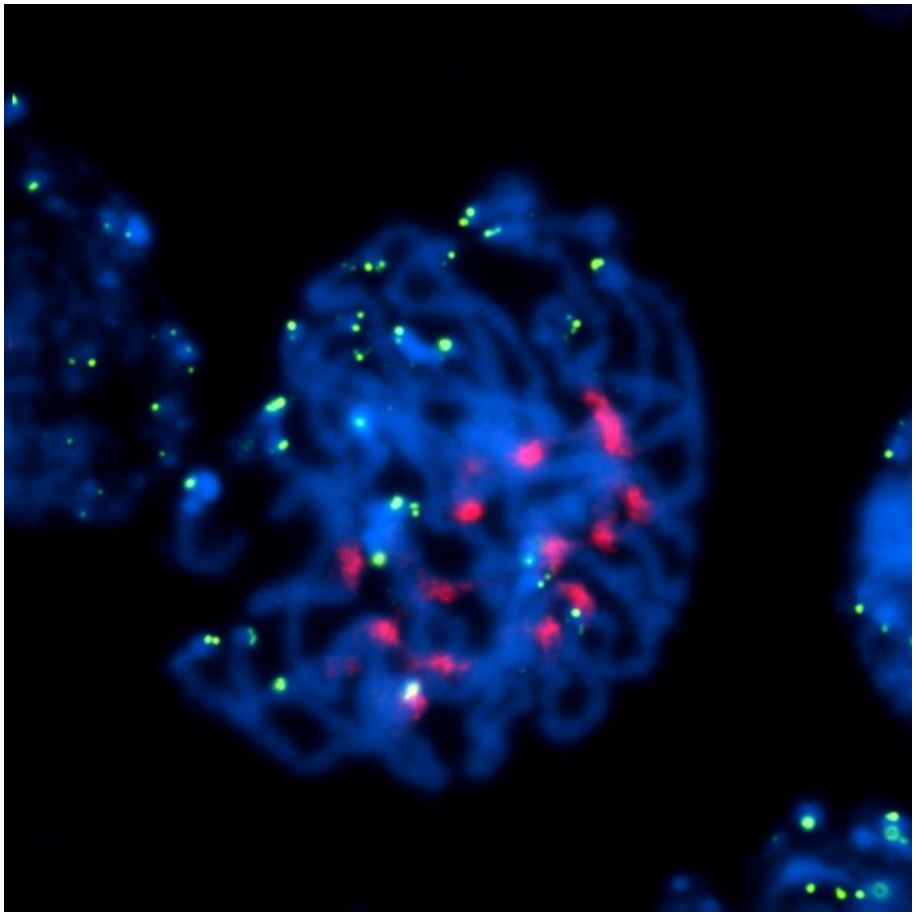


Figure 3 Cell in interphase

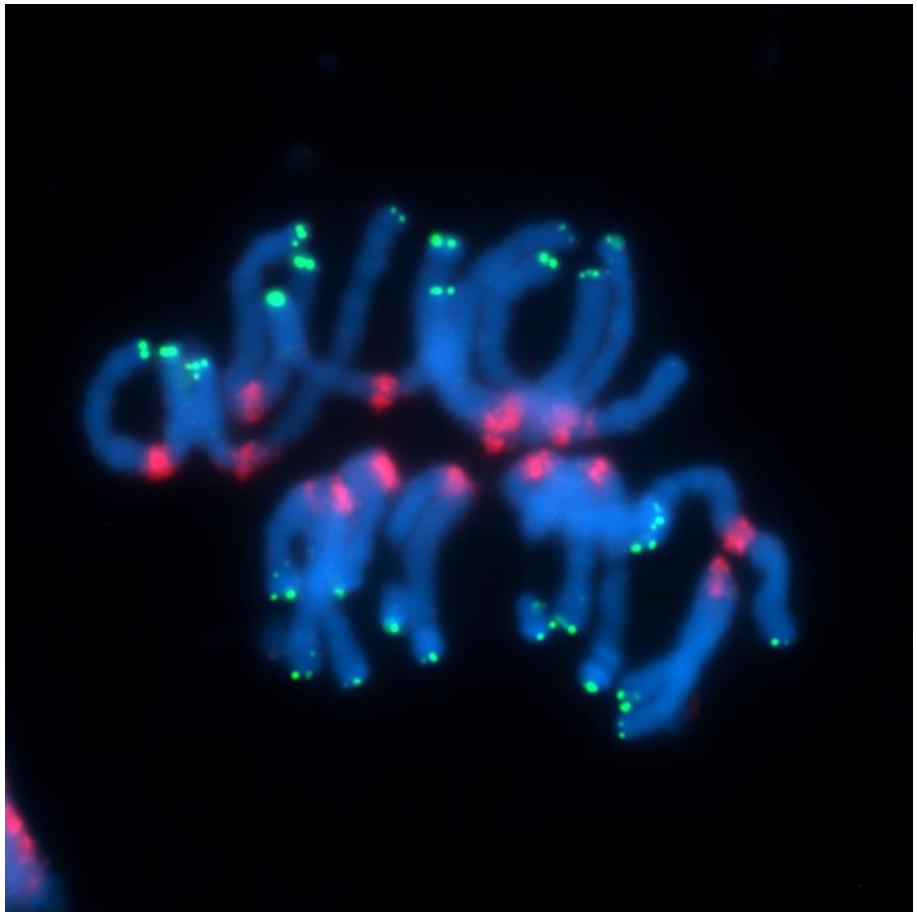
The following images show the cell progressing through all the phases of mitosis.



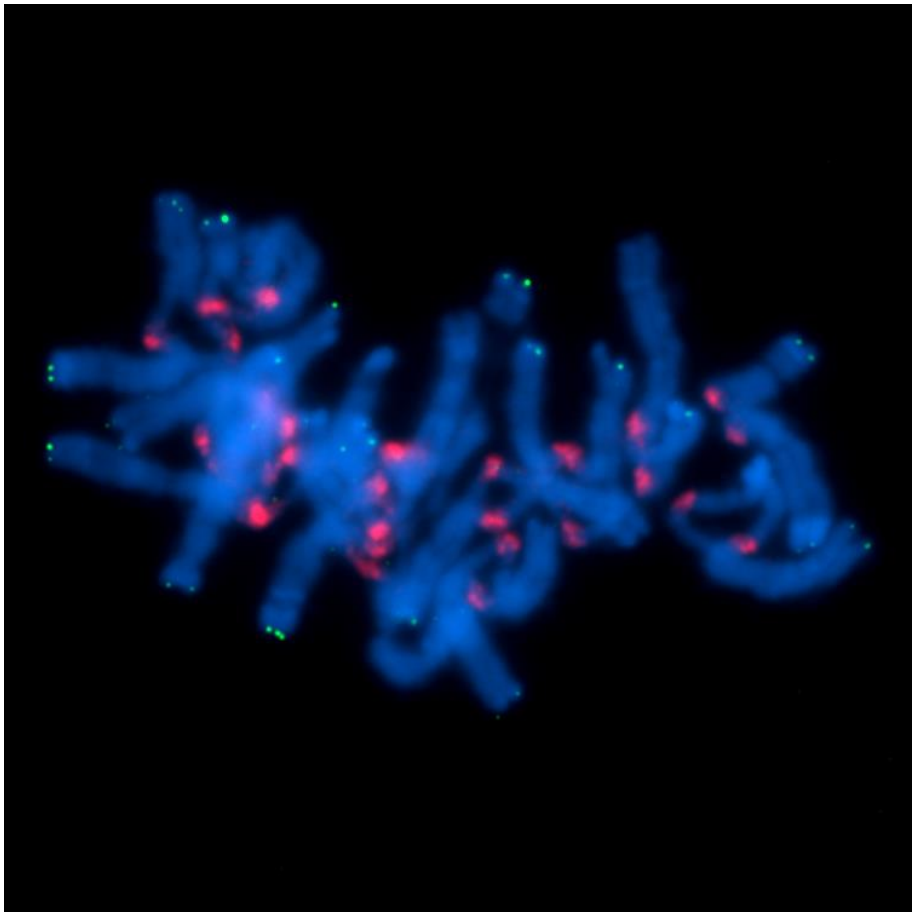
Interphase



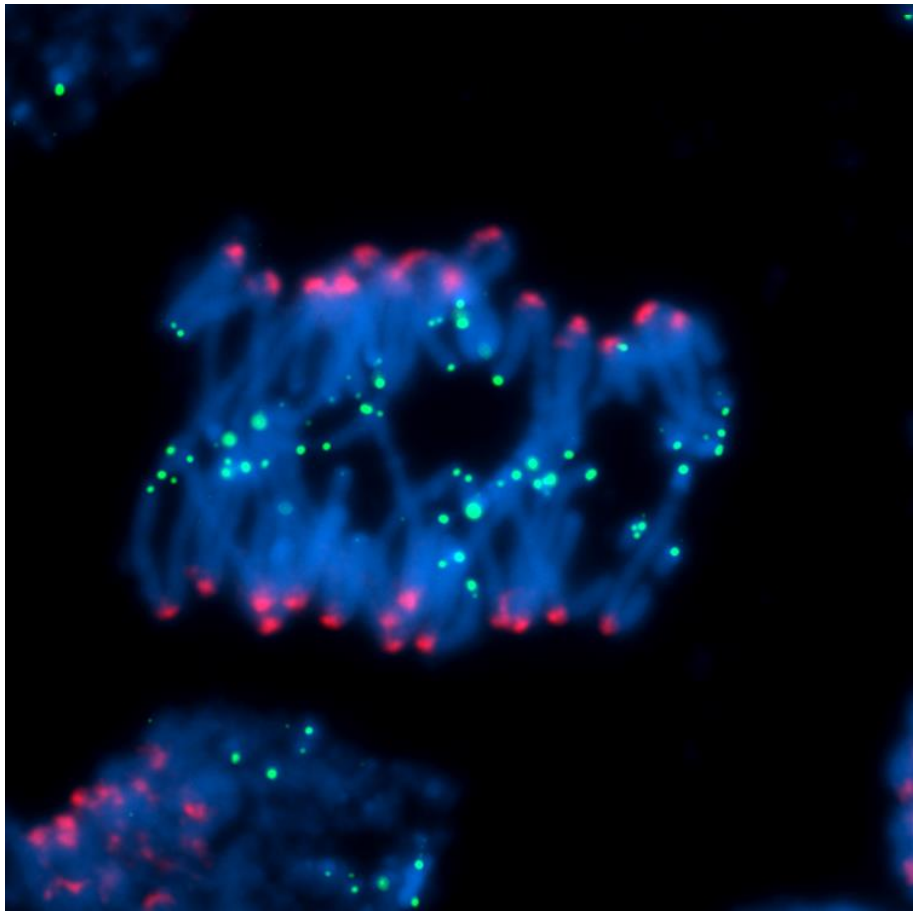
Prophase



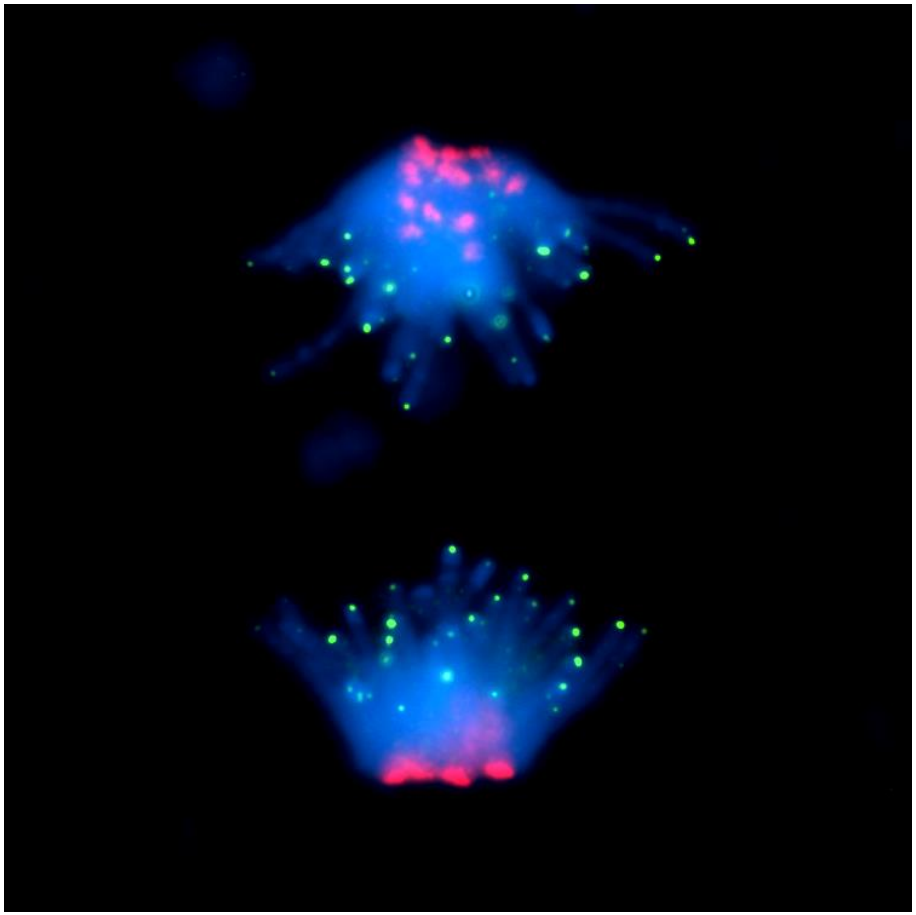
Early metaphase



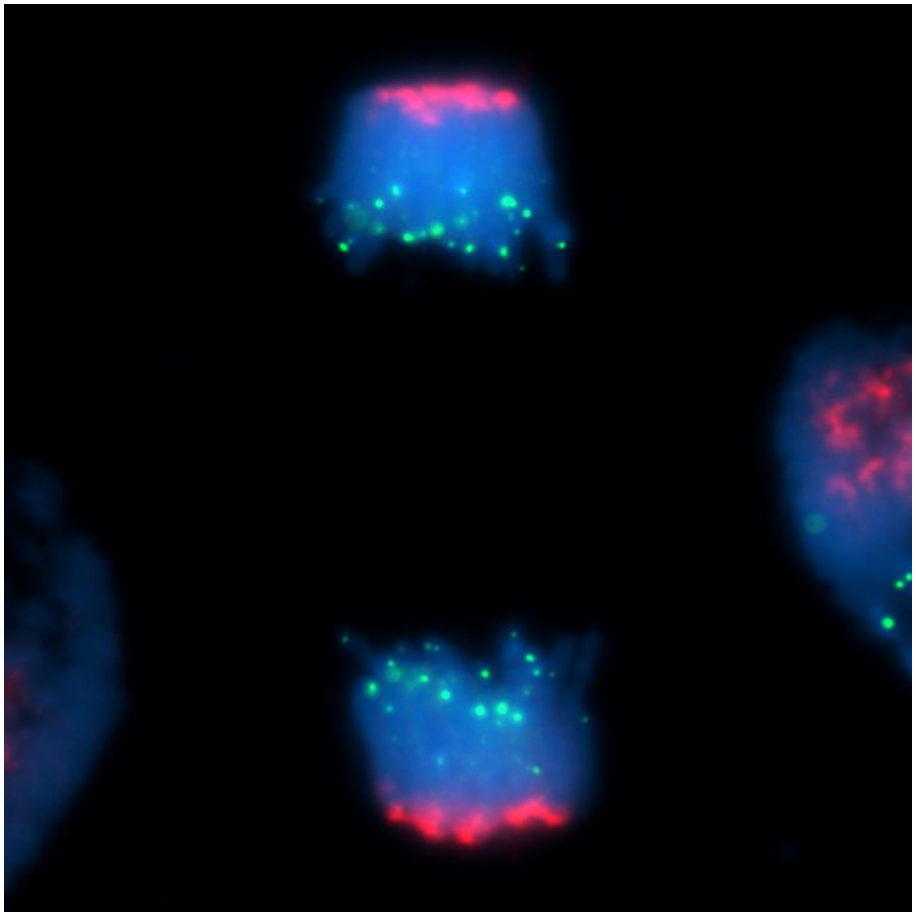
Late metaphase



Early anaphase



Late anaphase



Telophase