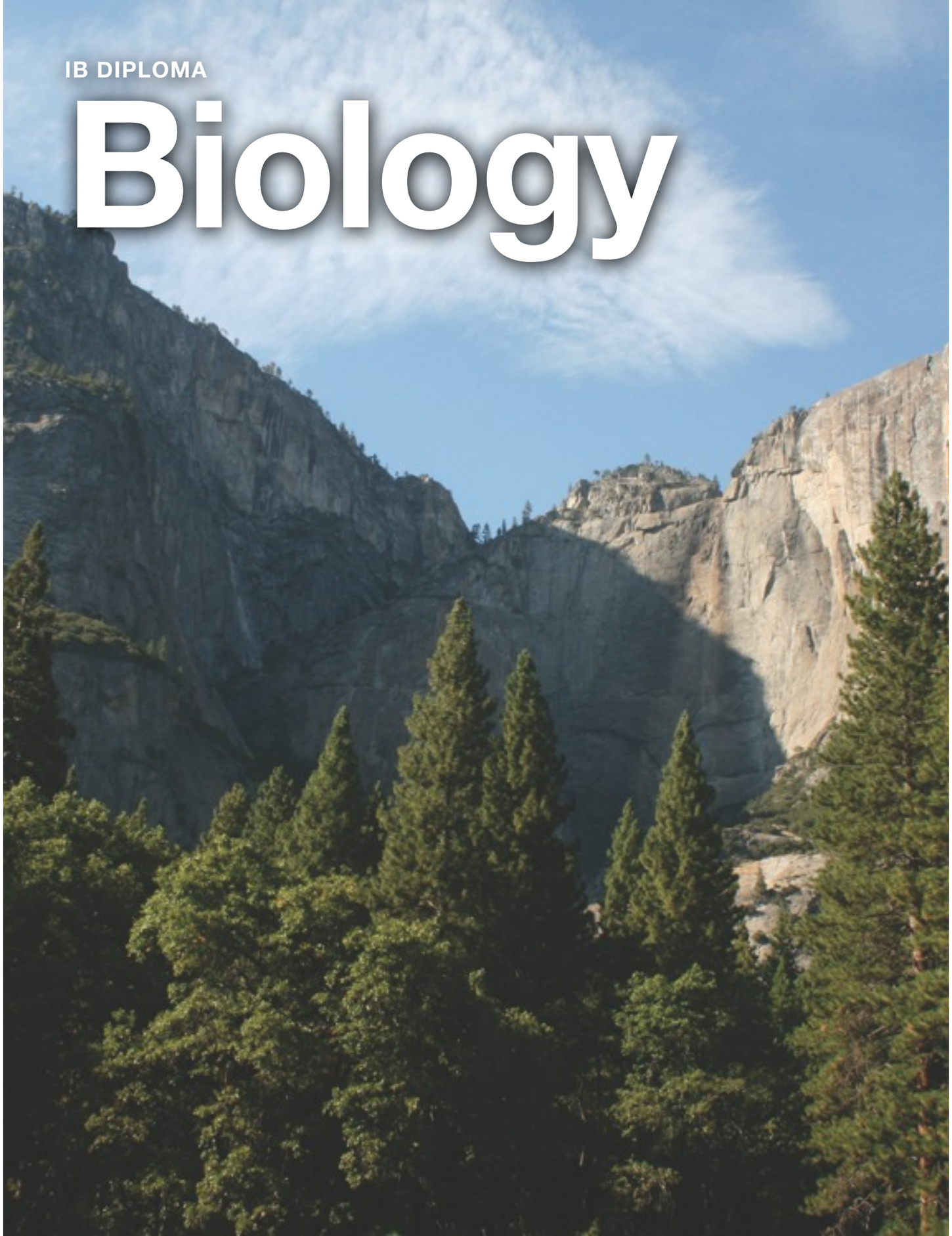
IB DIPLOMA

Biology



Preface

This resource supplements the text:

Biology 4th Edition by Minka Peeters Weem et al.

ISBN: 978 – 1 – 921917 – 23 – 3

published in print form by IBID Press.

It is not intended to be a stand alone resource for the IB Diploma Course.

We have produced this resource to provide a few of the things that are difficult to include in print media:

- Video material.
- Additional photographs.
- Enlargements of the more detailed diagrams from the text.
- Internet links.

The main intention of this resource is to support the cross-curricular objectives of the IB Diploma courses. Students will be challenged to address the historical aspects of science, the mathematical background of the sciences and the over-arching principle that the pursuit of knowledge is a powerful human drive.

Chapter 1

Cell Biology

Section 1

Cell Biology

CONTENTS

Sometimes unicellular organisms (e.g. *Scendensis*) live together in small colonies, what advantage might this confer?

Additional material

Scaling

When three dimensional objects are scaled up (or down), they are scaled in three directions - length width and height.

As the cell gets bigger, the surface area gets smaller in proportion to the volume. This makes exchange of raw materials such as oxygen harder for larger cells.

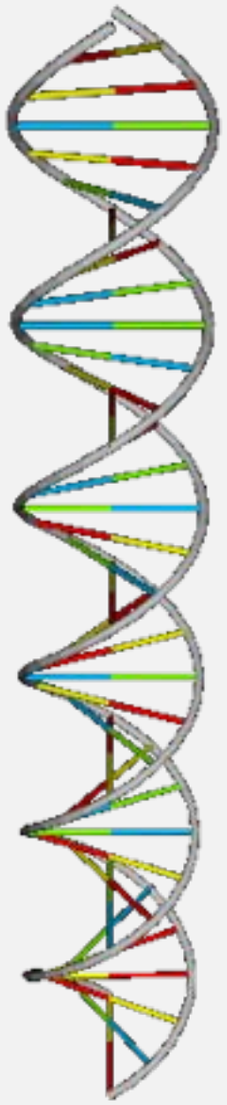
Interactive 1.1 The Effects of Scale

3d scaling of a building.

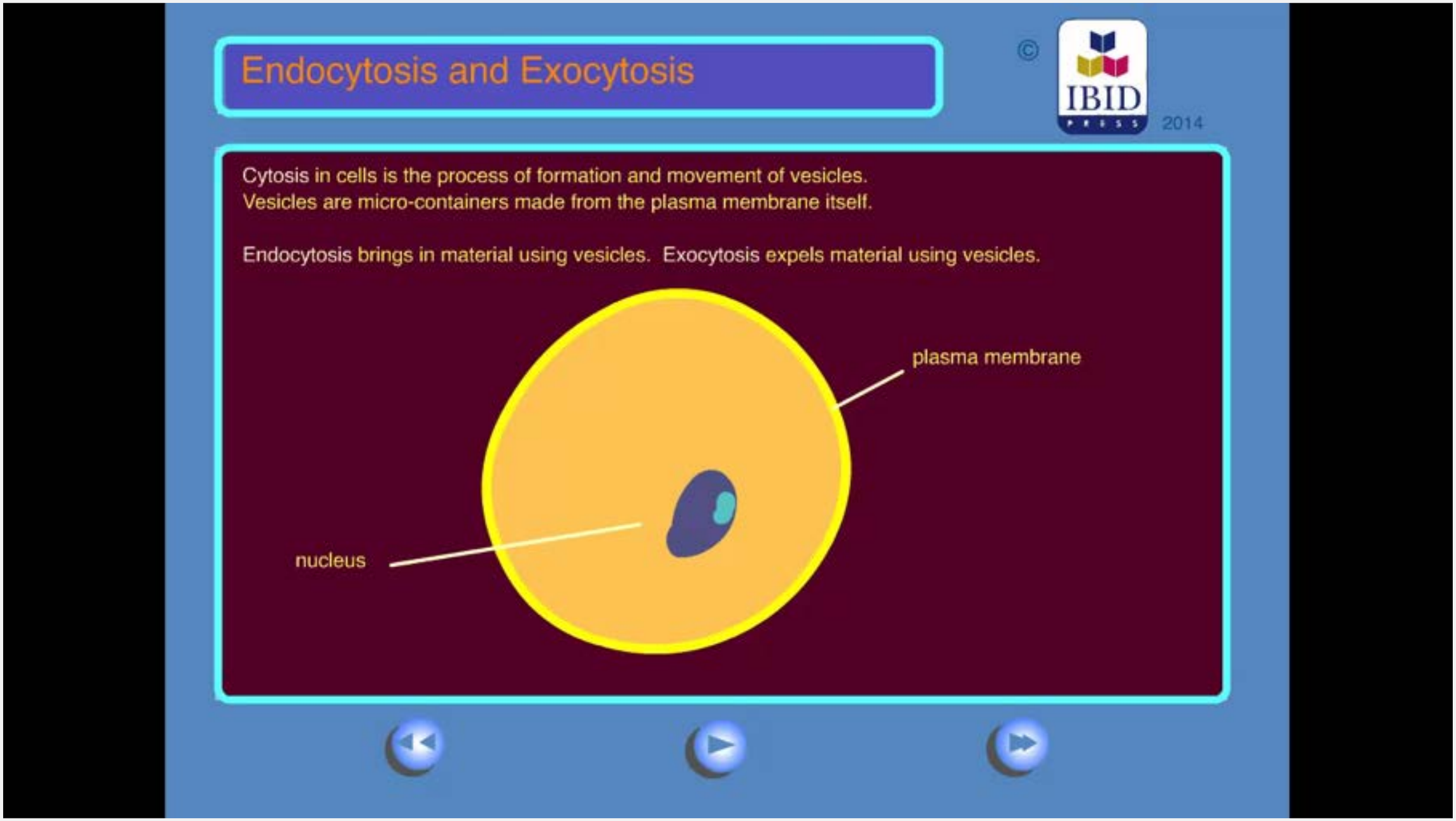
Interactive 1.2 Scaling

Interactive 1.3 Objects of Various Sizes

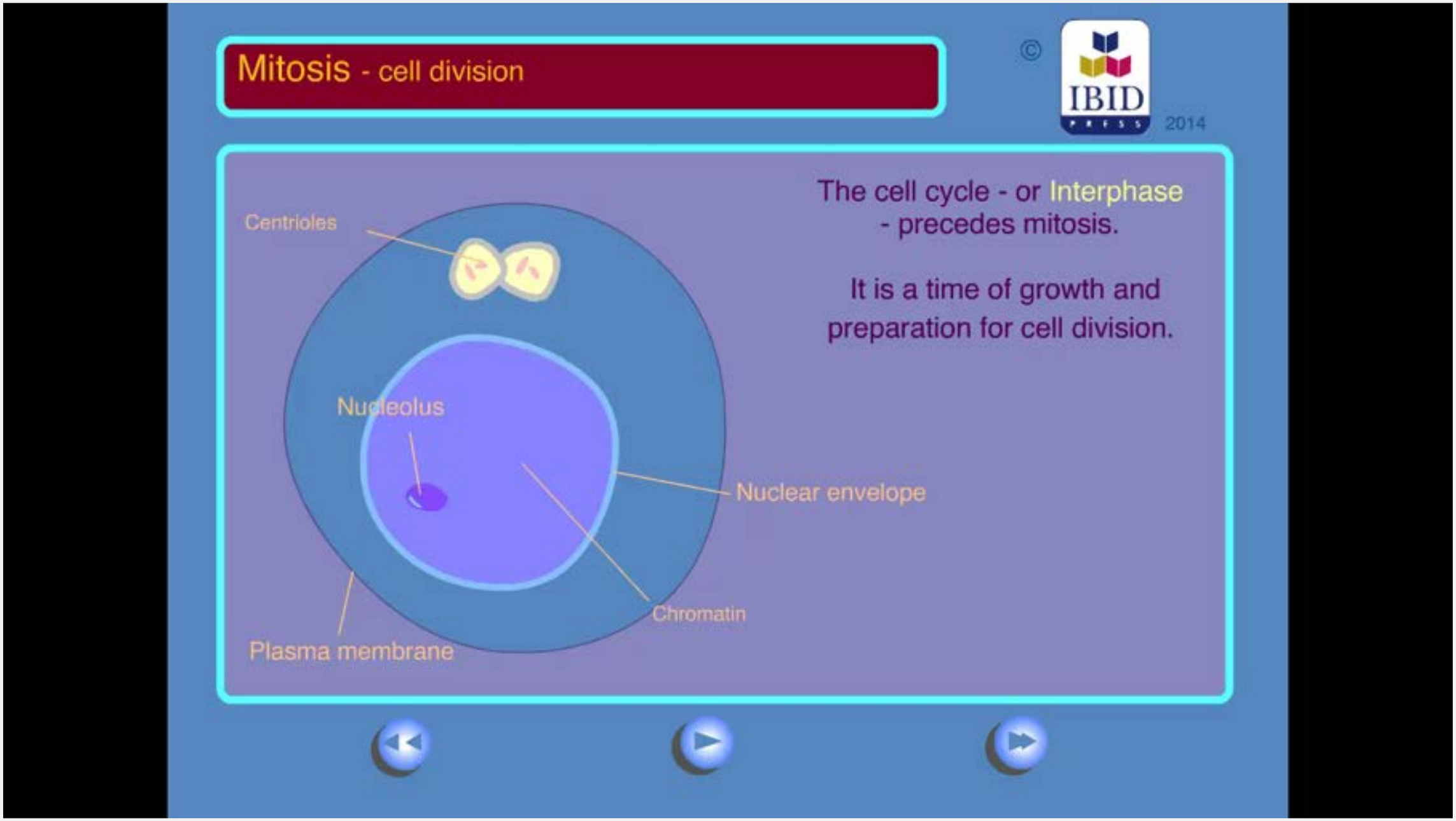
Interactive 1.4 The Double Helix



Movie 1.1 Endocytosis and Exocytosis



Movie 1.2 Mitosis



Enlarged diagrams

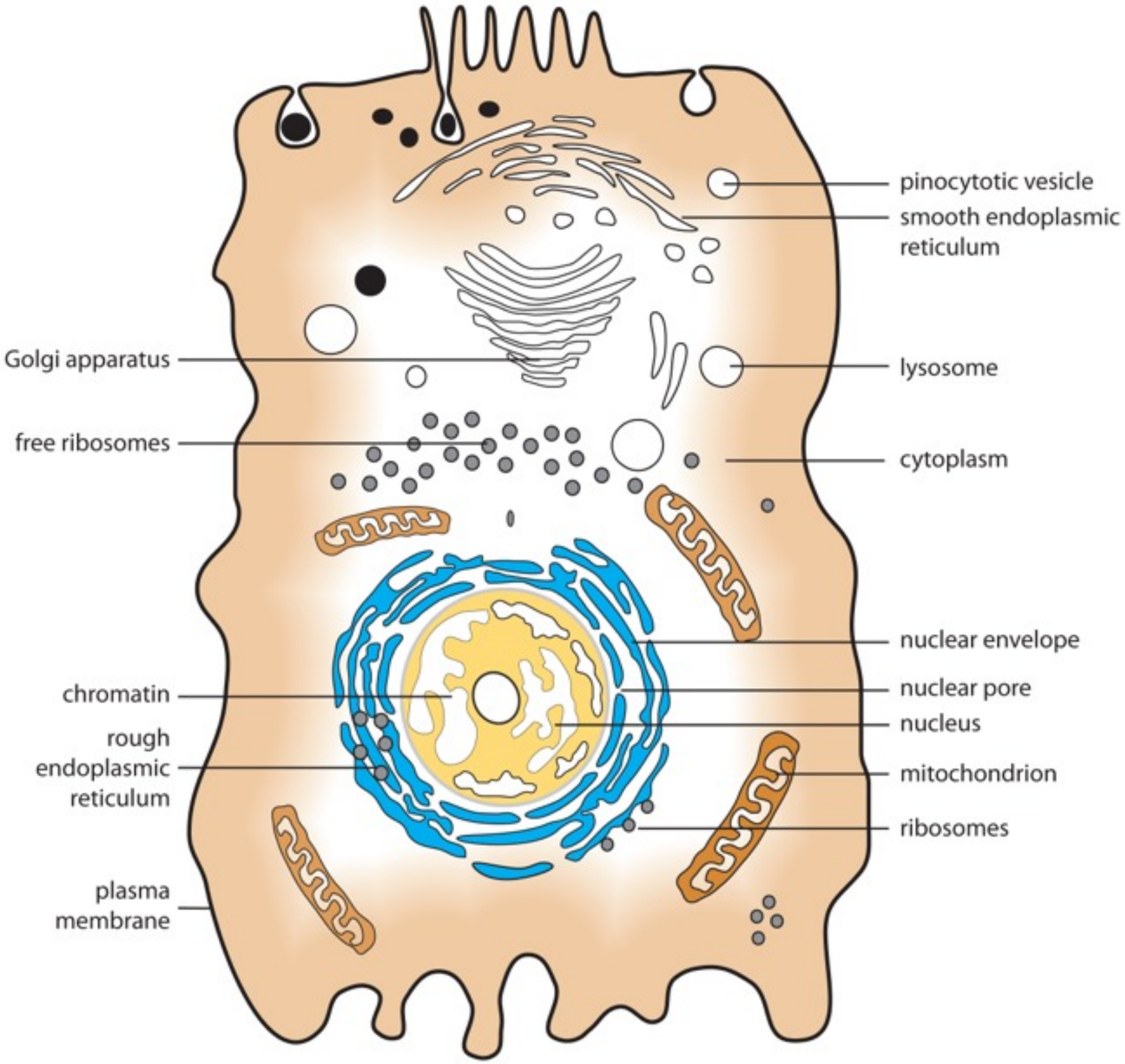


Figure 122 A 'general' animal cell

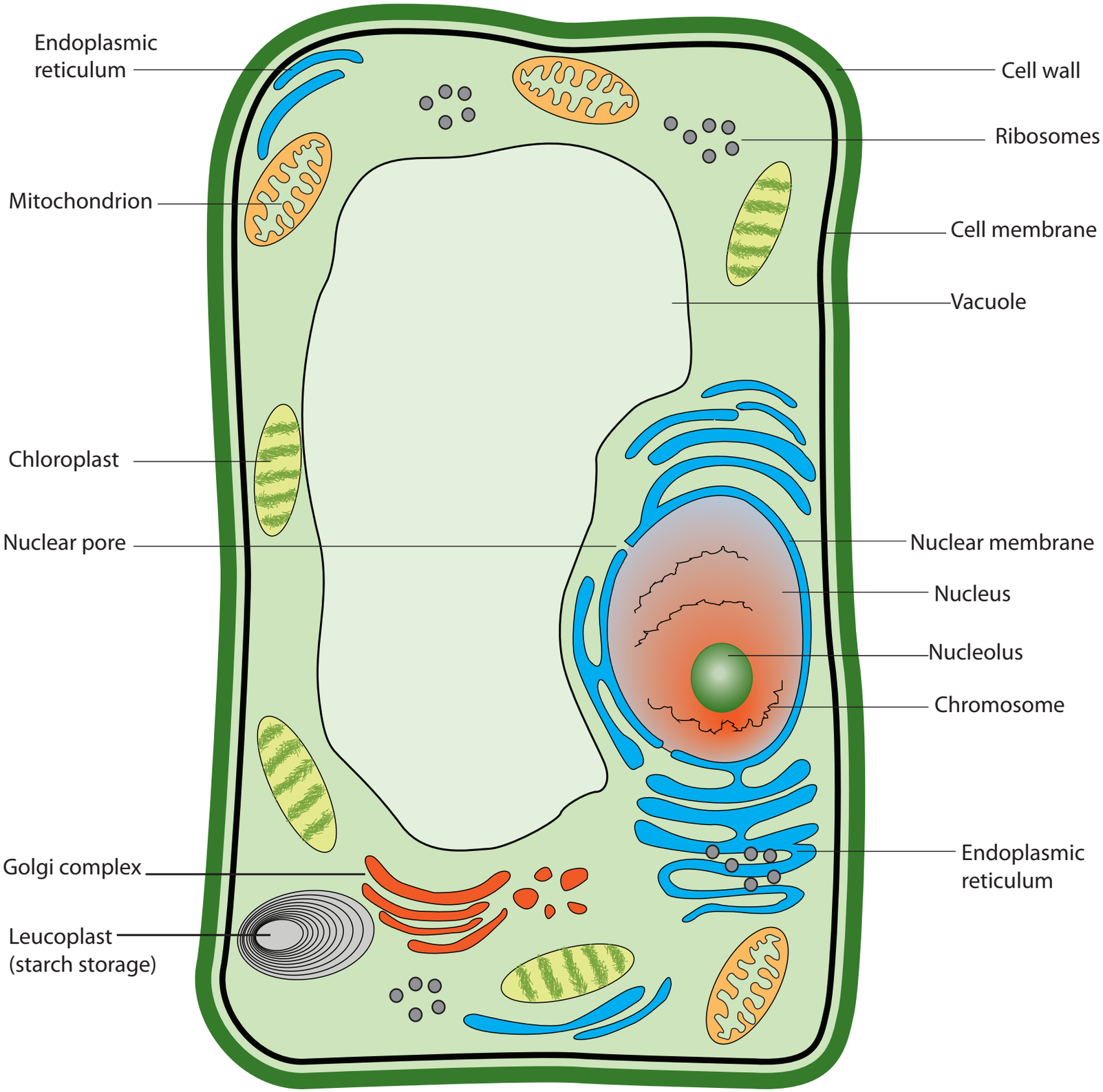


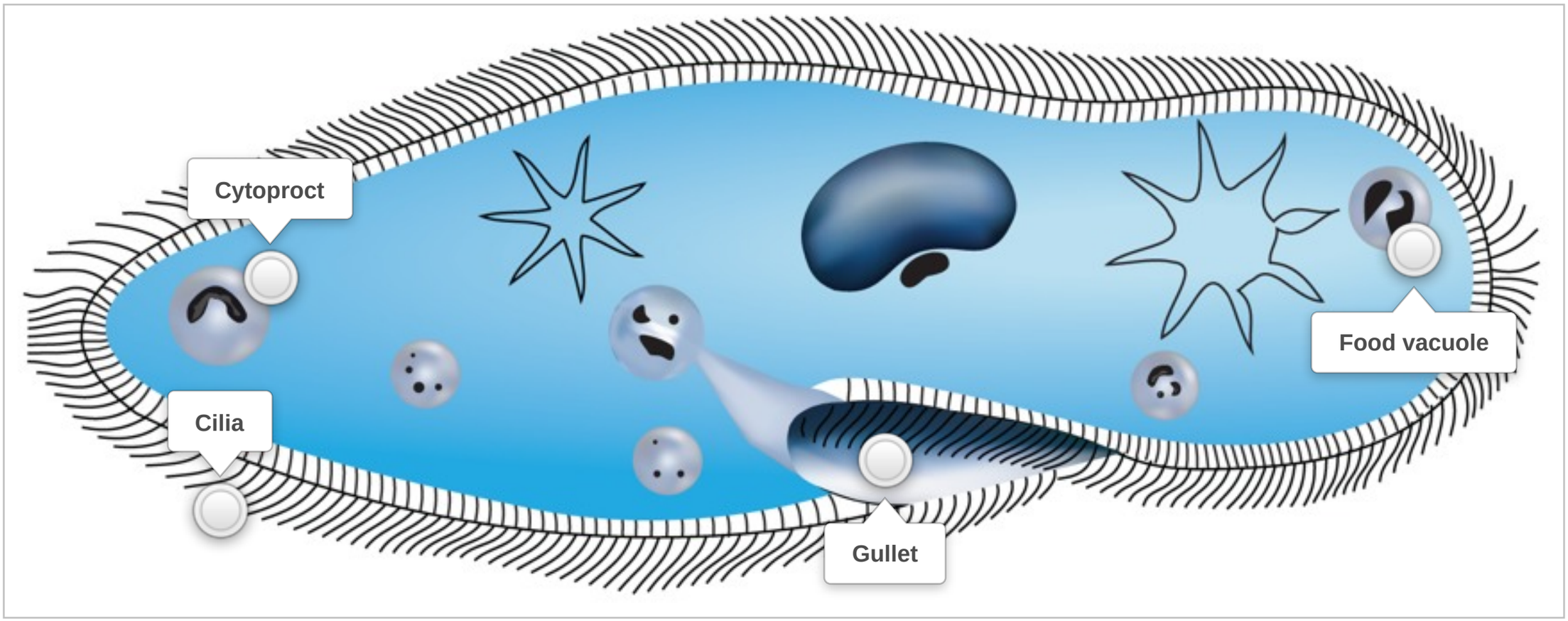
Figure 123 A ‘general’ plant cell

Labelling exercises

Review 1.1 Labelling Exercise

Question 1 of 3

Ciliate - Paramecium



Gullet | Food vacuole | Cilia | Cytoproct

Check Answer

Internet resources

Chapter 1.1

An excellent website illustrating the sizes of things:

http://scaleofuniverse.com

Animation to illustrate Pasteur's experiment

(See http://bcs.whfreeman.com/thelifewire/content/chp03/0302003.html for a visual of his experiment.)

Good site for histology images

http://www.canyons.edu/departments/bio/107Pig/histology.html

this website refers to Stargardt's disease

http://www.advancedcell.com/news-and-media/press-releases/act-confirms-clinical-trial-participant-showed-improvement-in-vision-from-20-400-to-20-40-following-treatment/index.asp

A list of events relating to research and use of stem cells can be found on

http://en.wikipedia.org/wiki/Stem_cell

Chapter 1.2

For an extensive description of binary fission and mitosis, see http://www.emc.maricopa.edu/faculty/farabee/biobk/biobookmito.html

Virtualhistology website http://www.visualhistology.com/products/atlas/VHA_Chpt1_Cells.html

Animation to show the comparison of light and electron microscopes especially power of magnification

Chapter 1.3

Details of a phospholipid molecule beyond the scope of this text can be found on http://www.uic.edu/classes/bios/bios100/lecturesf04am/lect02.htm

Chapter 1.4

An animation of facilitated diffusion by transport proteins can be found on

http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter2/animation__how_facilitated_diffusion_works.html

This sophisticated mechanism of the sodium / potassium pump is explained at

http://www.chem.purdue.edu/courses/chm333/Movies/12.5-potassium_channel.mov

Chapter 1.5 nil

Chapter 1.6

An animation of mitosis in an animal cell can be found at :

http://www.cellsalive.com/mitosis.htm

Could use pics or movie or animation of cell division

If you find it helpful to use a song to remember these events, you can either make your own or do an internet search on "mitosis song". Make sure that you check the scientific accuracy of these songs!

A visual representation of the process of supercoiling is found on

http://www.youtube.com/watch?v=N5zFOScowqo

relevant, existing IBID animations Endocytosis and Exocytosis, Mitosis

Answers to exercises

Multiple Choice Questions

1B, 2C, 3D, 4B, 5C, 6D, 7A, 8C, 9B, 10B, 11C, 12A, 13B, 14A, 15B, 16D, 17A, 18B, 19A, 20B, 21A, 22A, 23D, 24C, 25B.

Short Answer Questions

26 The correct order is: atom, DNA double helix (thickness, length is much more), thickness of membrane, organelle, prokaryotic cell, eukaryotic cell

27 (a) The child has the larger surface area.

(b) dog: SA/V = 0.13/2 = 0.065

child: SA/V = 0.9/24 = 0.0375

the dog has a higher SA/V ratio than the child

(c) If the SA/V ratio is larger, the organism is likely to lose more heat so based on this, the dog would need more food per kg body weight than the child. However, as the child is likely to be growing and the dog is fully grown, the child is likely to eat more. The level of metabolic activity may also be different which would affect the amount of food needed.

28 (a) Refer to Figure 116.

(b) Refer to Figures 122 and 123.

29 (a) Refer to Figure 131

organelle	structure	function
rER	small structures, consisting of 2 subunits, each made of ribosomal RNA and protein	proteins for use outside the cell are synthesised here
lysosome	membrane surrounding (hydrolytic) enzymes	intracellular digestion and autolysis
Golgi apparatus	stack of flattened, membrane bound sacs, forming an extensive network in the cell	intracellular transport, processing and packaging of proteins and glycoproteins
mitochondrion	double membrane, inner membrane folded into cristae, surrounding matrix.	involved in the release of energy from organic molecules as ATP via process of respiration
nucleus	contains DNA in linear chromosomes, surrounded by nuclear envelope with pores	controls the activity of the cell by transcribing certain genes and not others (see 3.5)

The membrane is made of a phopholipid bilayer. This consists of a number of phospholipid molecule. Each phospholipid molecule is made of a polar/hydrophilic phosphate, attached to a central glycerol molecule which also has 2 non-polar/hydrophobic lipid tails. In the phospholipid bilayer, the phosphate groups are found on either side of the layer and the lipid tails are facing each other in the centre.

In between the phospholipid molecules, there are cholesterol molecules and proteins. Integral proteins are proteins which are mostly found in between the phospholipid molecules of the membrane and peripheral proteins are mostly found outside the phospholipid bilayer but interacting with the phosphate heads.

(b) the middle of the phospholipid bilayer is hydrophobic/non-polar which means that the part of the protein that is found in this area also needs to be composed of non-polar amino acids. If it were polar, it would move through the phospholipid bilayer to find other polar molecules to make hydrogen bonds. This would obviously disrupt the structure of the membrane.

30.

(a)	creation of two genetically identical nuclei	mitosis	telophase
(b)	biochemical reactions	interphase	
(c)	separation of sister chromatids	mitosis	anaphase
(d)	DNA replication	interphase	S-stage
(e)	chromosomes moving to the equator	mitosis	metaphase
(f)	protein synthesis	interphase	

31 Asexual reproduction, cloning, growth, repair. Mitosis, together with meiosis, is also part of the process of producing gametes.

32 Volume is length x width x height so as the cell becomes larger, volume increases to the power of 3. Surface area is length x width so surface area increases to the power of 2.

The rate of use of resources (nutrients, oxygen) and the rate of heat and waste production (urea, carbon dioxide) are linked to the volume of the cell. Rate of exchange (of e.g. oxygen) is linked to

the surface area. So the need for e.g. oxygen will increase faster than the ability to take it up.

33 real size x magnification = measured size

real size = measured size / magnification

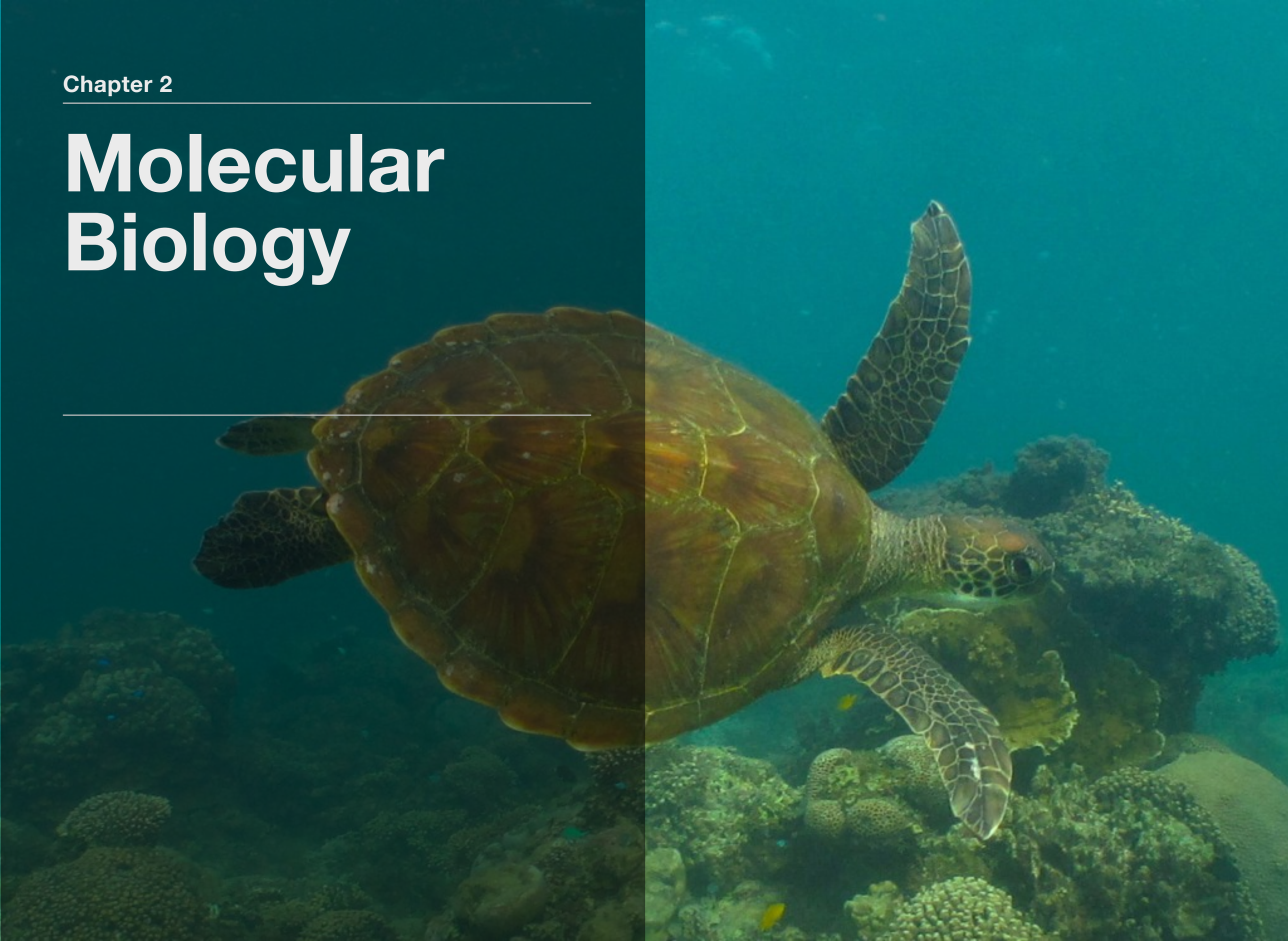
$$\text{real size} = \frac{\text{measured size}}{\text{magnification}} = \frac{8 \times 10^{-3}}{400} = 20 \times 10^{-6}$$

magnification is 20×10^{-6}

the actual size of the nucleus is 20 micrometres

Chapter 2

Molecular Biology



Section 1

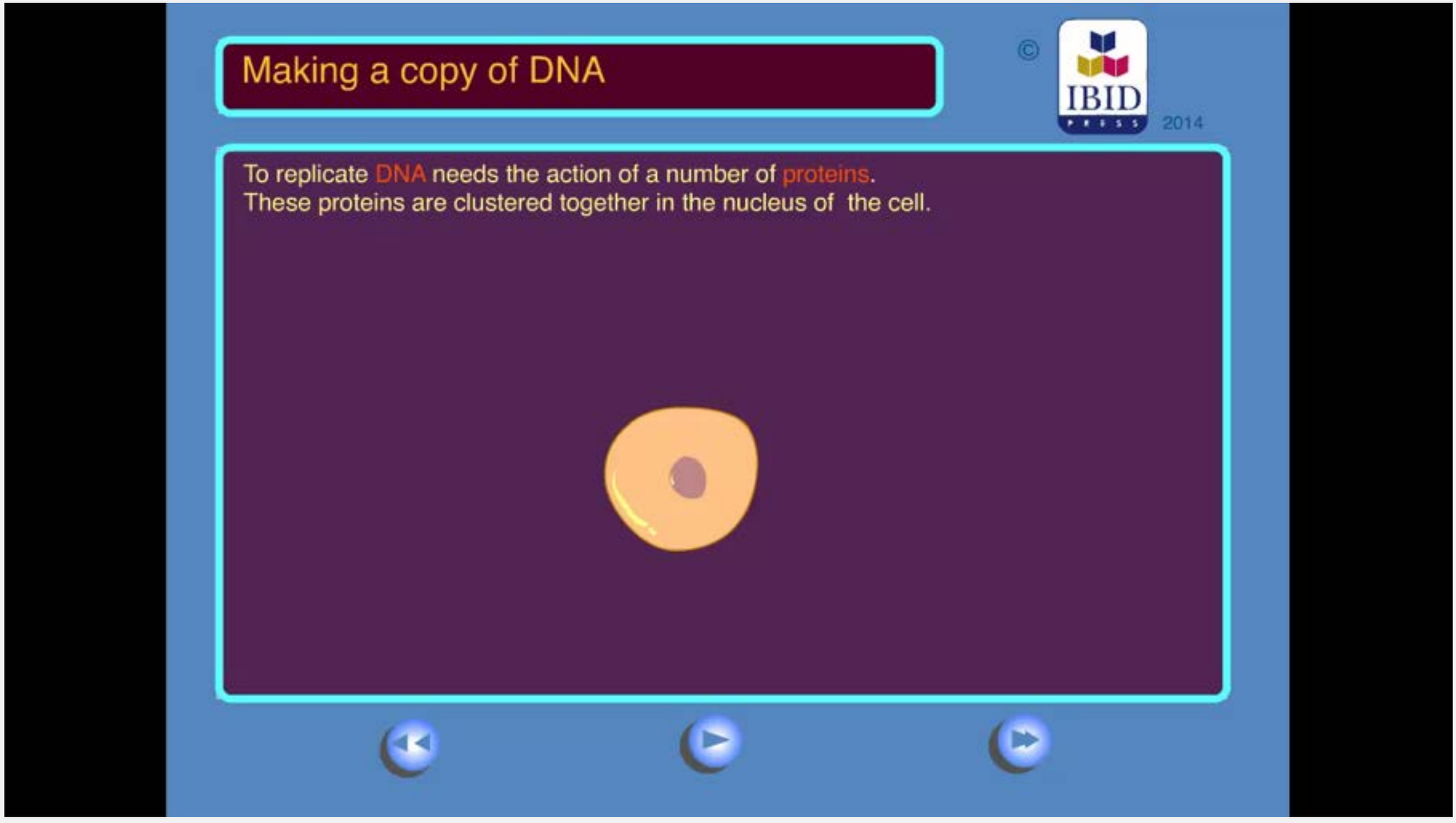
Molecular Biology

CONTENTS

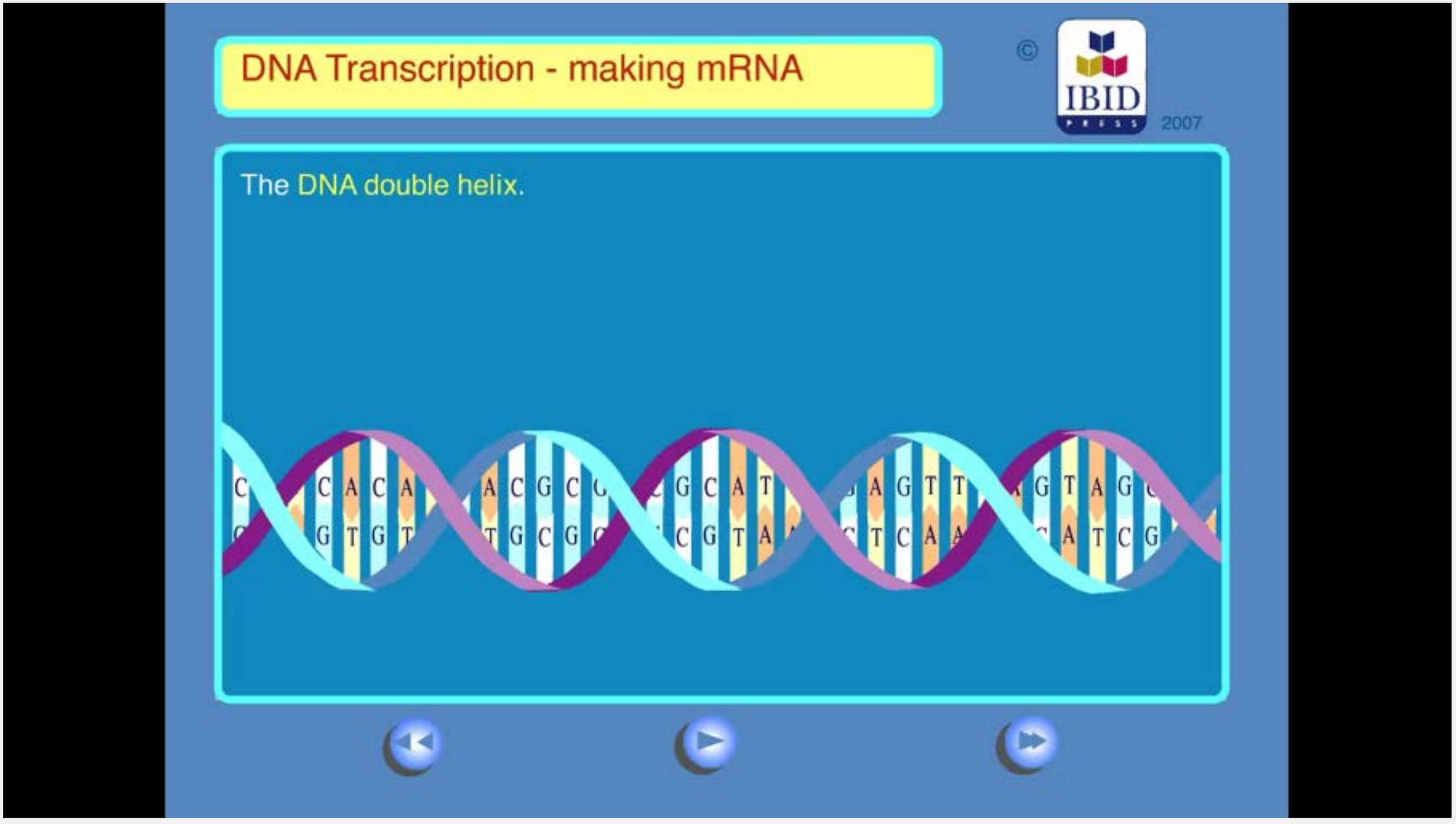
Surface tension is important for organisms living on the surface of water.

Additional material

Movie 2.1 DNA Replication

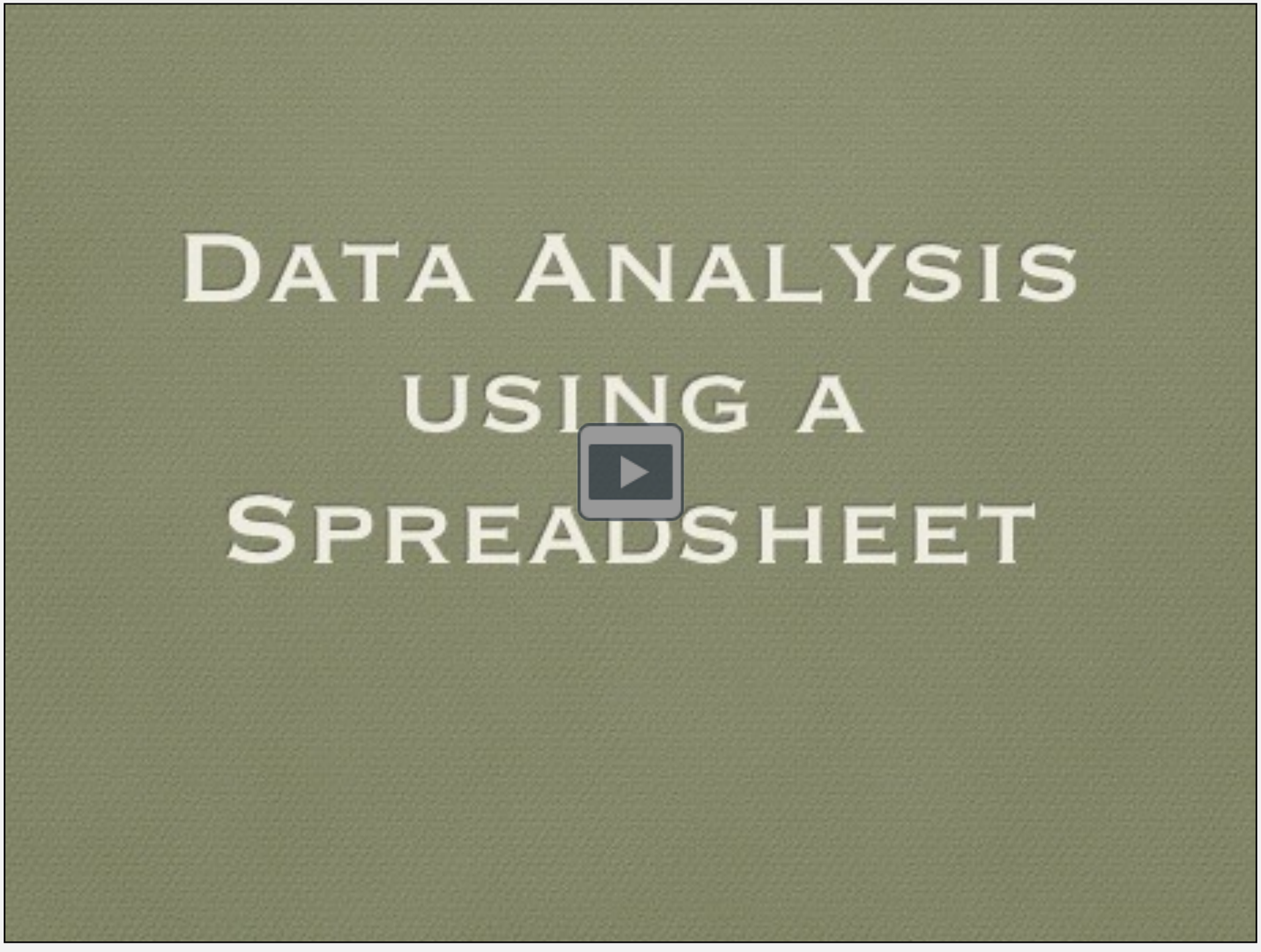


Movie 2.2 DNA Transcription



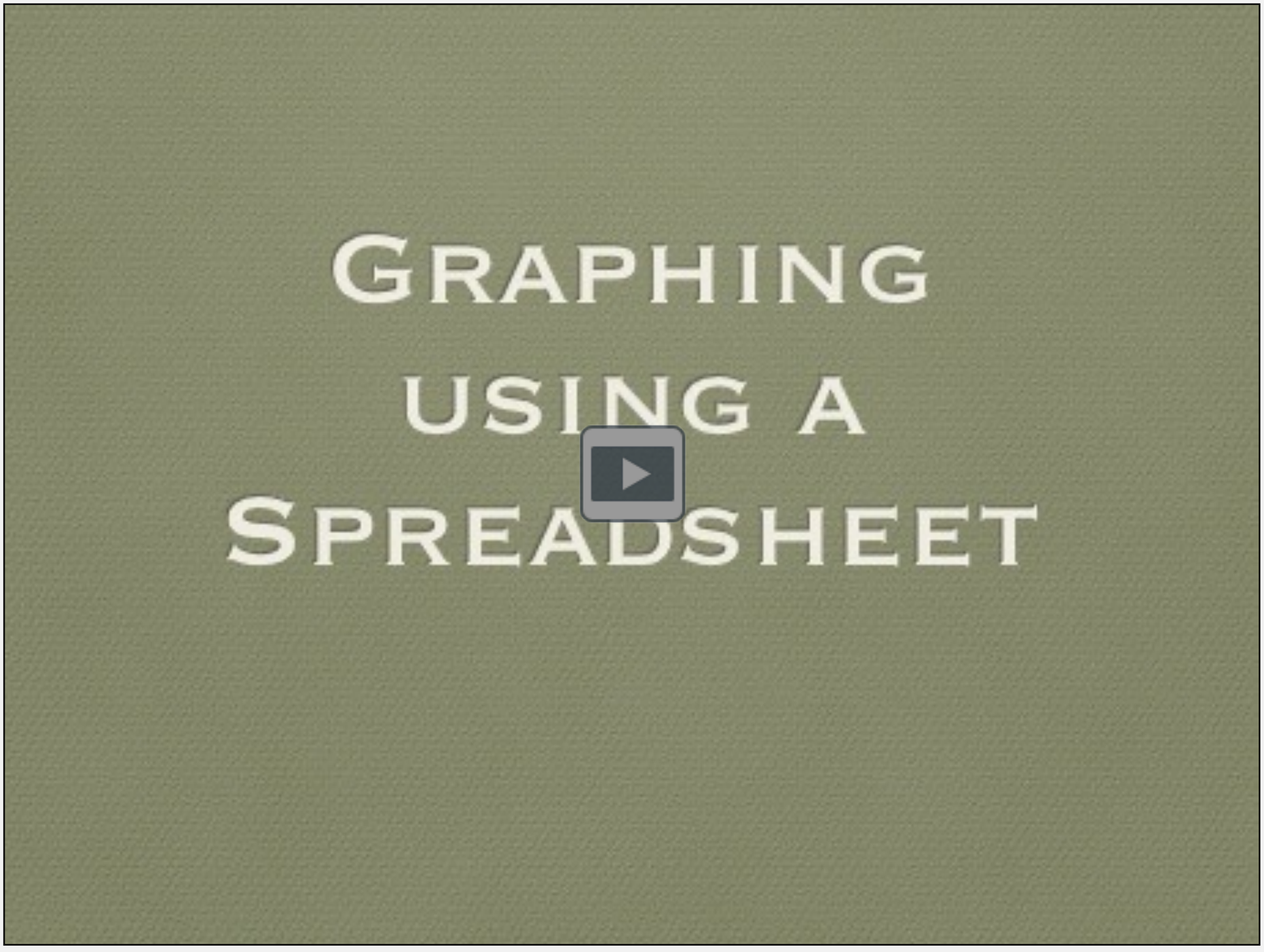
Interactive 2.1 Glucose structure

Interactive 2.2 Using a spreadsheet to analyse data.



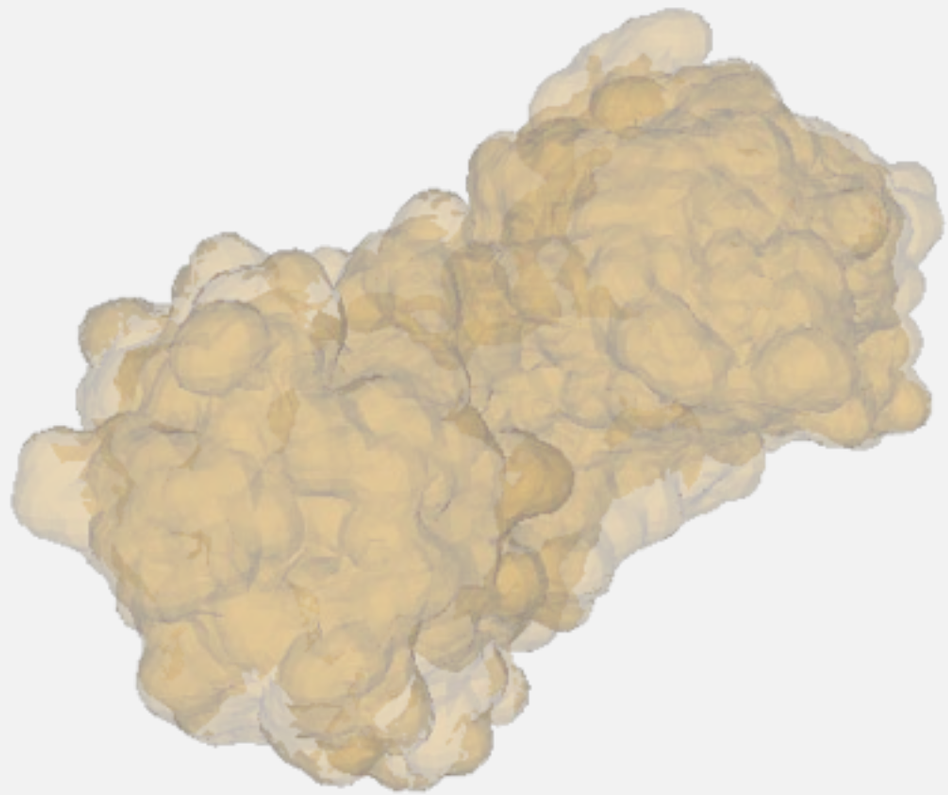
We are looking at some data from Figure 2112, page 90

Interactive 2.3 Graphing using a spreadsheet



This works on from Interactive 2.2

Interactive 2.4 A Human Enzyme - surface model



Human Alcohol Dehydrogenase. Notice the 3D structure and potential binding sites for substrate and inhibitors.

Figure 287
Menselsohn and Stahl's experiment

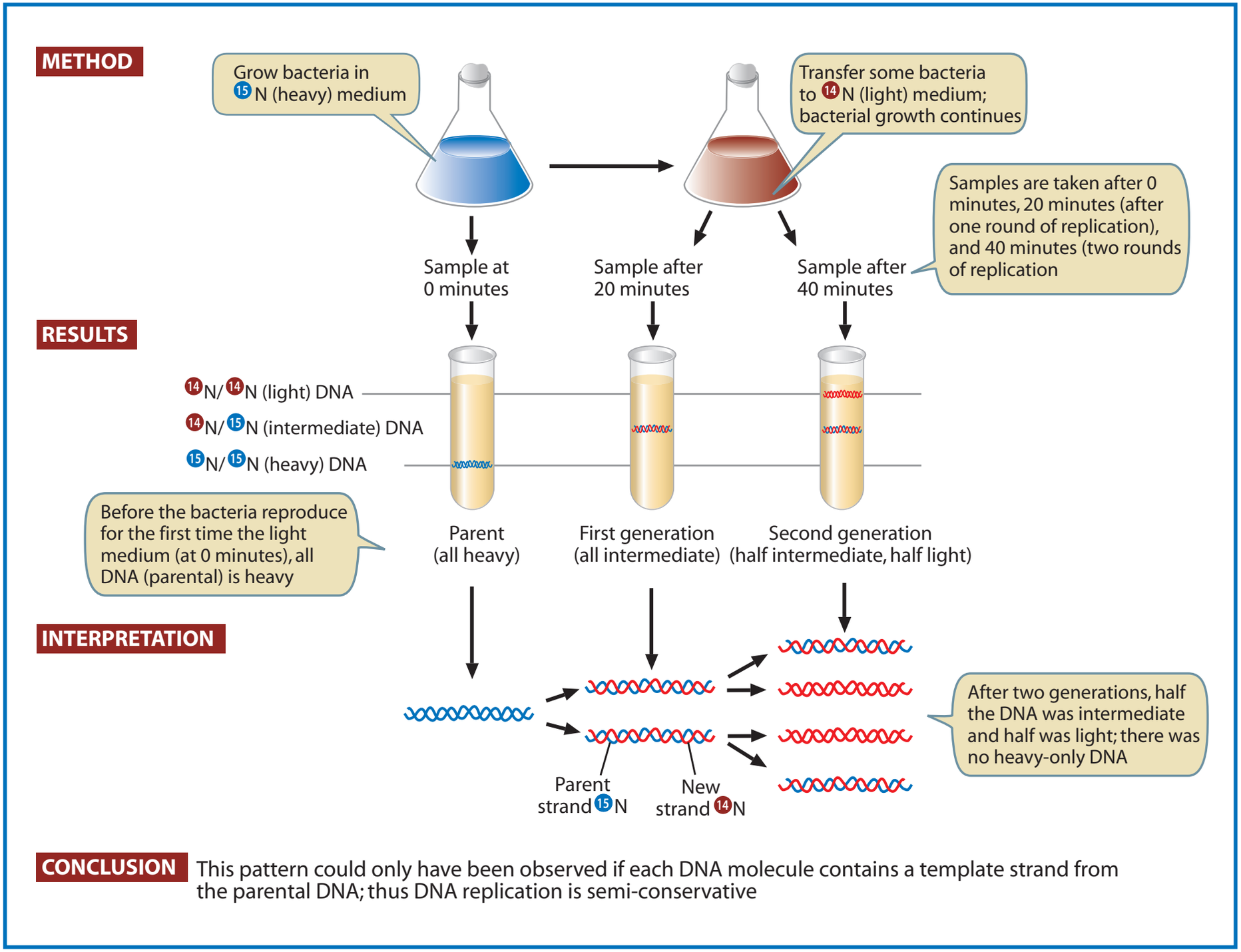
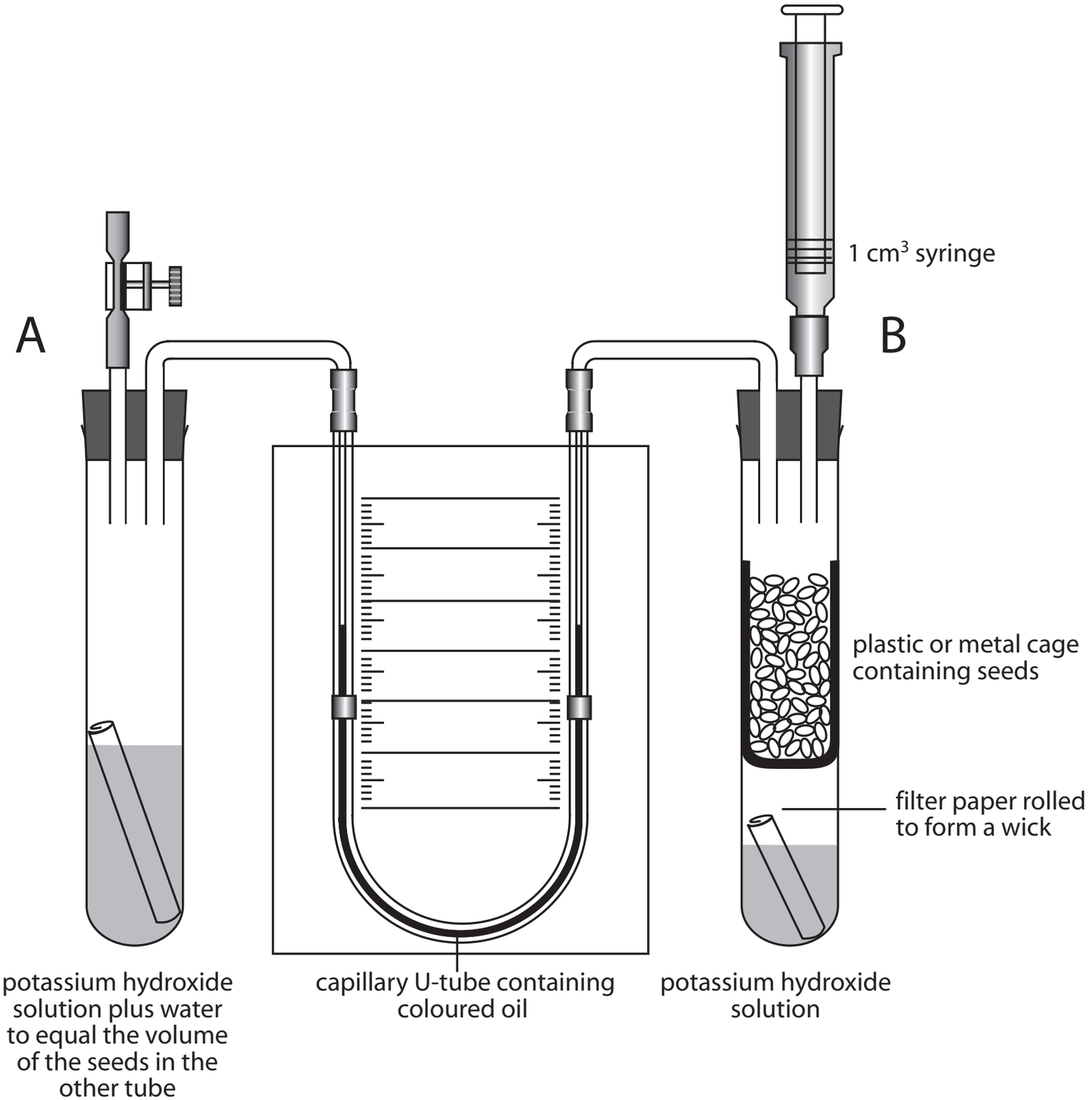


Figure 2111 A more accurate respirometer



Internet resources

Under 2.2.3 there is info about health claims, propose to put this in a Info Box and also include websites here as below

It is possible to manipulate the result of research without falsifying the results. Ben Goldrace gives a 15 minute presentation about ways of accidentally or deliberately being involved in bad science.

http://www.ted.com/talks/ben_goldacre_battling_bad_science.html

This site contains a 15 min presentation about research and some common errors in their approaches. It is indirectly related to this topic but could be followed up in ToK.

It could be read together with

http://www.bmj.com/press-releases/2012/07/18/%E2%80%9Cstriking-lack-evidence%E2%80%9D-back-claims-popular-sports-brands

where the idea of suppressing unfavourable research may be a reason for the different results between the manufacturers and studies done independently.

Led by the Harvard School of Public Health, research may suggest that a healthy diet is not necessarily always a low fat diet and that the lowering blood cholesterol levels that have been measured have not been accompanied by a lowering decline in heart disease. They suggest that a low carb diet may actually reduce obesity and heart disease.

http://www.nytimes.com/2002/07/07/magazine/what-if-it-s-all-been-a-big-fat-lie.html?pagewanted=all&src=pm

Global Health Issues.

Between 1980 and 2008, the number of obese people in the world has doubled. Figure ... shows the global prevelance of obesity per country in 2008 (based on WHO data)

http://www.hsph.harvard.edu/obesity-prevention-source/map-of-global-obesity-trends/

The number of overweight people is now similar to the number of underweight people: approximately 15% of the world population.

http://blog.luckyvitamin.com/wp-content/uploads/2008/10/map21.jpg

In 2004, 4.8% of the global deaths were caused by overweight and obesity but 3.8% by a dietary energy deficiency in children.

Kwashiorkor, a condition caused by a diet with insufficient protein, is almost exclusively found in developing countries. It is very common in sub-Saharan Africa but also found in South East Asia and Central America. Kwashiorkor can be caused by

flooding or drought but since the condition is chronic, it is never caused by just natural disasters.

Anorexia nervosa is an eating disorder where the patient voluntarily reduces their food intake because they have an extreme fear of gaining weight. They also have a distorted perception of themselves, i.e. they are slim, possibly underweight but see an overweight person when they look in the mirror. It is a serious condition, which may well become fatal. There is evidence to suggest that genetically some people are more likely to become anorexic than others but there often is a cultural trigger in a society which promotes thinness as the ultimate (female) ideal, often illustrated by extremely thin models in magazines and fashion shows.

http://www.hitideonline.com/opinion/2011/12/08/statistics-say-no-to-looking-like-a-vs-angel/

Globally, coronary heart disease is the most common cause of death.

2.7

The site below contains a quick outline of DNA structure and an outline of Meselsohn's and Stahl's experiments.

http://www.sumanasinc.com/webcontent/animations/content/meselson.html

See https://highered.mcgraw-hill.com/sites/0072507470/student_view0/chapter3/animation__how_translation_works.html for an excellent animation.

2.9

More details about TLC and paper chromatography are available at

http://www.docstoc.com/docs/42155633/Paper-and-Thin-Layer-Chromatography

Answers to exercises

Multiple Choice Questions

1D, 2C, 3B, 4A, 5D, 6A, 7D, 8A, 9D, 10A, 11A, 12B, 13C, 14D.

Short Answer Questions

15 Water molecules have a negative and a positive side. This means that they are polar. There are hydrogen bonds (electrostatic attraction forces) between the negative side of one molecule and the positive side of another which causes the cohesion forces between water molecules.

Thermal properties : water needs a large amount of energy to warm up and a lot more energy to change from solid to liquid or liquid to gas at a constant temperature. This is because of the strong cohesion forces between molecules.

Water is a good solvent for polar molecules. Polar molecules can interact with water molecules in the same way that other water molecules do. Non-polar molecules do not interact with water molecules and therefore do not dissolve well.

16 (a) carbon, hydrogen, oxygen

(b) carbon, hydrogen, oxygen

(c) carbon, hydrogen, oxygen, nitrogen

17 (a) monosaccharides e.g. glucose, see Fig 295(a)

(b) glycerol and fatty acids – see Fig 208

(c) amino acids – see Fig 213

18 The condensation reaction between monosaccharides is between two -OH groups, forming water. This leaves one O in place which forms an oxygen bridge between the monosaccharides. The condensation reaction between two amino acids is between NH2 of one amino acid and COOH of the other amino acid. The H atom of the NH2 group combines with the -OH of the -COOH group, forming a water molecule and a peptide bond.

19 (a) Enzymes are proteins. Increasing the temperature changes the three dimensional shape of any protein, so also that of the active site of the enzyme. If the active site changes shape, then the substrate will no longer bind and the enzyme does not work anymore.

(b) Increasing substrate concentration will make it more likely that the active site of any enzyme has a substrate attached. Therefore the rate of the reaction will increase until all active sites are filled with substrate at any time. Further increasing the substrate concentration will not increase the rate of reaction.

(c) Denaturation occurs when the shape of the active site of the enzyme changes. The substrate no longer fits and the rate of the reaction becomes very low.

20 (a) covalent bond caused by a condensation reaction

(b) covalent bond caused by a condensation reaction

(c) hydrogen bonding caused by electrostatic forces of attraction forces between either oxygen or nitrogen in one base and hydrogen in the other.

(d) covalent bonds are stronger because they involve sharing pairs of electrons.

(e) because A and T both form two hydrogen bonds and C and G both form 3 hydrogen bonds. Also, A and G are purines (have two rings) while C and T are pyrimidines (have one ring) and there is room for exactly three rings between the sides of the DNA double helix.

Chapter 3

Genetics

Section 1

Genetics

CONTENTS

Normal and abnormal red blood cells. What might cause this condition?

Additional material

Gallery 3.1 Genetic diversity

Mammals and birds have different adaptations to life in cold conditions

Enlarged diagrams

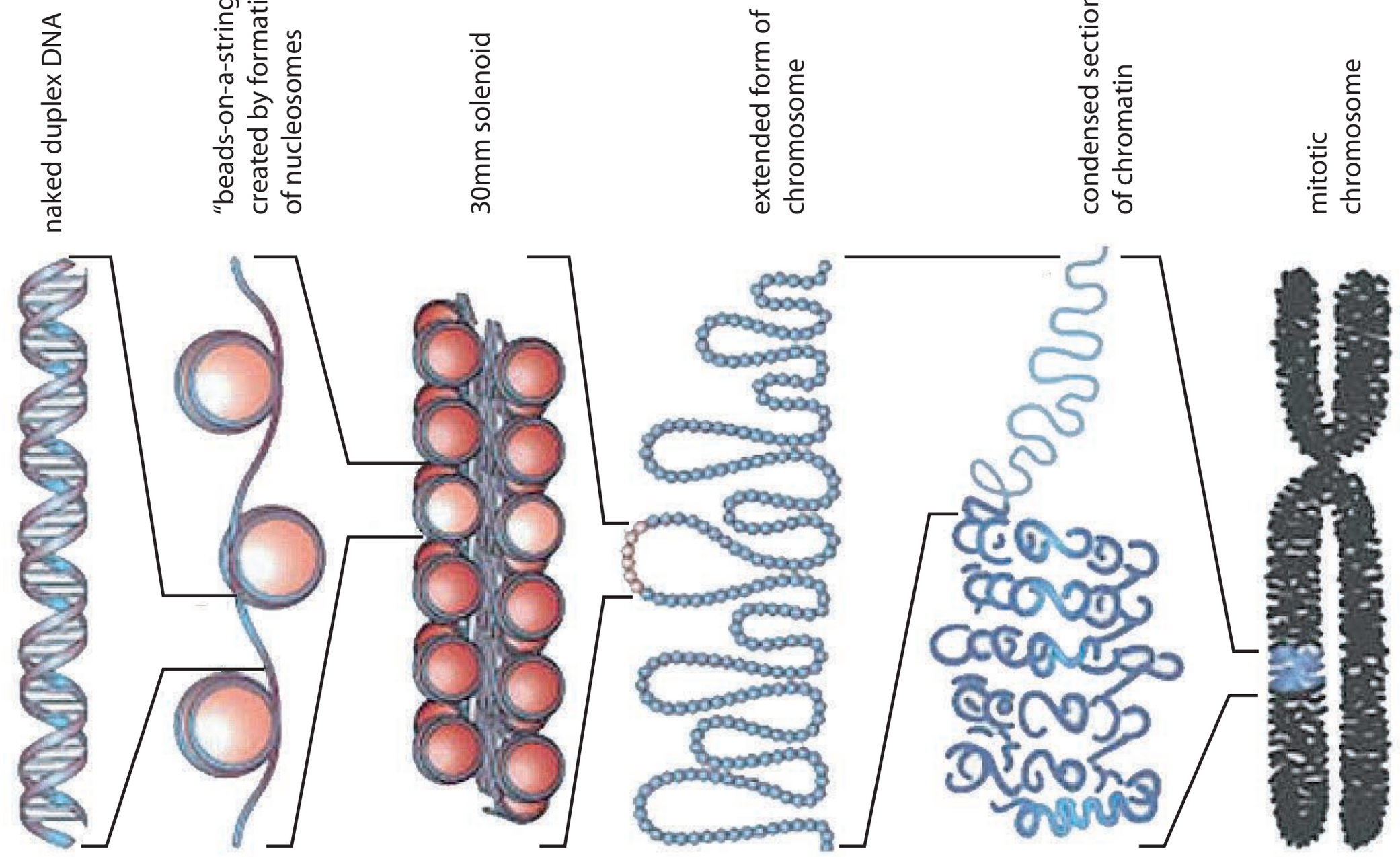


Figure 308 The composition of chromosomes

Fig 316 The stages and phases of Meiosis

THEN FOR EACH CELL, A FURTHER DIVISION OCCURS PRODUCING A TOTAL OF **4** HAPLOID DAUGHTER CELLS

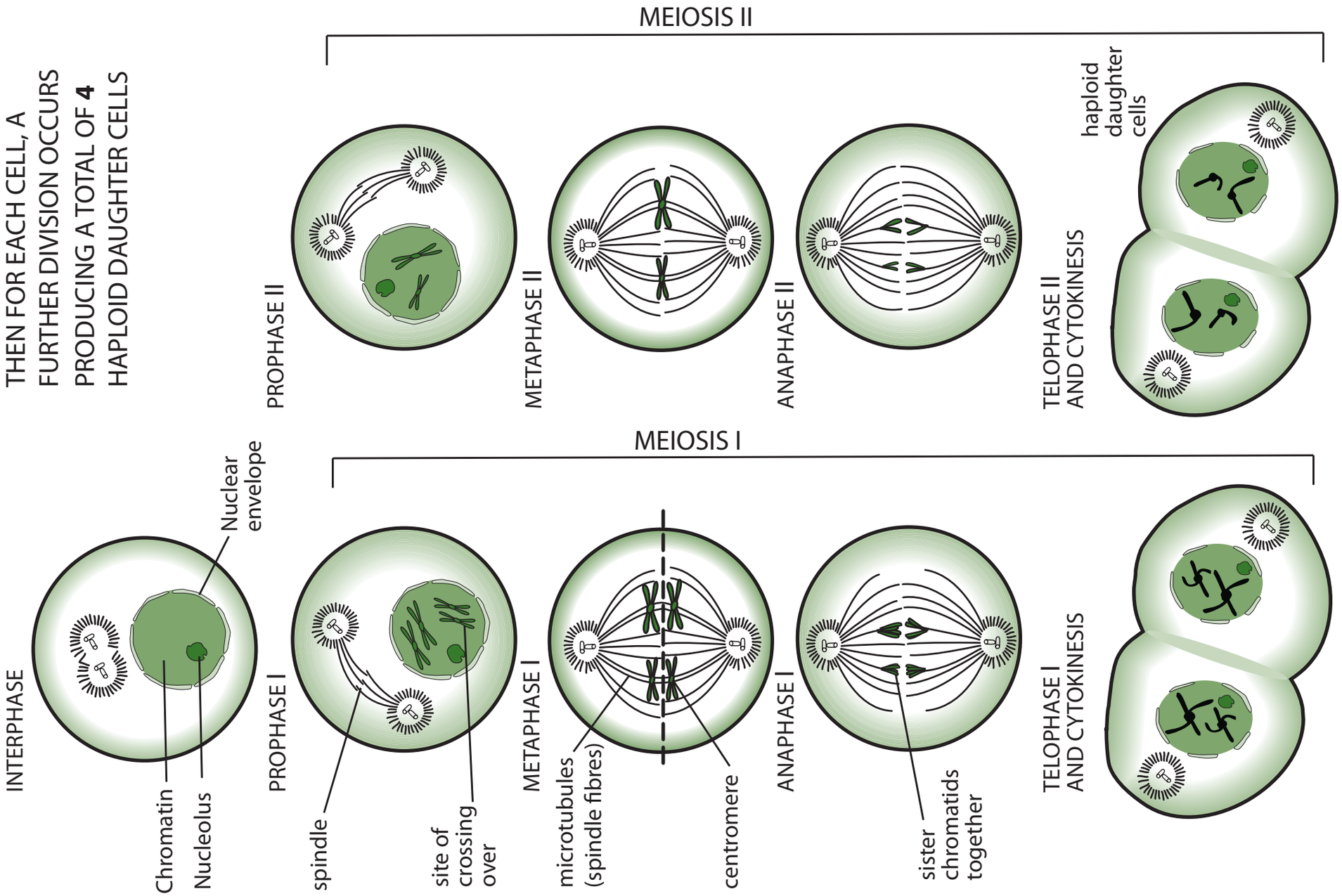
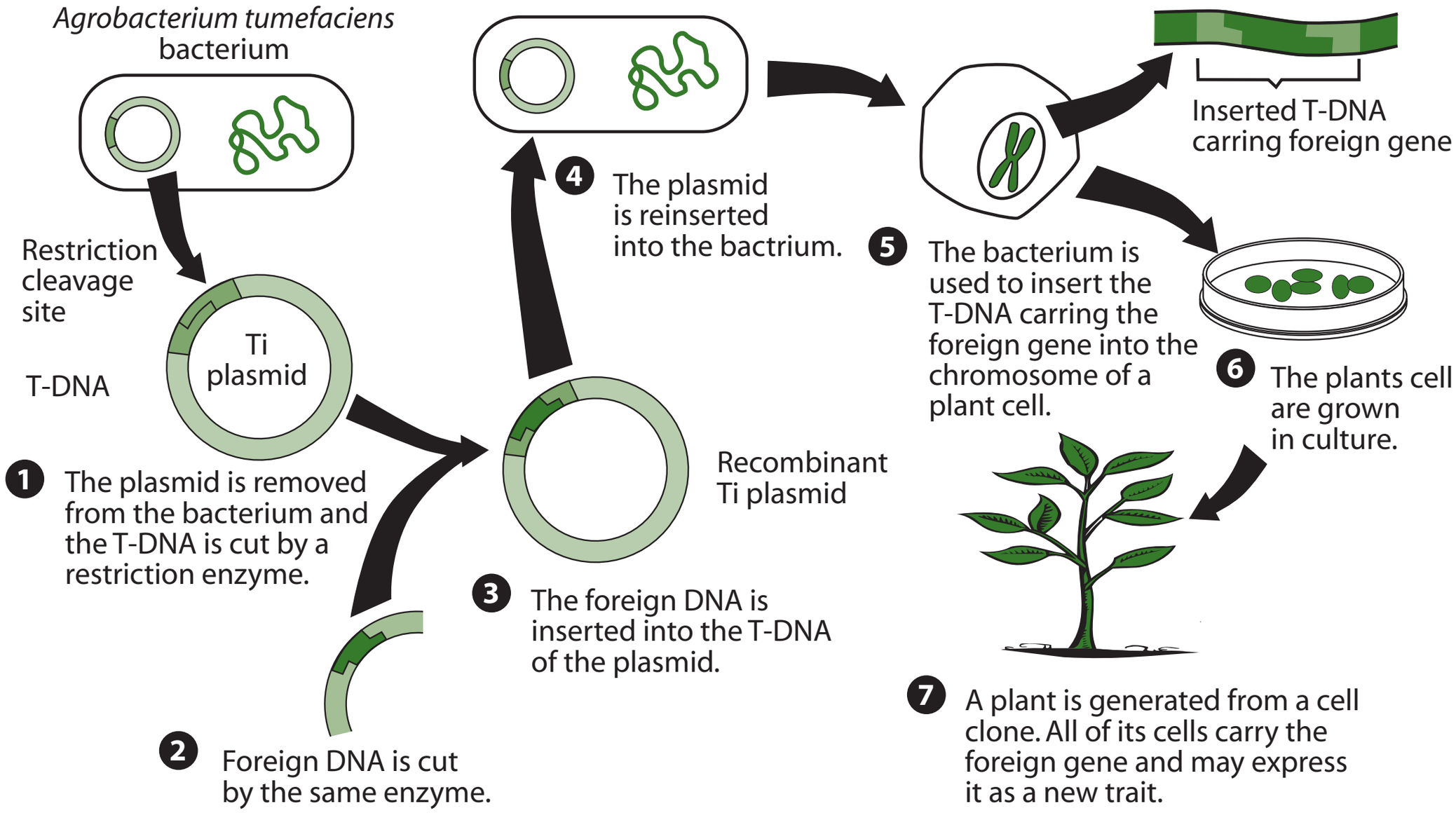
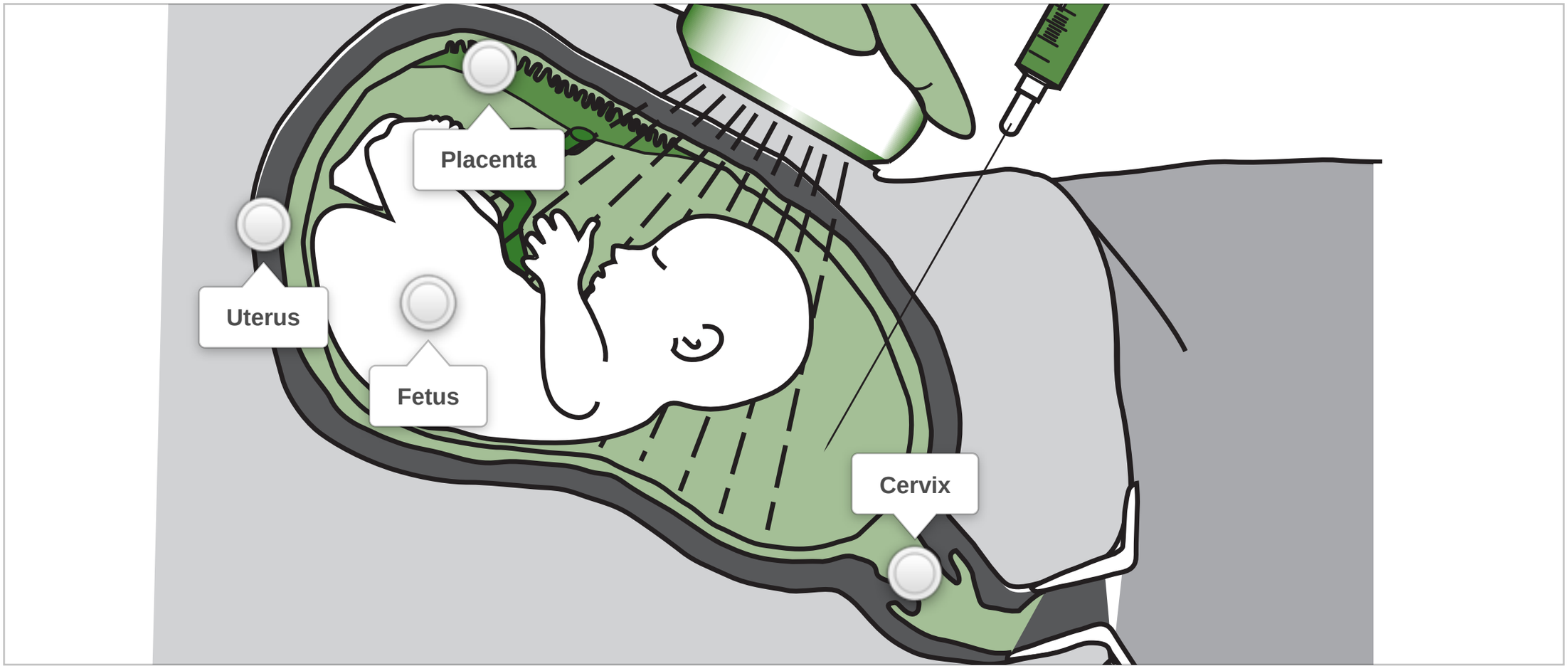


Figure 354 The use of plasmids to transfer genes



Labelling exercises

Review 3.1 Amniocentesis



Placenta | Fetus | Uterus | Cervix

Check Answer

Internet resources

Chapter 3.1

Under 3.1.7

From syllabus

- Application: Comparison of the number of genes in humans with other species.
- At least one plant and one bacterium should be included in the comparison and at least one species with more genes and one with fewer genes than a human.

COMMENTS

http://www.indiana.edu/~ensiweb/lessons/molb.ws.pdf

http://moodle.eosmith.org/pluginfile.php/3428/mod_resource/content/1/Cytochrome%20C%20answers.pdf

These are about a.a. sequences in the cytochrome c protein which is not what the guide says.

Is the Gene Bank they mention GenBank?

http://www.ncbi.nlm.nih.gov/genbank/

Chapter 3.3

A detailed animation video can be found on

http://highered.mcgraw-hill.com/olc/dl/120074/bio19.swf

or at

http://www.youtube.com/watch?v=kVMb4Js99tA

Fig 3.3.4

This is visualised in a funny square dance on

http://www.youtube.com/watch?v=eaf4j19_3Zg

Under 3.4.4

A good explanation of the Cystic Fibrosis disease can be found on

http://learn.genetics.utah.edu/content/tech/genetherapy/cysticfibrosis/

this is a big slab of studies that have been done, I put one in the book, these are not essential, could just put the URLs

http://www.pnas.org/content/98/21/11913.full

Temporal and spatial overlap between monarch larvae and corn pollen

Results presented here have two important implications. First, a portion of the monarch population is exposed to and probably consumes corn pollen that collects on milkweed plants growing in cornfields. Recent research suggests that the Bt corn hybrids most commonly planted produce levels of toxin in their pollen that are unlikely to have severe fitness consequences on monarchs (22–24), but our findings indicate the need to evaluate future transgenic hybrids on the basis of their protein toxicity and expression in pollen. Second, regardless of risks imposed by transgenic corn, changes in agricultural practices such as weed control or the use of foliar insecticides could have large impacts on monarchs by affecting milkweed density and condition, or monarch survival.

http://www.pnas.org/content/98/21/11919.full

Corn pollen deposition on milkweeds in and near cornfields

Table 2

Pollen density, cm^2	Inside a cornfield			From edge of cornfield	
		0 m	1 m	2 m	4–5 m
0–100	0.527	0.833	0.900	0.974	0.996
100–200	0.170	0.093	0.062	0.024	0.004
200–300	0.101	0.033	0.022	0.000	
300–400	0.072	0.017	0.006	0.002	
400–500	0.041	0.008	0.002		
500–600	0.041	0.007	0.002		
600–700	0.021	0.002	0.001		
700–800	0.009	0.002	0.000		
800–900	0.009	0.003	0.001		
1000–1100	0.000	0.001	0.001		
1100–1200	0.003		0.000		
1200–1300	0.001		0.001		
1300–1400	0.000				
1400–1500	0.000				
1500–1600	0.002				
Average	170.6	63.1	35.4	14.2	8.1
Sample size	1456	1265	1107	422	1056

Frequency distribution of pollen density levels on milkweed leaves inside a cornfield and at different distances from the cornfield edge (0 m) Based on data from sampling dates at 50–100% anthesis (days 6 and 11 for Ontario 2000 and days 6, 9, and 14 for Maryland 2000).

Determining the potential negative impact on the monarch population of Bt corn pollen at the densities we observed requires information on the threshold pollen density above which there are fitness or mortality consequences and the probability of larvae feeding on milkweeds growing in and near Bt corn fields. Companion papers provide information on toxicity (5, 6) and exposure probabilities (14), and a summary paper (7) combines this information with pollen density data to produce a full risk assessment.

http://www.pnas.org/content/98/21/11925.full

Monarch larvae sensitivity to *Bacillus thuringiensis*- purified proteins and pollen

Larvae in these tests were exposed for up to 5 days and, with the exception of event 176 pollen, significant adverse effects in terms of weight gain or mortality were not observed. Experiments are underway to determine whether subtle effects could occur when larvae are exposed to Bt pollen for longer periods. Corn hybrids that produce event 176 pollen represent a small percentage (<2%) of the total corn planted in the U.S. (20). Additionally, seed companies producing event 176 hybrids have chosen not to seek U.S. EPA re-registration for event 176 in 2001, and will phase out the marketing of event 176 hybrids. Pollen levels measured on milkweed leaves in cornfields during anthesis do not commonly exceed 1000 grains/cm2; average values range from 10 to 425 grains/cm2 (16). These results suggest that pollen from Cry1Ab (events Bt11 and Mon810), Cry1F, and experimental Cry9C hybrids will have no acute effects on monarch butterfly larvae in field settings.

http://www.pnas.org/content/98/21/11937.full

Impact of Bt corn pollen on monarch butterfly populations: A risk assessment

Monarch populations share their habitat with corn ecosystems to a degree previously undocumented (4). Despite this conclusion, the portion of the monarch population that is potentially exposed to toxic levels of Bt corn pollen is negligible and declining as planting of event 176 hybrids is phased out through 2003. The exposure portion (Pc) of the risk (R) equation described above is low, and the toxicity portion (Pt) of this equation for the dominant corn hybrids is negligible, therefore the impact of Bt corn on monarch populations should remain low.

Analysing the information and data provide the following information :

- Larvae will eat some pollen but this contains low level Bt toxin
- Almost no Bt corn pollen is found more than 5 m from a field of Bt corn

- One field showd a reduced survival of monarch larvae near a Bt corn field compared to a non-Bt corn field but this result was not found in a similar experiment in another state.
- The use of pesticides for non-Bt corn would do more harm than the pollen of the Bt corn.
- Hybrid plants from event 176 are the most likely to cause harm to monarch larvae although this is still unlikely.
- Seeds from event 176 are phased out.

So the overall conclusion could be that the potential harm done by pollen of Bt corn on the larvae of Monarch butterflies is very small.

Answers to exercises

Multiple Choice Questions

1B, 2B, 3D, 4D, 5B, 6A, 7C, 8B, 9D, 10D, 11C, 12B.

Short Answer Questions

13 Refer to Figure 330

The results of the self-fertilisation of the F1 will be :

genotypes : 25% TT, 50% Tt, 25% tt

phenotypes : 75% tall, 25% short

14 Use: w+ = wild type, w = black

A x B gives only wild type colour so at least one parent must be w +w+

A x C gives some black (ww) so both A and C must have a w allele and be w+w

B x C gives only wild type colour so at least one parent must be w+w+

Therefore; A is w+w, B is w+w+, C is w+w

15 If a mouse has two c alleles, it will not be able to produce pigment, so it will be albino. It will still have the alleles for wild type colour or black colour but they will not be seen because the mouse will be albino.

If a mouse is wild-type colour or black colour, it has at least one allele for making pigment (C).

phenotypes possible	genotypes
albino	ccAA or ccAa or ccaa
wild type	CCAA or CCAa or CcAA or CcAa
black	CCaa or Ccaa

(a)

Punnett square	ccAA (albino)	genotype parent	
cA	gametes		
CCaa (black)	Ca	CcAa wild type	genotype offspring phenotype offspring
genotype parent	gametes		

(b)

Punnett square		CcAa				genotype parent
		CA	Ca	cA	ca	gametes
CcAa	CA	CCAA wild type	CCAa wild type	CcAA wild type	CcAa wild type	genotype offspring phenotype offspring
	Ca	CCAa wild type	CCaa black	CcAa wild type	Ccaa black	genotype offspring phenotype offspring
	cA	CcAA wild type	CcAa wild type	ccAA albino	ccAa albino	genotype offspring phenotype offspring
	ca	CcAa wild type	Ccaa black	ccAa albino	ccaa albino	genotype offspring phenotype offspring
genotype parent	gametes					

The ratio of the phenotypes of the offspring will be: Wild type: 9, black: 3, albino: 4

16 (a) Exp A : Yellow is dominant over white

Exp B : Short is dominant over long

(b)

phenotypes possible	genotypes
yellow	YY or Yy
white	yy
short	SS or Ss

(c) since the F1 contains some long plants with white flowers, their genotype is yyss. The genotype of the parent plant with white flowers and long stems is also yyss.

So the yellow flowered short stemmed parent must be heterozygous YySs.

Punnett square		yyss	genotype parent
		ys	gametes
YySs	YS	YySs yellow short	genotype offspring phenotype offspring
	Ys	Yyss yellow long	genotype offspring phenotype offspring
	yS	yySs white short	genotype offspring phenotype offspring
	ys	yyss white long	genotype offspring phenotype offspring
genotype parent	gametes		

There is 25% chance of each of the types of offspring. The results found match this ratio.

17 (a) Refer to Figure 333

Baby has phenotype B so can have genotype I^BI^B or I^Bi.

(b) Mother is type A so can be genotype I^AI^A or I^Ai.

Father's father is type A so can be genotype I^AI^A or I^Ai.

Father's mother is type B so can have genotype I^BI^B or I^Bi.

Baby does not have an allele I^A so he must have received allele I from his mother.

Baby is type B so he must be I^Bi, as he has received I from his mother.

In order to be I^Bi, he must have received I^B from his father who must have been I^Bi, having received I from his father (the paternal grandfather of the baby who was type A) and I^B from his mother (the paternal grandmother who was type B).

Paternal grandfather must have been I^Ai.

Paternal grandmother was either I^BI^B or I^Bi.

18

Possible phenotypes	Genotypes
red polled	C^R C^R PP or C^R C^R Pp
red horned	C^R C^R pp
roan polled	C^R C^W PP or C^R C^W Pp
roan horned	C^R C^W pp
white polled	C^W C^W PP or C^W C^W Pp
white horned	C^W C^W pp

(a)

P : red polled x white horned phenotypes parents

C^R C^R PP x C^W C^W pp genotypes parents

C^R P x C^W p gametes

F1 C^R C^W Pp genotype F1

roan polled phenotype F1

(b) A Punnett square to help work out the F2 generation

Punnett square	CR CW Pp					genotype
		CR P	CR p	CW P	CW p	gametes
CR CW Pp	CR P	CR CR PP red polled	CR CR Pp red polled	CR CW PP roan	CR CW Pp roan polled	genotype F2 phenotype F2
	CR p	CR CR Pp red polled	CR CR pp red horned	CR CW Pp roan polled	CR CW pp roan horned	genotype F2 phenotype F2
	CW P	CR CW PP Roan polled	CR CW Pp roan polled	CW CW PP white polled	CW CW Pp white polled	genotype F2 phenotype F2
	CW p	CR CW Pp roan polled	CR CW pp roan horned	CW CW Pp white polled	CW CW pp white horned	genotype F 2 phenotype F 2
genotype F1	gametes					

F2 : red polled + red horned + roan polled + roan horned + white polled + white horned

3 1 6 2 3 1

19.

Phenotypes possible	Genotypes
male normal	X^HY
male haemophiliac	X^hY
female normal	X^HX^H
female carrier	X^HX^h
female haemophiliac (very rare)	X^hX^h

(a) Mother must be carrier X^HX^h. Father is normal X^HY. Since Mohammed is male, he cannot be a carrier so he has no chance of passing on the haemophilia allele to his children. He could have children with haemophilia if his wife is a carrier.

(b) Latifa inherits a normal allele from her father X^H. She has 50% chance of inheriting a normal allele from her mother X^H but also 50% chance of inheriting the haemophila allele from her mother X^h. So she has a 50% chance of being a carrier. If she is a carrier, she will pass her haemophilia allele on to 50% of her children. That means that each of her sons will have a 50% of being a haemophiliac and each of her daughters will have a 50% chance of being a carrier. So if Latifa is a carrier, 25% of her children are likely to be haemophiliacs.

The above is based on the assumption that Latifa's husband is not a haemophiliac.

20 Similarities

• in both divisions, chromosomes move to the equator

• meiosis II is similar to mitosis

• both involve spindle formation

• in both chromosomes/homologous pairs move to the poles

• both increase the number of cells

	Mitosis	Meiosis
purpose	growth, repair	production of gametes
number of divisions	one	two
number of cells produced	two	four
possible in	haploid/diploid nuclei	diploid (or more) nuclei
nuclei produced	as parent	haploid (reduction division)
chromosome movement	chromosomes line up at the equator	meiosis I : homologous pairs line up at the equator
crossing over	no	possible
chiasmata	no	possible

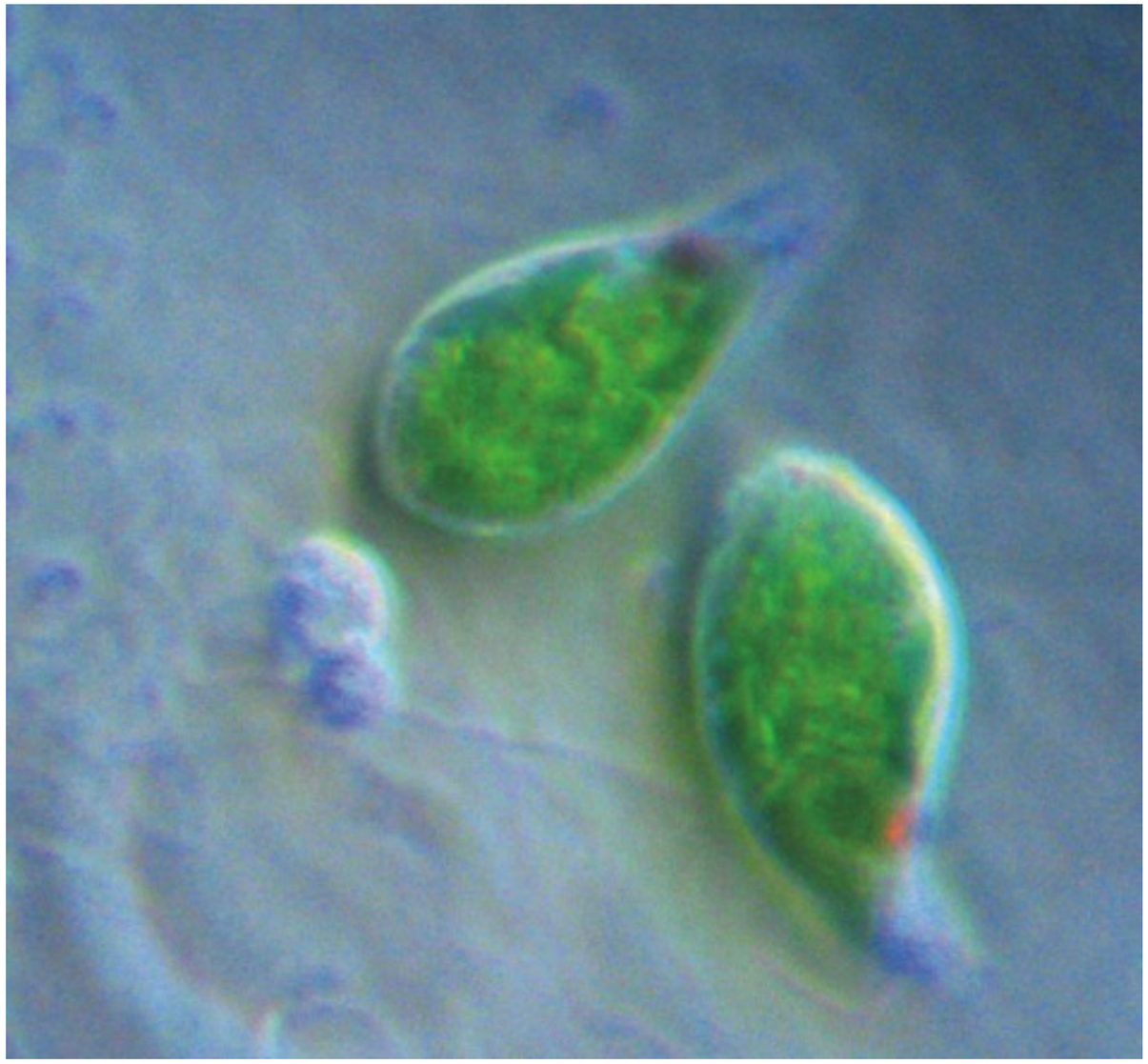
Chapter 4

Ecology

Section 1

Ecology

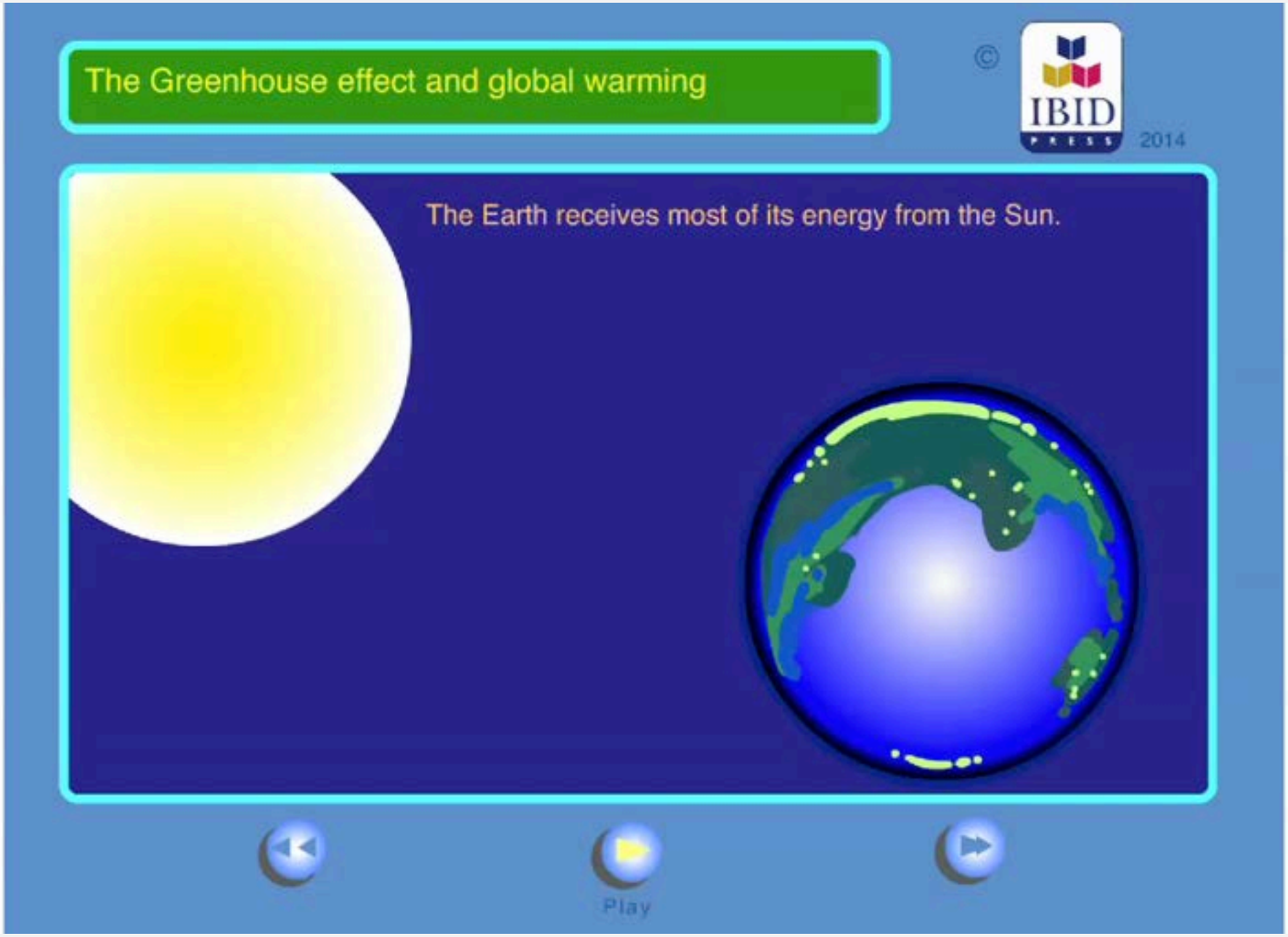
CONTENTS



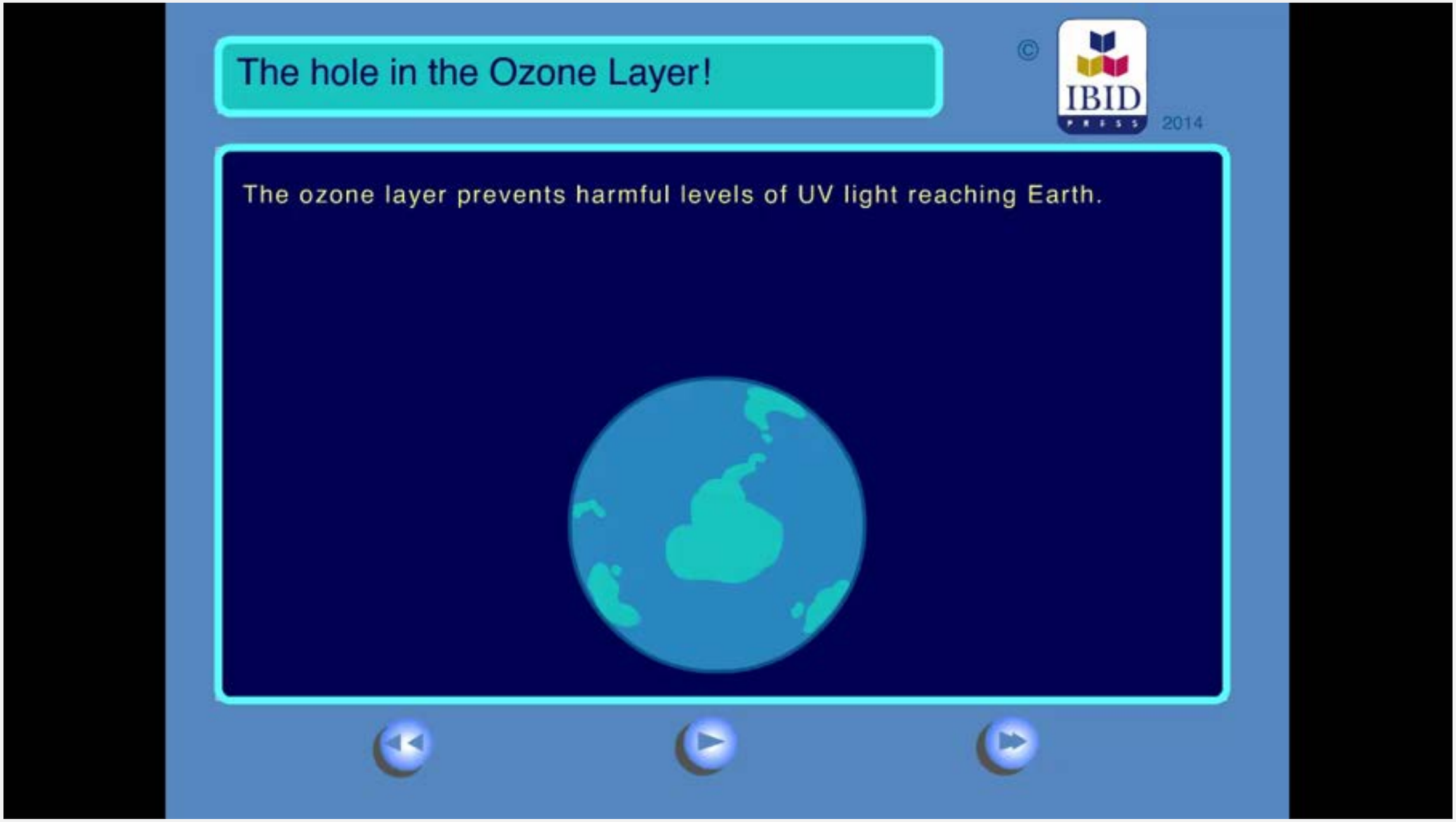
These are unicelluar algae, what are the advantages and disadvantages of unicellularity?

Additional material

Movie 4.1 The Greenhouse Effect



Movie 4.2 Ozone Hole



Movie 4.3 Iguazu Falls

Iguazu Falls in South America is part of a rain forest ecosystem and rich in biodiversity.

Gallery 4.1 Images of Unspoilt Environments

Yosemite National Park, California, USA. One of Abraham Lincoln's lesser known legacies. Others such as John Muir were instrumental in its protection. Consider why National Parks such as this are important.

Enlarged diagrams

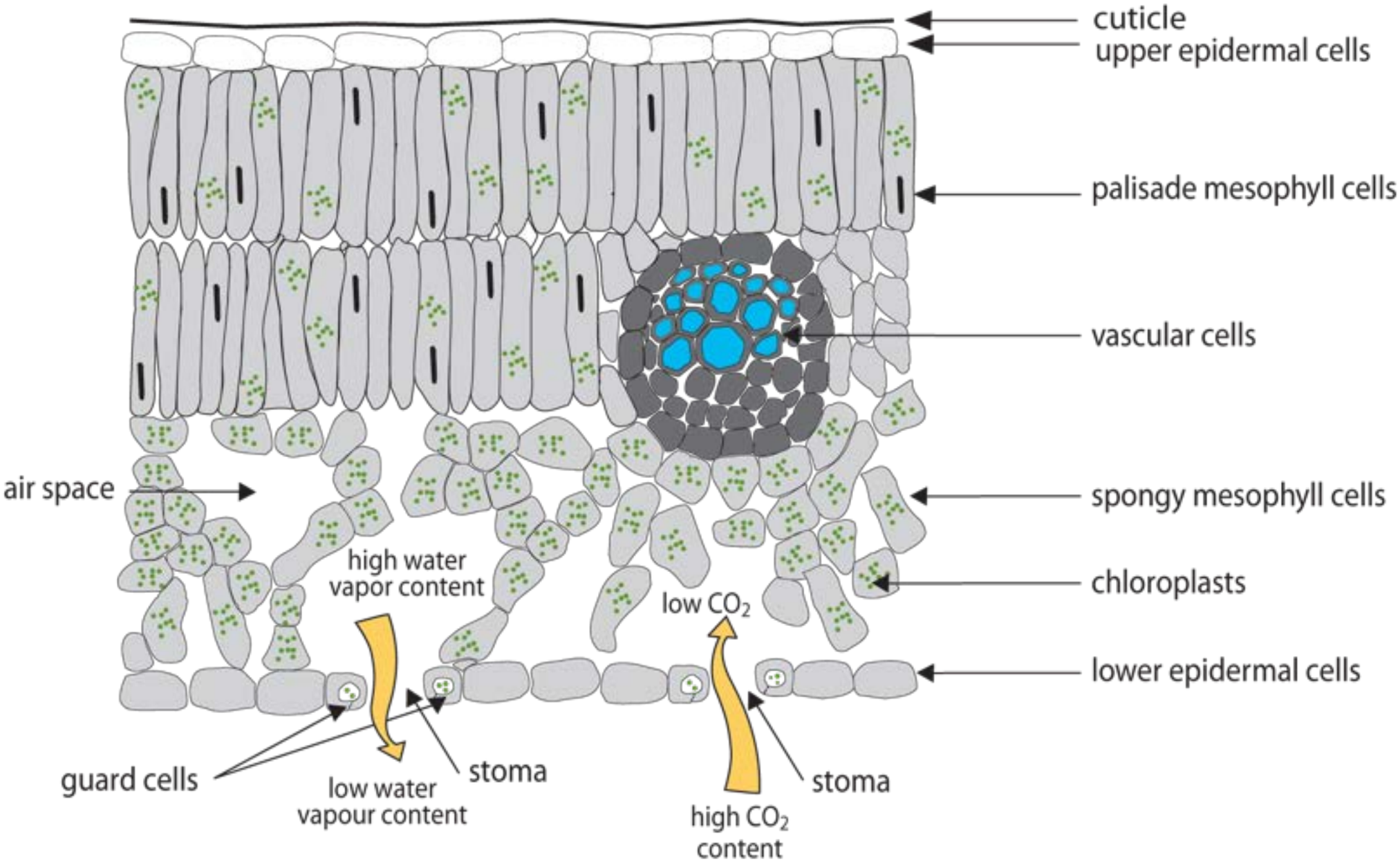


Figure 414 Leaf structure

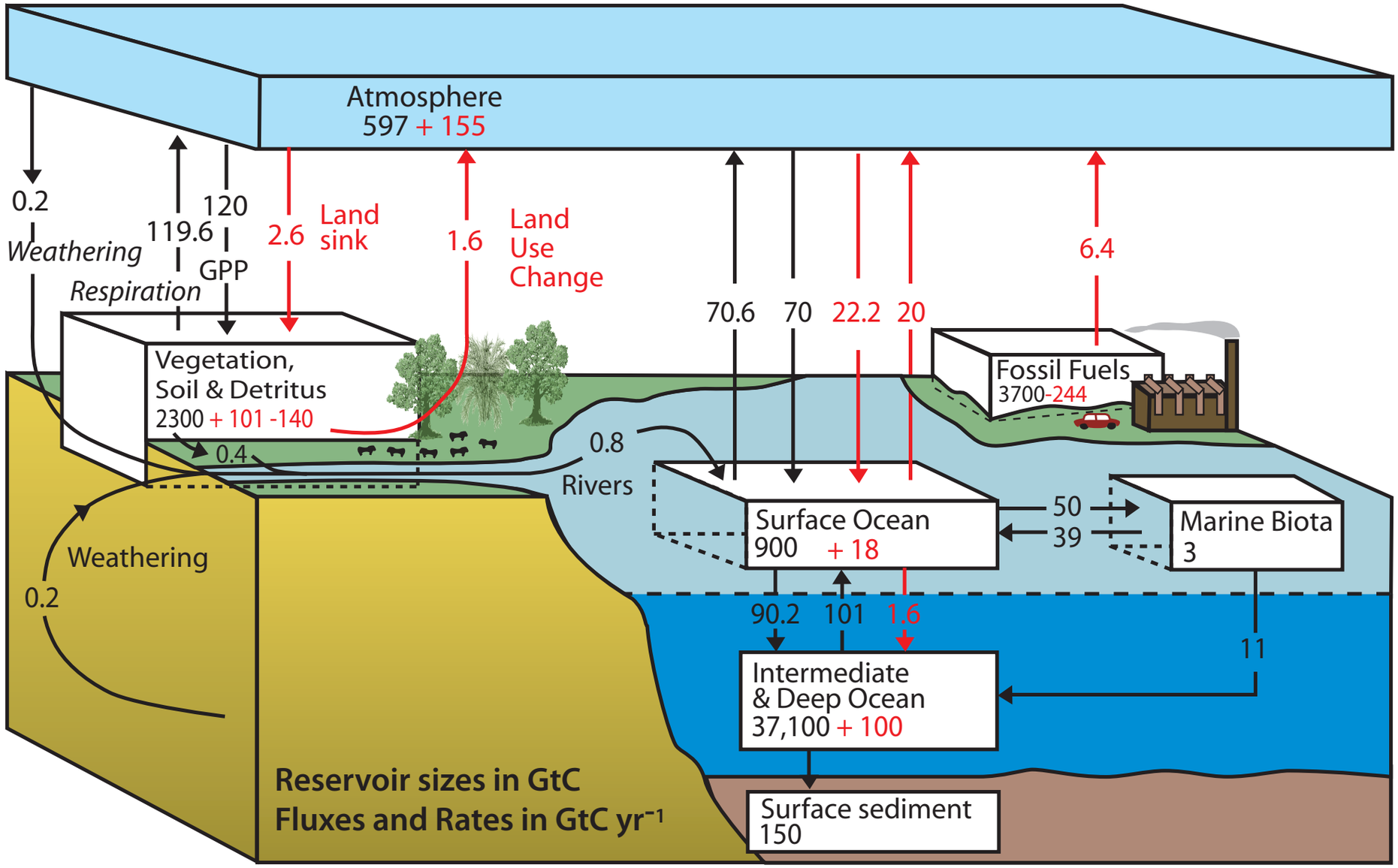
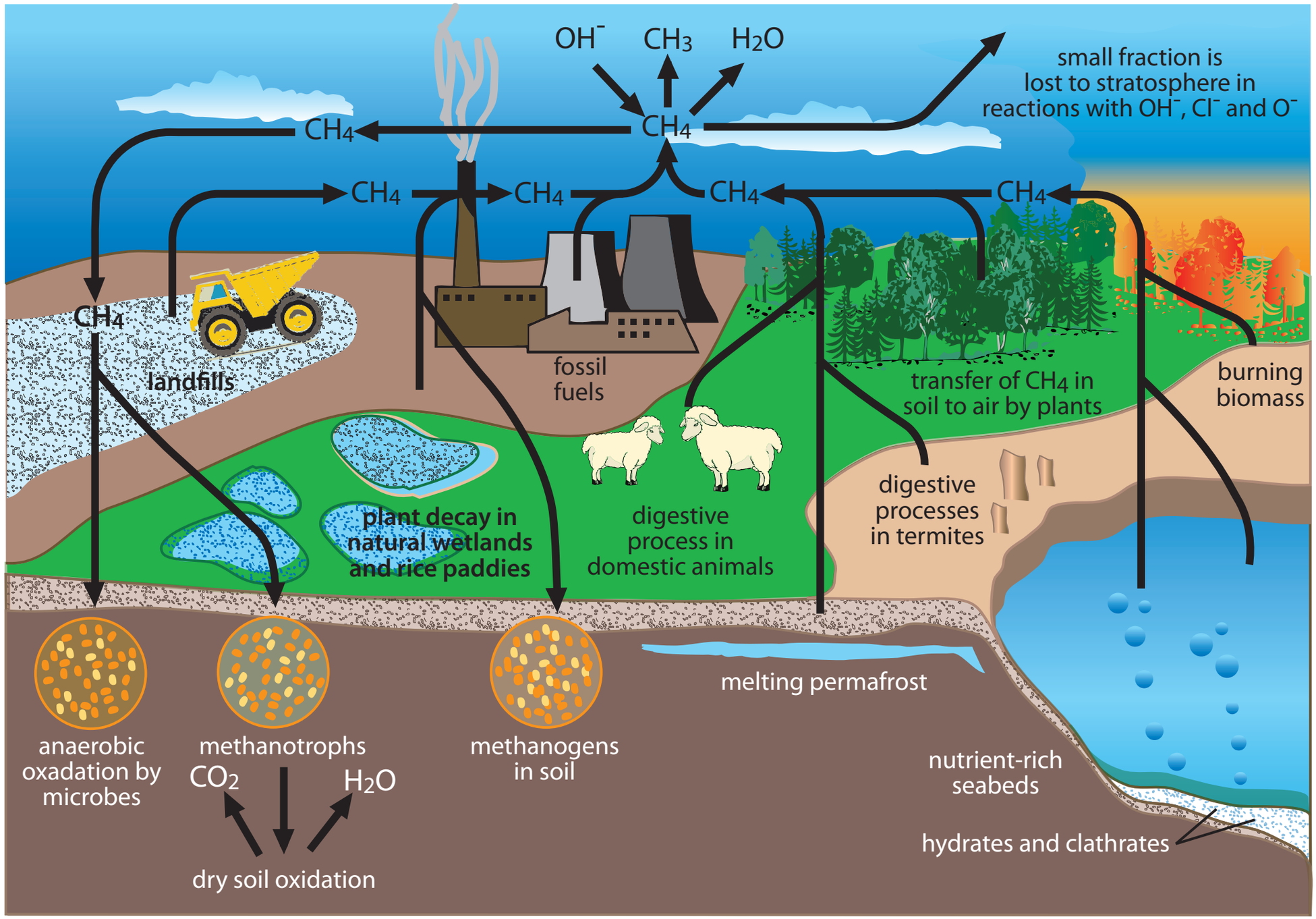


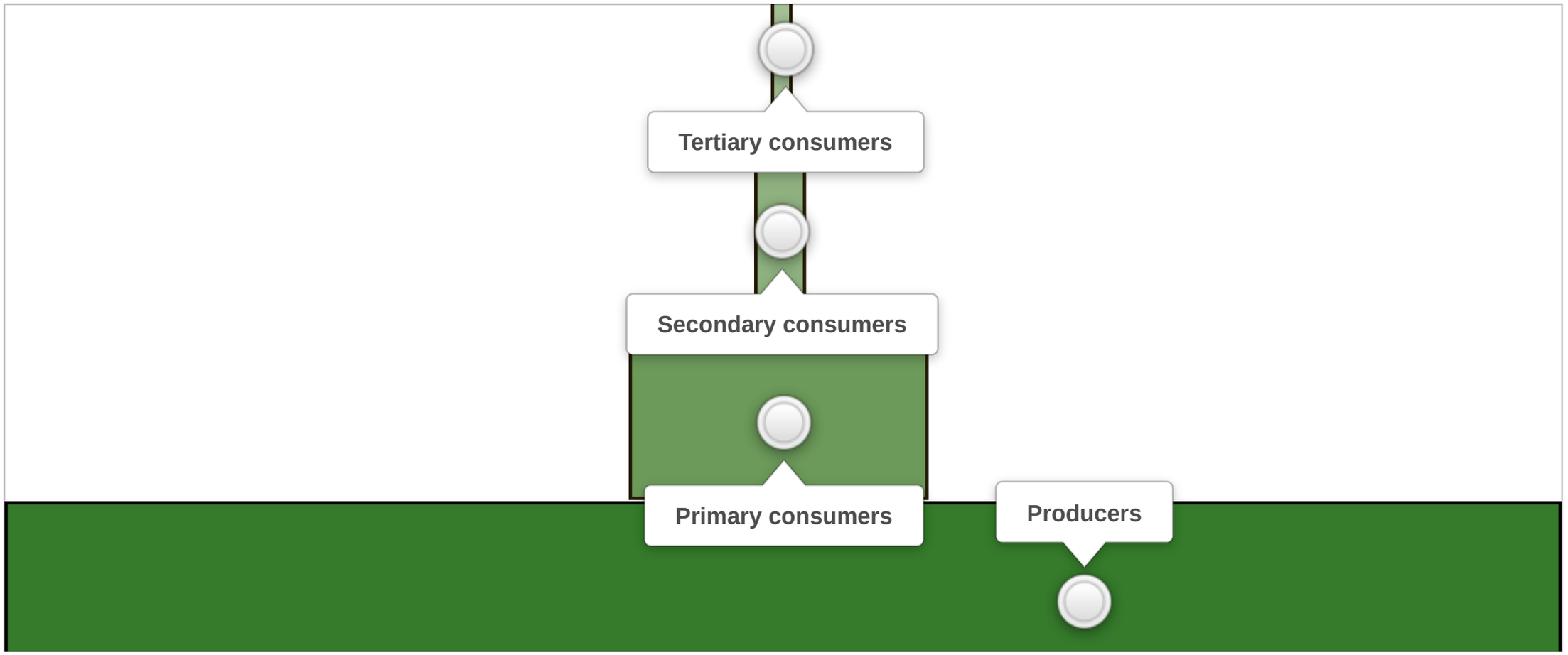
Figure 416 Carbon fluxes

Figure 420 The methane cycle



Labelling exercises

Review 4.1 An energy pyramid



Producers | Primary consumers | Secondary consumers | Tertiary consumers

Check Answer

Internet resources

Chapter 4.1

Chi squared test

An explanation can also be found on

http://www.youtube.com/watch?v=WXPBoFDqNVk

http://www.docstoc.com/docs/84881059/Ecology_-Energy-Flow-and-Nutrient-Cycles

The effect on specific areas could be rather different. Already 10 years ago, NASA suggested that global warming, resulting in the melting of polar ice caps could possibly change currents in the oceans which would actually make Europe and North America colder than it has been.

http://science1.nasa.gov/science-news/science-at-nasa/2004/05mar_arctic/

http://ozclimatesense.com/the-greenhouse-gases-global-warming/

Evaluating claims that human activities are not causing climate change.

There are many ways to look at data. The illustration below shows two sides of the argument about global warming and the role of carbon dioxide. Both sides have arguments which seem to make sense and it is not always easy to decide which of these ways of looking at the available information is correct.

http://www.informationisbeautiful.net/visualizations/climate-change-deniers-vs-the-consensus/

http://en.wikipedia.org/wiki/File:Climate_science_opinion2.png

There are individual scientist who do not agree with all aspects of the idea that global warming is occuring and that human action is a major contributor to the fact. They are listed at

http://en.wikipedia.org/wiki/List_of_scientists_opposing_the_mainstream_scientific_assessment_of_global_warming

http://www.hk-phy.org/energy/power/source_phy/flash/formation_e.html

Animation about coal formation.

http://www.hk-phy.org/energy/power/source_phy/flash/formation_e.html

animation about formation of oil and gas

Answers to exercises

Multiple Choice Questions

1D, 2C, 3C, 4D, 5B, 6C, 7B, 8B, 9A, 10D, 11C, 12B, 13B, 14B, 15A.

Short Answer Questions

16 Refer to Figure 411.

Processes include:

- photosynthesis: carbon dioxide absorbed from air into plants
- food chain : producers/autotrophs → primary consumers/ heterotrophs/ herbivores → secondary consumers/carnivores
- detritivores and/or saprotrophs digest dead plants/animals
- (cellular) respiration : carbon dioxide from plants and animals and decomposers released into air
- Combustion of fossil fuels, eg, coal and natural gas releases carbon dioxide
- volcanoes/forest fires release carbon dioxide
- carbon is found as carbon dioxide in air and dissolved in water
- carbon is found in organisms (carbohydrates, proteins, lipids, nucleic acids, etc)

17 For this experiment, the null hypothesis would be:

H0: "there is no preference for a specific kind of food among these finches".

The alternative hypothesis would be : H1: "there is a preference for a specific kind of food among these finches".

If there was no food preference, the finches would sample all foods the same number of times. As the total number of times food was sampled is 100 (45+38+10+5+2), our expected value for each food would be 20. (total/types of food, so 100/5). In order to find chi-squared, we need to calculate the square of the difference between the observed and expected values.

type of food	expected values (E)	observed values (O)	O - E	$(O - E)^2$	$(O-E)^2/E$
sunflower seeds	20	45	25	625	31.3
millet seeds	20	38	18	324	16.2
mealworms	20	10	-10	100	5
broccoli	20	5	-15	225	11.3
peach	20	2	-18	324	16.2
total					79.9

So chi-squared is 79.9 for this experiment. Since we have 5 categories (types of food), there are 5-1 = 4 degrees of freedom.

For $p < 0.05$, the critical value for chi squared at 4 degrees of freedom is 9.48. The calculated value for chi squared (79.9) exceeds the critical value so we reject the null hypothesis.

Conclusion: we reject the null hypothesis and conclude that there is a food preference among this group of finches, given these kinds of food.

Chapter 5

Evolution and Biodiversity

Section 1

Evolution and Biodiversity

CONTENTS

These gulls are an example of a 'ring species', what does this mean and how does it come about?

Additional material

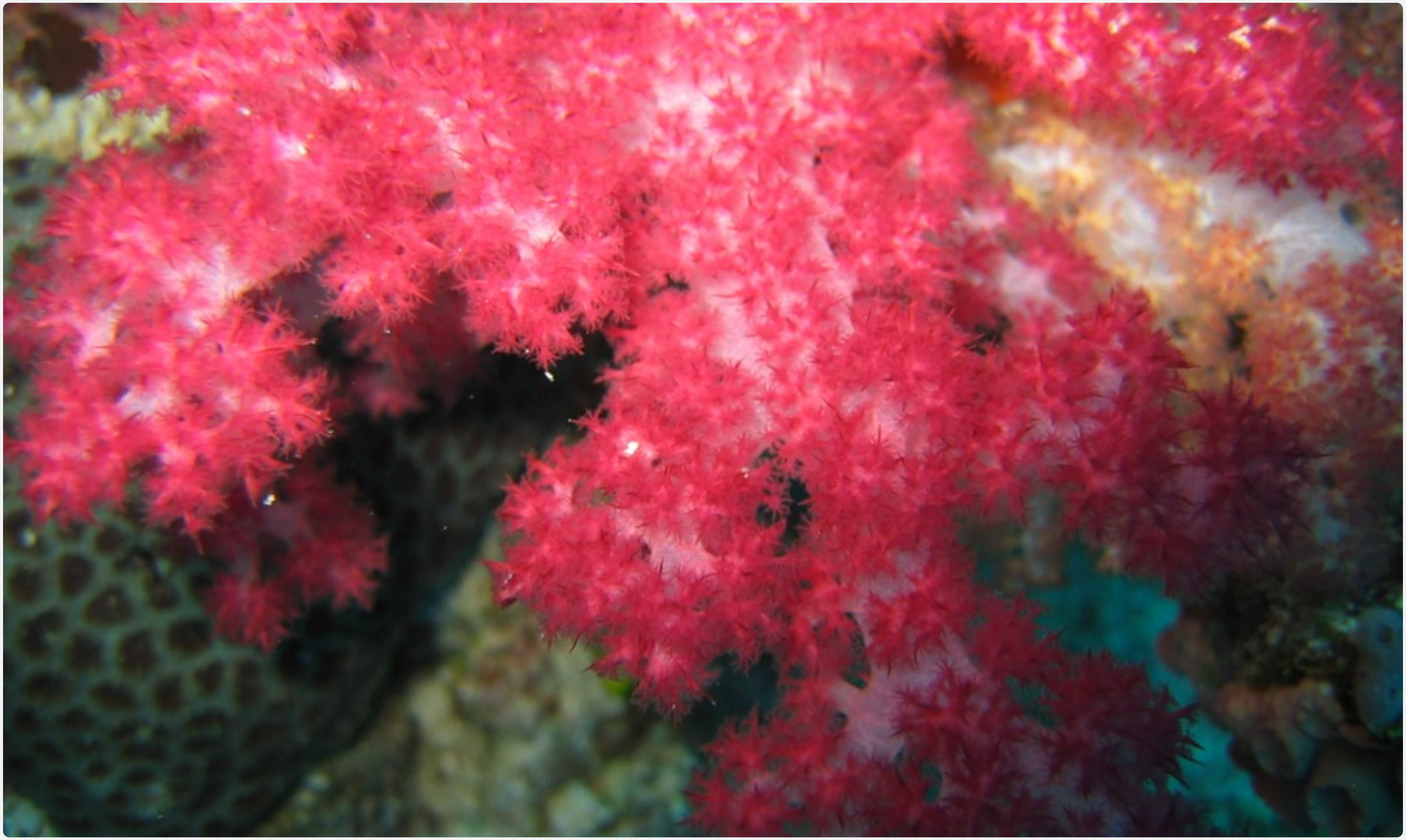
Gallery 5.1 Images of Evolution - The air

Red-footed booby (Galapagos Islands) - there is a blue-footed species too. Suggest how this divergence came about.

Gallery 5.2 Images of Evolution - The land

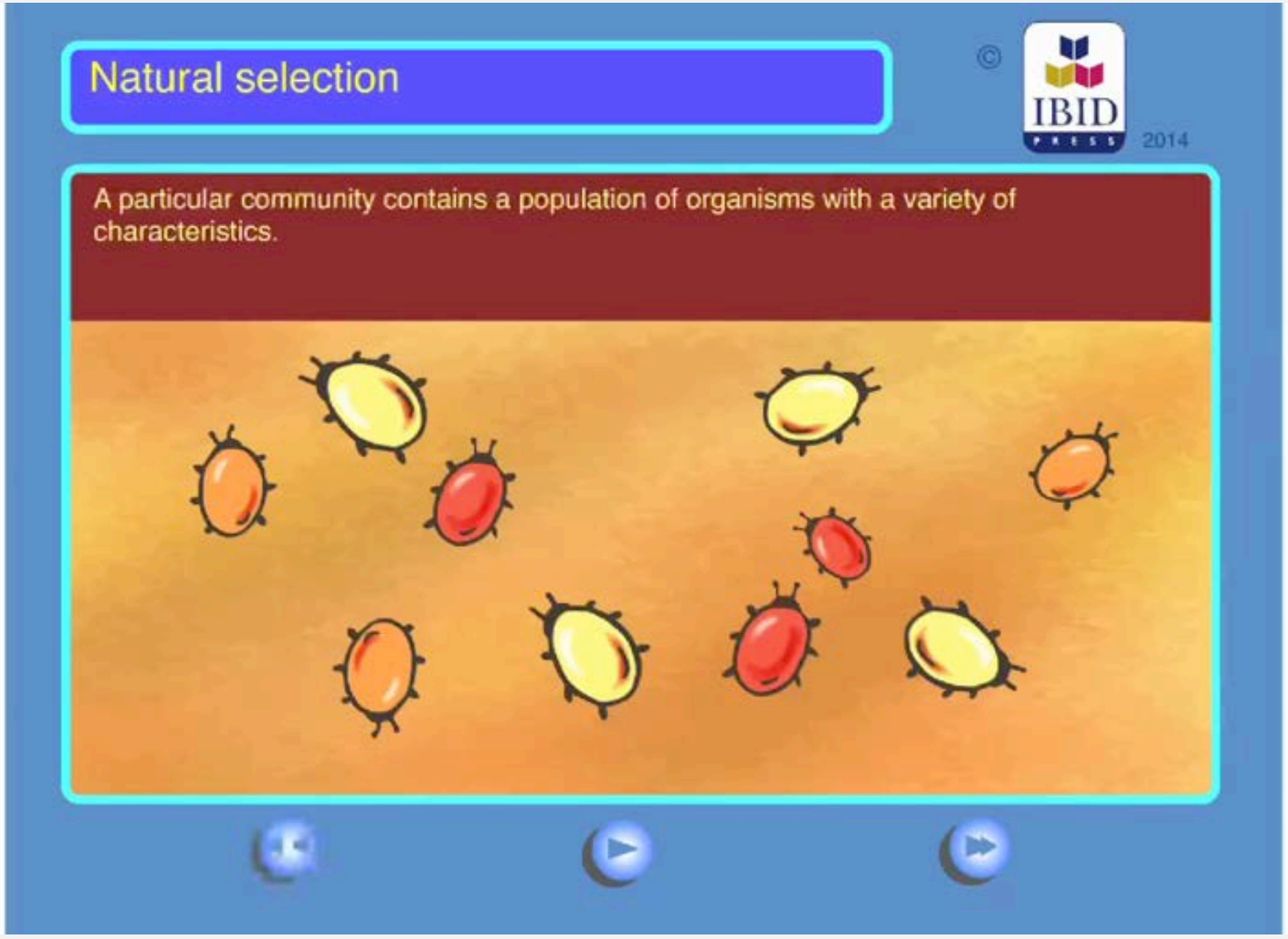
Marine Iguana (Galapagos Islands) - one of Darwin's curiosities. Suggest a reason for this colouration and behavioral adaptation.

Gallery 5.3 Images of Evolution - The Sea



Soft Coral - Papua New Guinea. Is this an animal or a plant, why?

Movie 5.1 Natural Selection



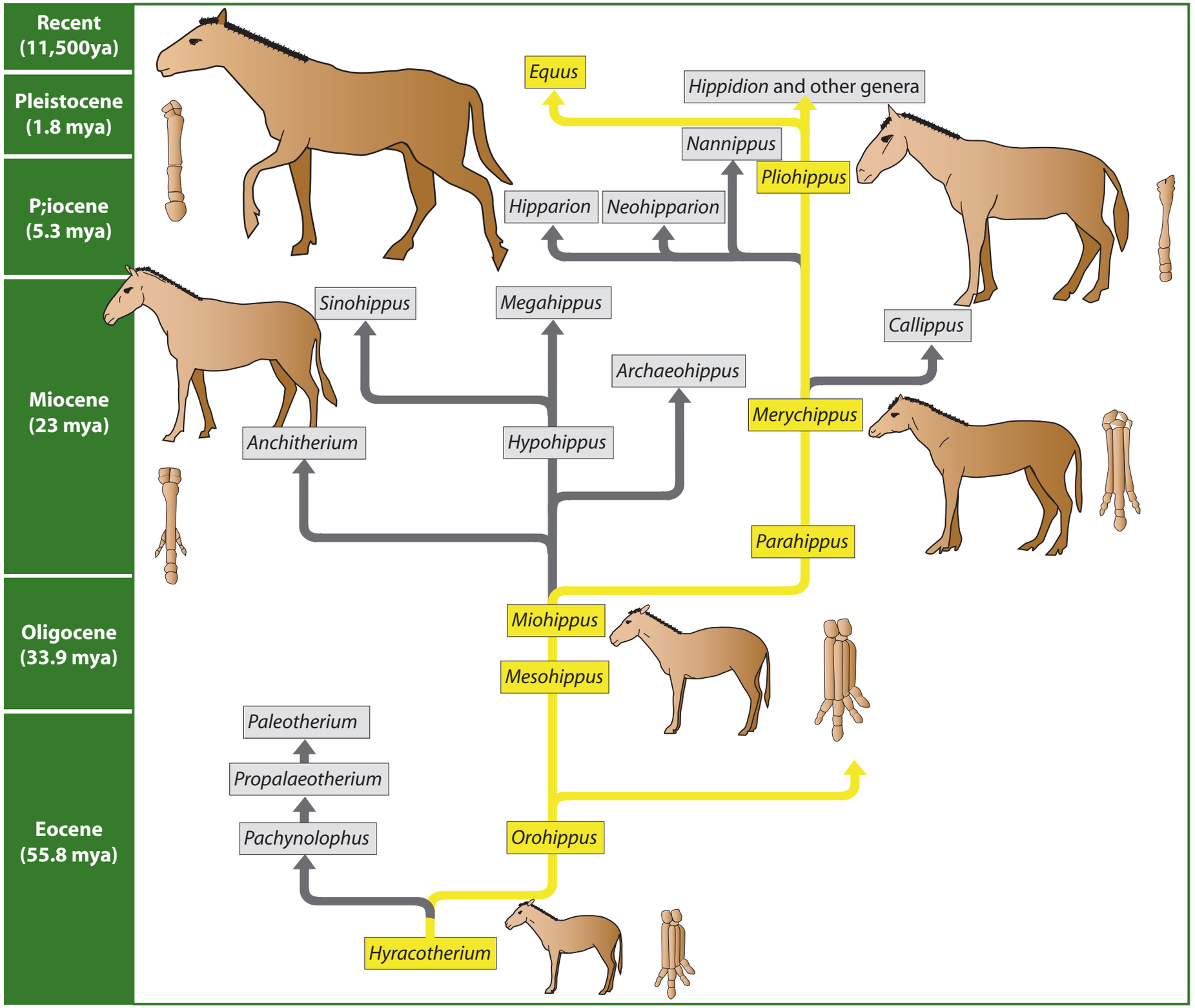
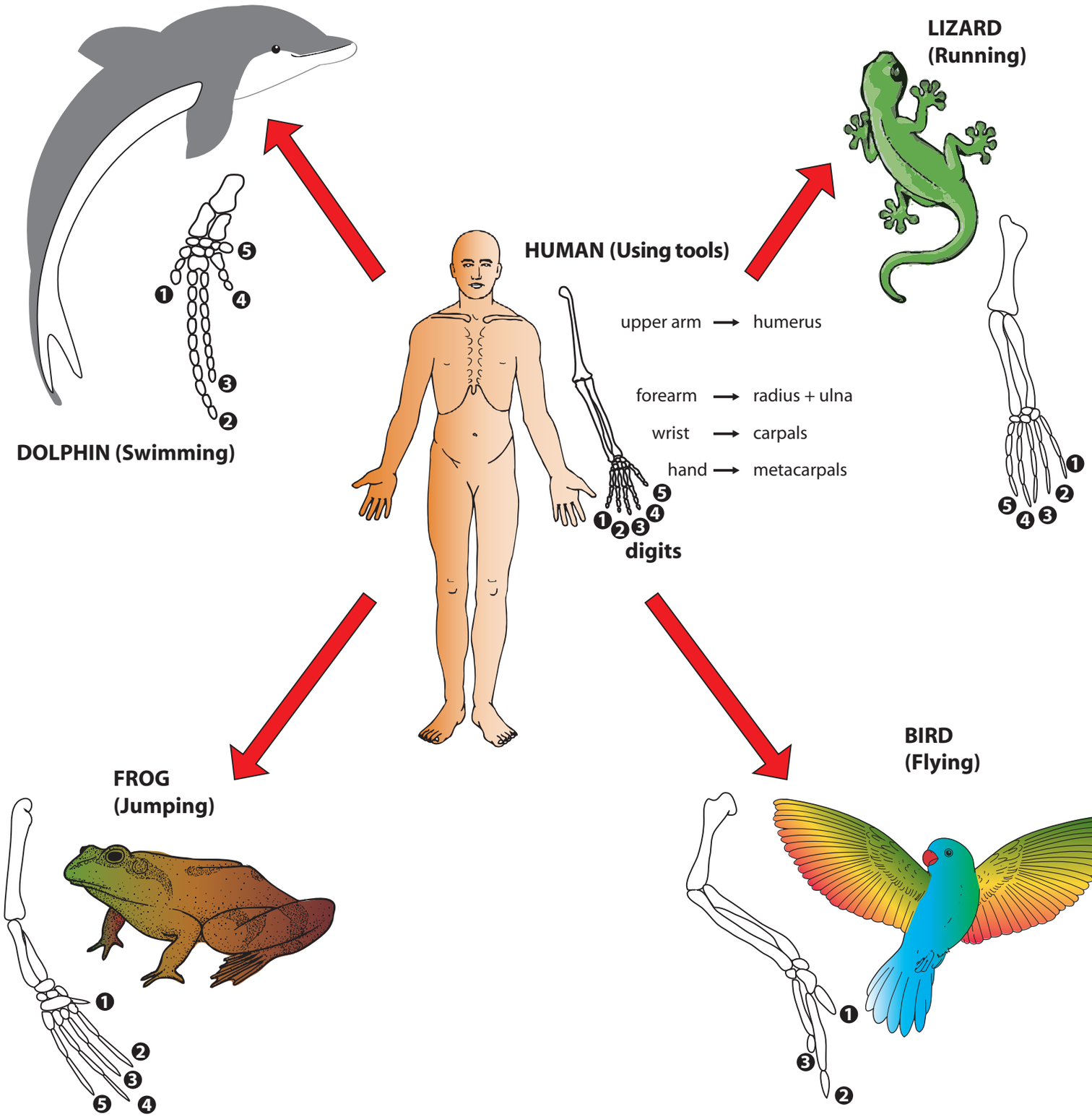


Figure 501 The evolution of the horse

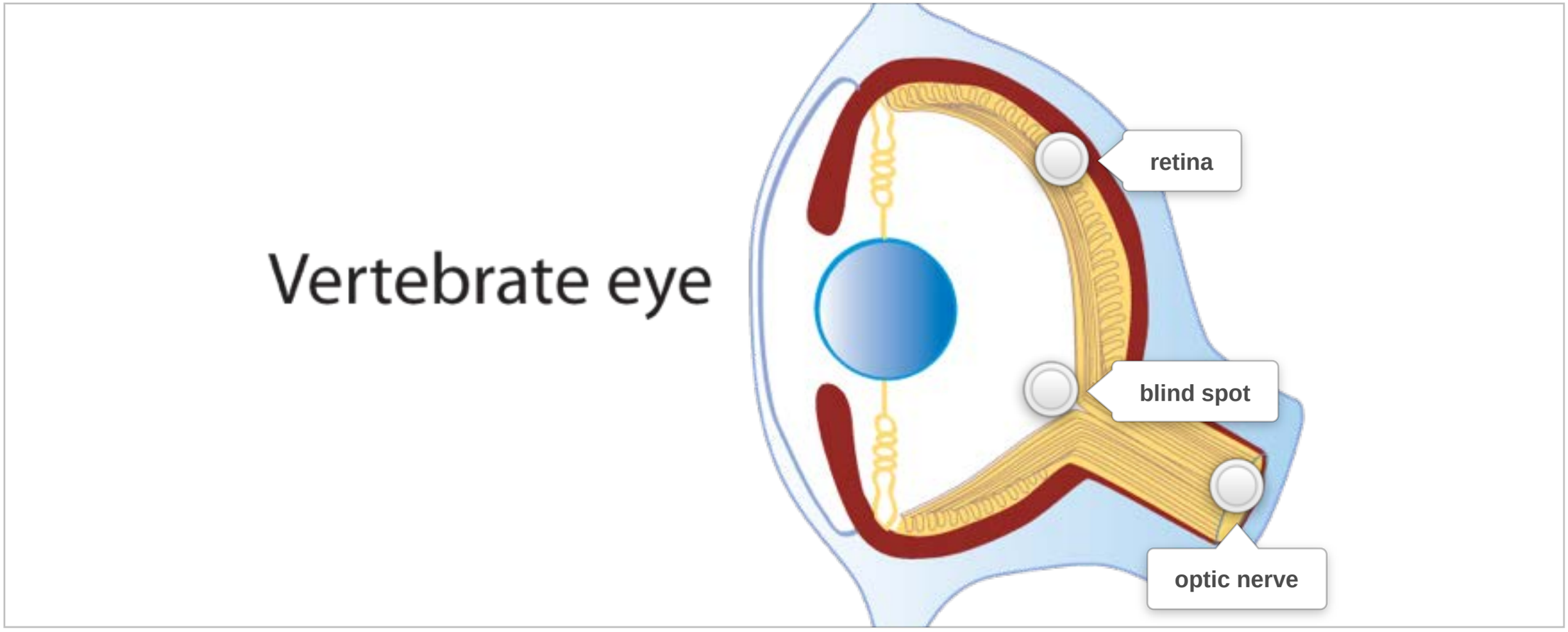
Figure 505 Comparison of forelimbs



Labelling exercises

Review 5.1 Eyes

Question 1 of 2



retina | blind spot | optic nerve

Check Answer

Internet resources

Additional e-resources

Chapter 5.1

It has been questioned whether breeding pedigree dogs has gone too far. A very disturbing BBC documentary about pedigree dogs was aired in 2008 and caused an outcry among dog lovers. The video is available on Youtube but please be warned that it contains some shocking material.

Recently discovered animals http://listverse.com/2012/12/12/10-incredible-recently-discovered-animals/

Plus our own Natural Selection animation as per previous list

Chapter 5.2

On http://www.visitzealandia.com/wp-content/uploads/2012/03/edu-adaptation-design.pdf

you find an exercise where you design animals adapted to specific environments.

A video about the Darwin and the Galapagos islands. From 9 min 30 seconds, it focusses on evolution in action among the finches at Daphne Major.

http://www.youtube.com/watch?v=n3265bno2X0

Answers to exercises

Multiple Choice Questions

1B, 2D, 3C, 4B, 5A, 6D, 7A,

Short Answer Questions

8 There are many possibilities here but one example is given below:

1. a. insect has wings . . go to 2

b. insect does not have wings . go to 6

2. a. wings are shorter than body . go to 3.

b. wings are as long as body . go to 4

3. a. body is gray . . . E

b. body is striped . . . F

4. a. antennae are short . . G

b. antennae are long . . go to 5

5. a. antennae are feathered . . H

b. antennae are not feathered . I

6. a. insect has tails . . . go to 7

b. insect does not have tails . go to 8

7. a. insect has two tails . . A

b. insect has three tails . . B

8. a. insect has antennae . . C

b. insect does not have antennae . D

9. Sexual reproduction increases variation because the genetic material of each individual comes from a sperm and an egg cell. Mendels first law (law of segregation) says that each trait has two alleles but they are separated during the formation of gametes so that a gamete has only one allele for each gene. Mendel's second law (law of independent assortment) says that the combination of alleles from different genes is random and that therefore the gametes of one organism are not all the same.

As a result, the combination of male and female gametes (which is sexual reproduction) will lead to a number of different individuals. This is obvious because it is clear that siblings from one set of parents are not identical to each other. In addition, it is possible that during Prophase I of Meiosis, an exchange of genetic material between non-sister chromatids occurs. This is called crossing over or recombination and will lead to more new combinations of genes, causing further variation.

10 The Peppered Moth rests on tree trunks covered in off-white lichens. The moth is the same colour and will spread its wings to blend in with their background. Occasionally a black moth appears in the population by mutation and is quickly seen and eaten by birds.

As a result of the Industrial Revolution, trees were covered in soot. Lichens died and the tree trunks became black. The white moths now were eaten more often and the few black ones had the advantage. In only a few years, the black moths were more common than the white ones.

11 (a) Homo sapiens. Notice that the name should be in italics or underlined (at least when writing by hand). The first letter of the genus name is capitalised, everything else in small print.

(b) Kingdom, phylum, class, order, family, genus, species.

12 Similarities : both are:

- autotrophs/producers
- have chlorophyll for photosyntesis
- have true roots, stems, leaves
- produce seeds

Differences:

Coniferophyta	*Angiosperma*
have needles	have leaves
no flowers	flowers (although small in wind pollinated plants)
seeds in cones	seeds in ovaries which become fruits

13. (a) all except Porifera

(b) all except Pporifera

(c). Platyhelminthes, Annelida, Mollusca and Arthropoda.

(d) Porifera, Cnidaria

14

Homologous structures	**Analogous structures**
result of a common ancestor	result of convergent evolution
same basic structure	different basic structure
different functions	same function
Examples	
bird's wing and dog's paw	bird's wing and insect's wing

15

- more offspring are produced than the environment can support
- so there is competition between members of the same species
- there are genetic differences between the members of the group
- which result in variation between them
- some individual are better adapted to the environment than others
- the better adapted individuals are more likely to survive
- the better adapted individuals are more likely to reproduce more offspring or better able to look after them so more offspring survive
- the genes which make them better adapted are passed on to the offspring
- so over generations, more and more individuals have these genes which changes the population as a whole
- this results in evolution by natural selection

16 According to the graph, 5000 years old would have 54% 14C and 20 000 years old would have 8% 14C compared to material that died very recently.

17 (a) The ancestor of the skunk and the otter lived more recently than that of the wolf and the leopard.

(b) Because their common ancestor lived more recently and cladograms shows the differences between the groups

Chapter 6

Human Physiology

Section 1

Human Physiology

CONTENTS

The *anopheles* mosquito is a human parasite, what disease(s) does it spread?

Additional material

Interactive 6.1 Schematic Human Skeleton

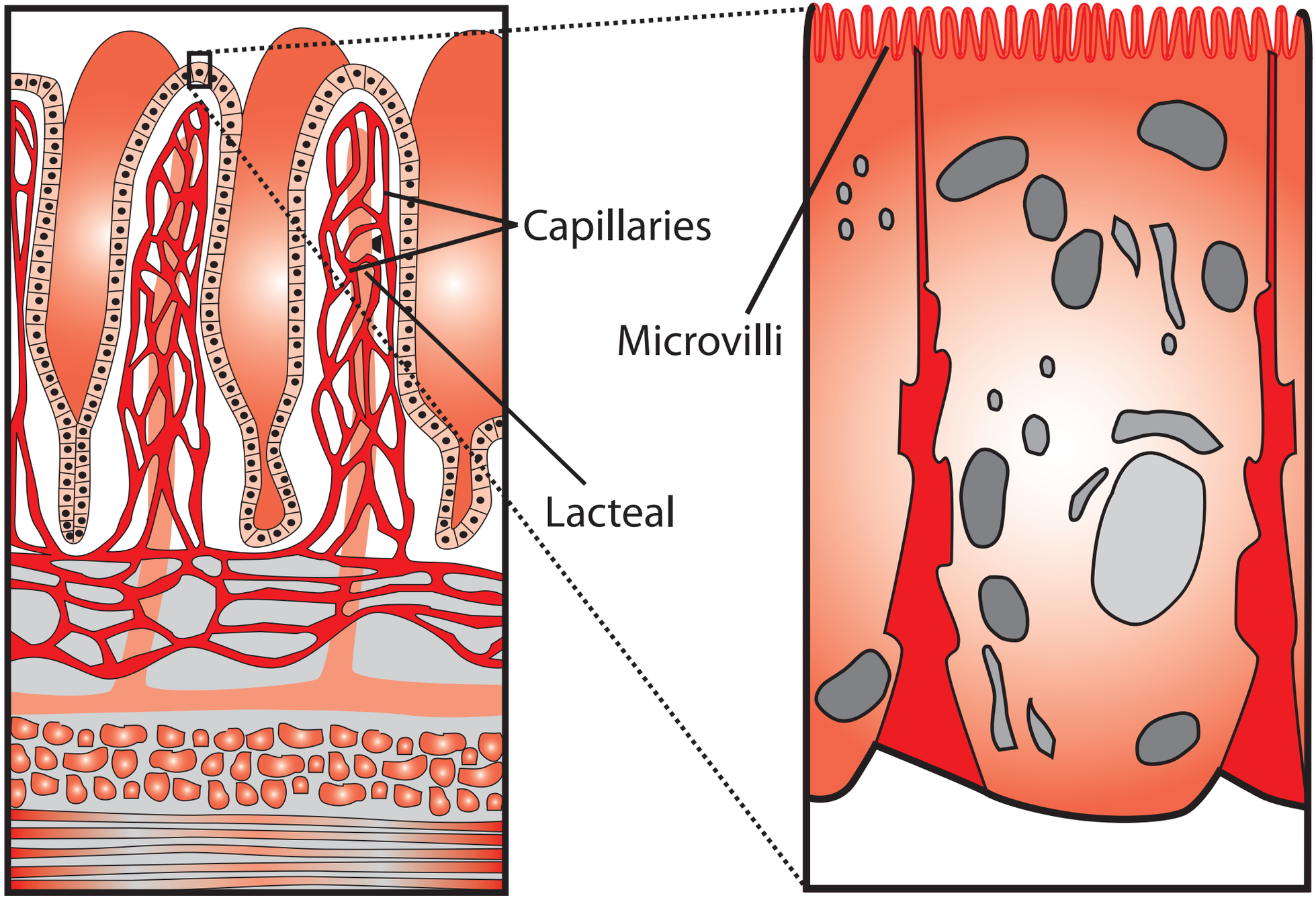


Figure 607 The structure of villi and microvilli

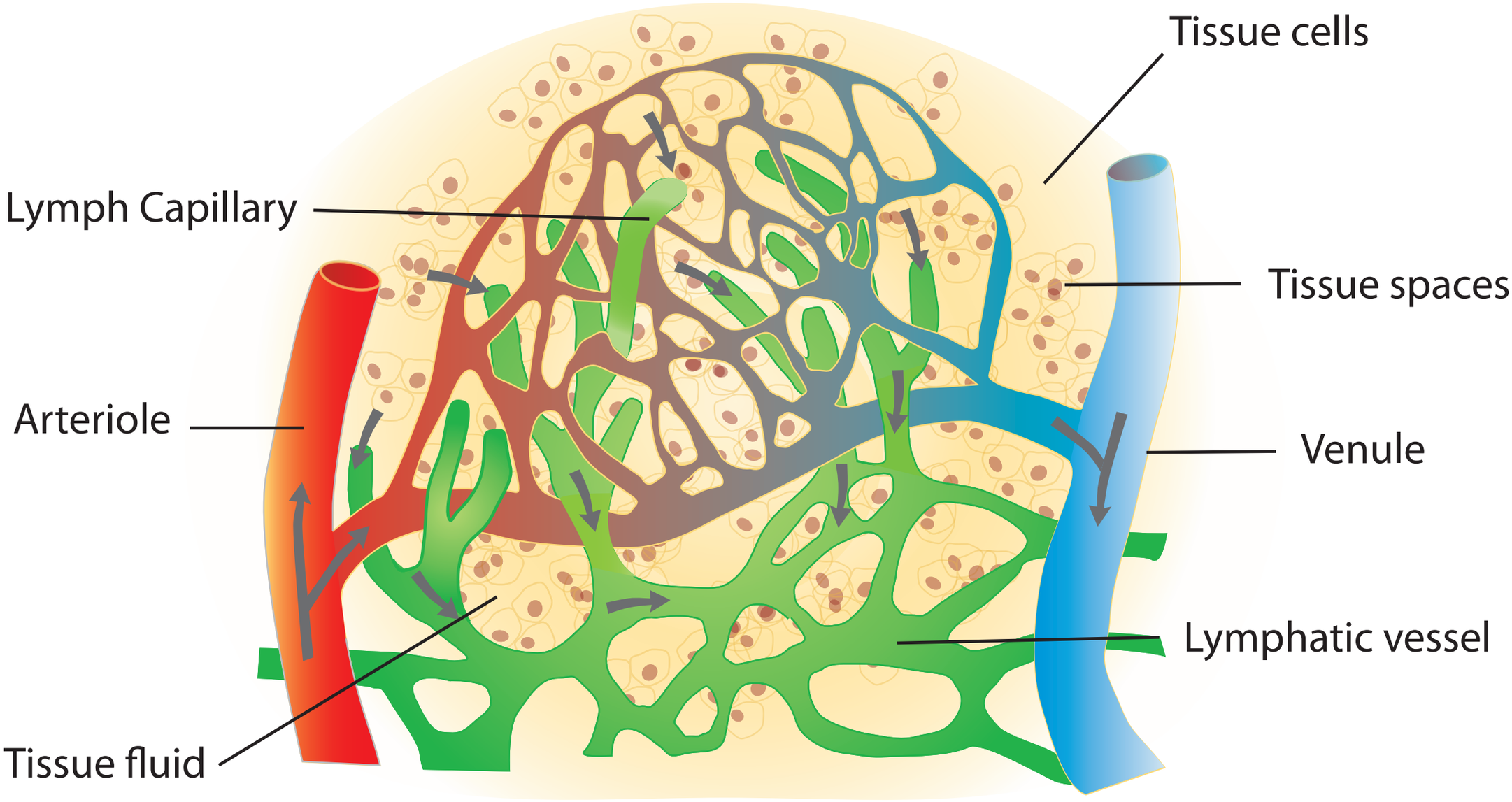
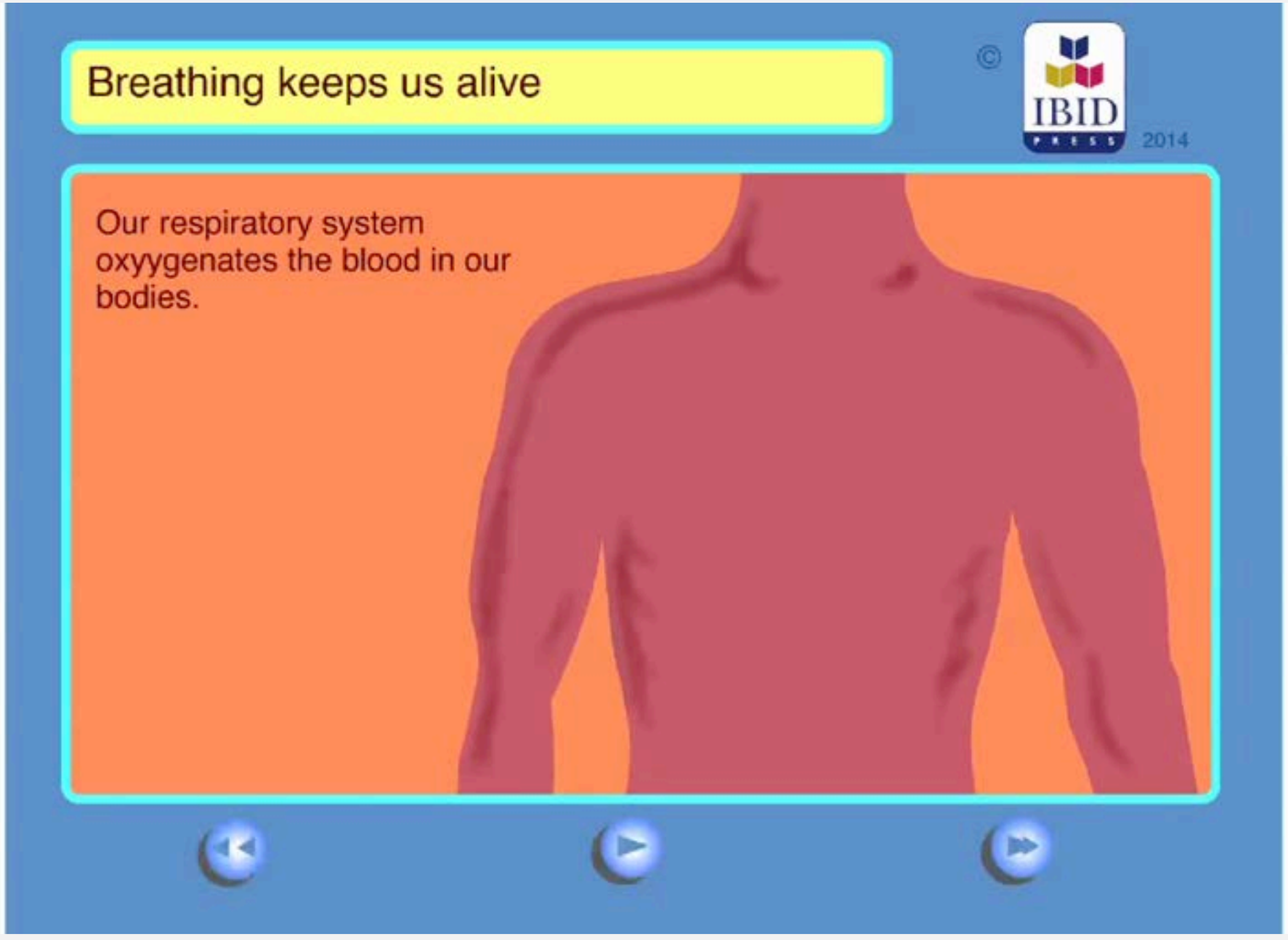


Figure 617 The lymph system

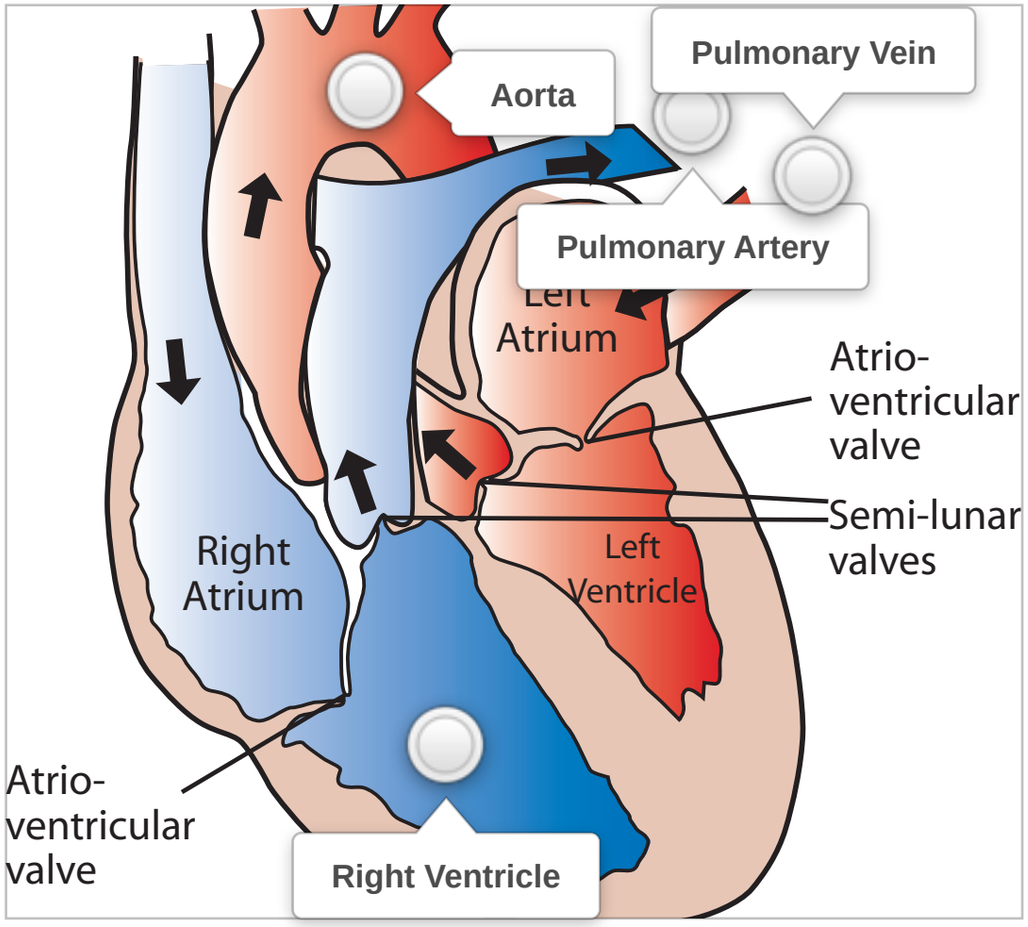
Movie 6.1 Breathing



Labelling exercise

Review 6.1 Labelling Exercise

The Heart



Aorta | Right Ventricle

Pulmonary Artery | Pulmonary Vein

Check Answer

Internet resources

Additional e-resources

Chapter 6

For a micrograph of lung tissue that you can zoom to see alveoli, see

http://141.214.65.171/Histology/Respiratory%20System/129_HISTO_20X.svs/view.apml?

More slides can be found on

http://histology.med.umich.edu/medical/respiratory-system

Pancreas cells from http://www.ric.edu/faculty/ptiskus/Stem_Cells/

A rapid explanation of type I, type II and gestational diabetes:

http://www.medicalnewstoday.com/info/diabetes/

Animation: how your heart pumps

http://www.mydr.com.au/heart-stroke/animation-how-your-heart-pumps

Threshold potential

The following might be helpful:

http://www.youtube.com/watch?v=7EyhsOewnH4

http://outreach.mcb.harvard.edu/animations/actionpotential_short.swf

any photos of pest insects for pesticides Box?

Answers to exercises

Multiple Choice Questions

1C, 2B, 3D, 4A, 5B, 6B, 7C, 8A, 9D, 10A, 11B, 12D, 13B, 14B, 15A, 16A, 17B, 18B, 19C, 20C, 21A, 22B, 23B, 24C, 25B, 26C, 27D, 28D.

Short Answer Questions

29

(a) Structure	(b) Function
villus	increase surface area which increases absorption
epithelial cells	these cells are permeable to nutrients which need to be absorbed
microvilli	increase surface area which increases absorption
capillary bed near surface of villus	removes absorbed nutrients and maintains concentration gradient proximity to surface reduces distance and speeds up absorption
lacteal	part of the lymphatic system which absorbs and transports lipids

30 (a) Diffusion, facilitated diffusion, active transport respectively.

(b) Both simple diffusion and facilitated diffusion through channel proteins are not specific (provided the transported particle can cross the phospholipid bilayer or go through the channel). Facilitated diffusion involving carrier proteins is specific.

Both are involved in transport across membranes:

Both do are passive (do not require energy)

Both move particles down the concentration gradient

(c) Simple diffusion is faster than facilitated diffusion because it can take place at more places at once in the membrane while facilitated diffusion can only occur where the correct proteins are found.

Simple diffusion moves particles through the phospholipid bilayer, facilitated diffusion does not.

Facilitated diffusion requires the presence of protein channels or carrier proteins, simple diffusion does not.

31 (a) The blood pressure in arteries can be high and a thick wall is needed to prevent the artery from bursting.

(b) Because a large proportion of the plasma has left the capillary to become tissue fluid and the remaining fluid is more viscous.

This is an advantage because there is more time to exchange soluble substances with the tissue.

(c) To prevent backflow of blood. Due to the higher pressure and speed of the blood in arteries, there is no risk of back flow there but the low pressure in veins makes it likely to flow in the wrong direction, e.g in the legs when we are standing up.

32 Include:

• nutrients e.g. glucose

• oxygen

• hormones

• antibodies

• waste e.g. urea and carbon dioxide

33 Include:

• antigen enters the organism

• lymphocyte that produces the correct antibody will recognise the antigen

• lymphocyte will form a clone

• all cloned cells produce the same antibody

• antibody will make antigen harmless

34 HIV reduces the number of lymphocytes. Lymphocytes make antibodies so HIV reduces antibody production.

35 (a) see Figure 638

(b) Structure	(c) Function
large surface area	a high rate of gas exchange can occur
thin	short diffusion distance
moist	gases can only cross a membrane when dissolved
good blood supply	maintains concentration gradient by removing materials

(c) To maintain the higher concentration of oxygen and the lower concentration of carbon dioxide in the lungs so that oxygen will diffuse from the air in the lungs into the blood and carbon dioxide from the blood into the air in the lungs.

36 Both refer to a difference in charge across the membrane of a neuron. A resting potential is fairly stable and usually around -70 mV. An action potential is a change in the potential across the membrane. The electric potential will change from -70 mV to +30 mV and back again. An action potential is what is measured as an impulse is conducted across the cell membrane of a neuron.

37 (a) The heat centre in the hypothalamus which senses the temperature and compares it to the desired value. Skin arterioles,

erector muscles that flatten or raise up hairs and sweat glands are all effectors.

(b) Include:

• vasodilation

• sweating

• increased metabolism

• ’fluffing’ of hair or feathers

• thick layer of brown fat or of blubber

• special structure hair

38 Both estrogen and progesterone inhibit secretion of FSH which is necessary for the development of a follicle and hence release of an egg cell. In the absence of FSH, no follicle will ripen and no egg cell can mature so no fertilisation can take place.

39 Include:

- dry skin is difficult to penetrate because it is made of tough cells and there are only few gaps
- normal bacteria growing on the skin will make it more difficult for pathenogenic bacteria to grow
- pH of skin is slightly acidic and many pathogens cannot grow there
- mucus is found where there is not enough other protection

  e.g. air passages sticky mucus traps bacteria and stops them from spreading

Chapter 7

Nucleic Acids

Section 1

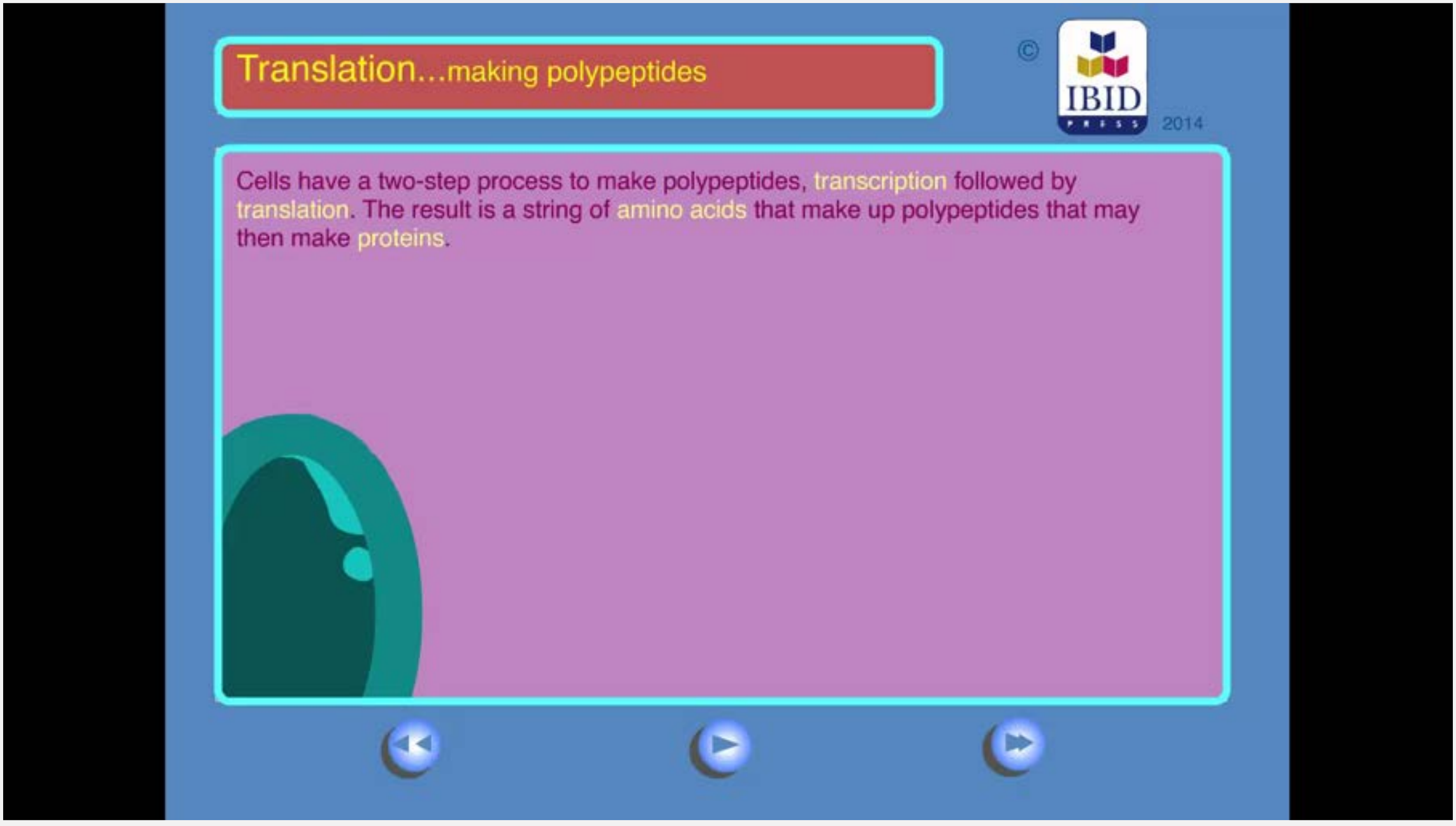
Nucleic Acids

CONTENTS

All of the somatic cells in a body have the same genes, this is a rather spectacular example of differential gene expression.

Additional material

Movie 7.1 Translation



Enlarged diagrams

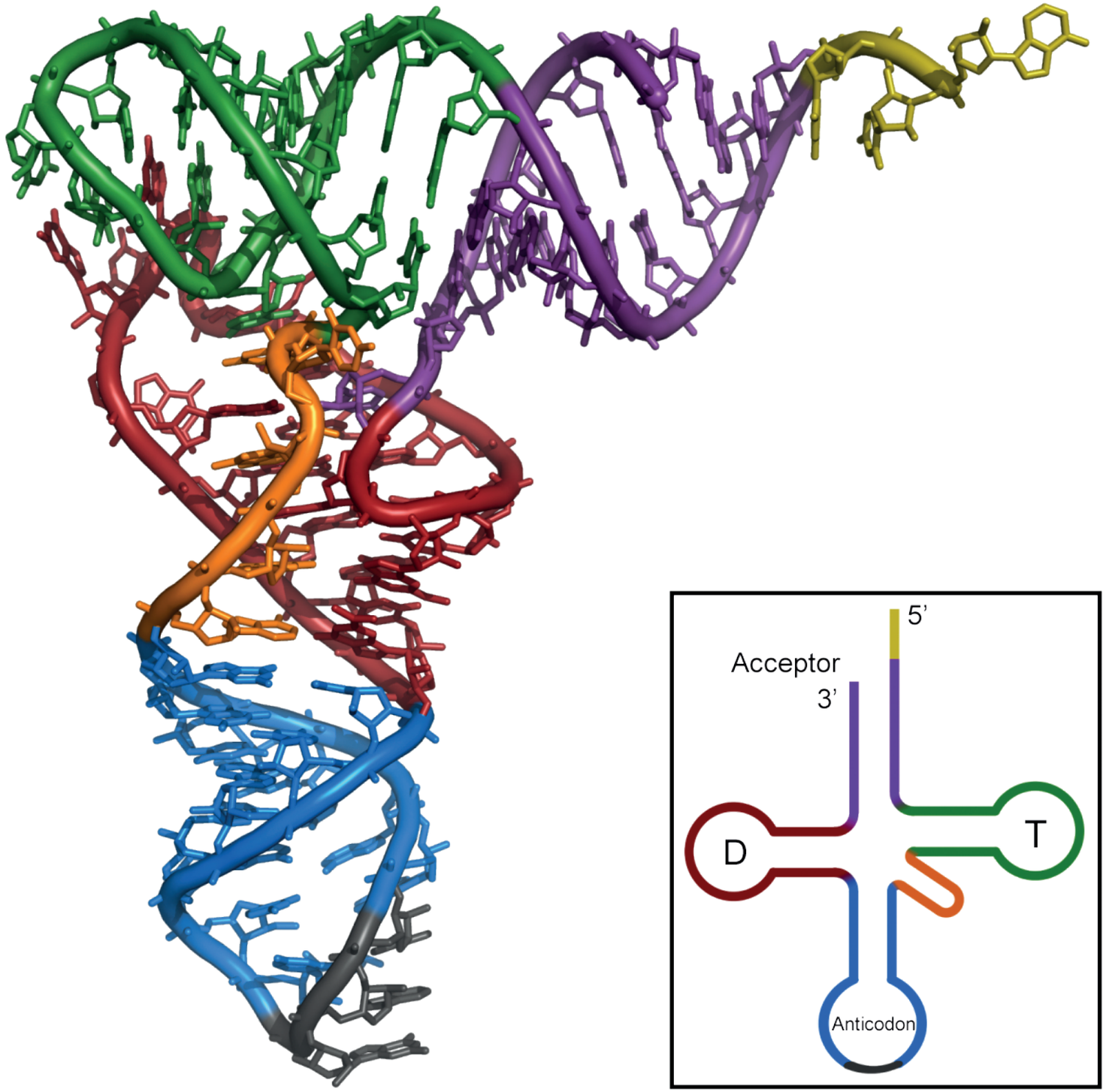


Figure 741 The 3D structure of tRNA

Internet resources

Franklin and Wilkins

Another overview of the process can be found on

http://www.dnalc.org/view/16422-Animation-19-The-DNA-molecule-is-shaped-like-a-twisted-ladder-.html

Herschet and Chase

A summary of the process can be found on the site below.

http://highered.mcgraw-hill.com/olcweb/cgi/pluginpop.cgi?it=swf::535::535::/sites/dl/free/0072437316/120076/bio21.swf::Hershey%20and%20Chase%20Experiment

Understanding how X-rays work can be difficult, an activity might help.

http://www-outreach.phy.cam.ac.uk/resources/dna/xrays.pdf

The interpretation of the X-ray diffraction pattern is shown in the link below.

http://www.dnalc.org/view/15014-Franklin-s-X-ray-diffraction-explanation-of-X-ray-pattern-.html

http://www.dnalc.org/view/15014-Franklin-s-X-ray-diffraction-explanation-of-X-ray-pattern-.html

This site also explains how Franklin and Wilkins came up with the dimensions of the helix and the number of base pairs per turn.

Translation MV software

The use of molecular visualization software can be used to analyse the structure of eukaryotic ribosomes and a tRNA molecule.

http://higheredbcs.wiley.com/legacy/college/boyer/0471661791/structure/tRNA/trna.htm

Please right click the main picture to select options of how to view the structure of tRNA.

http://www.dnatube.com/video/59/Ribosome-structure-and-tRNA-binding-site-3D-structure

Translation animation

An animation of the process of translation is shown in

http://www.youtube.com/watch?v=5bLEDd-PSTQ

this site also contains many other interesting and relevant animations.

Another overview of this process can be seen in

http://www.dnalc.org/resources/3d/16-translation-advanced.html

Utilisation of molecular visualization software to analyse the association between protein and DNA within a nucleosome.

http://www.umass.edu/molvis/bme3d/materials/explore.html#nucleosome

and

http://www.biochem.umd.edu/biochem/kahn/teach_res/nucleosome/jmol-nsome.html

show 3D visualisations of a nucleosome. They can be rotated by using the mouse.

Answers to exercises

Multiple Choice Questions

1B, 2A, 3C, 4A, 5D, 6B, 7D, 8D, 9B, 10D.

Short Answer Questions

11 A drawing similar to Figure 709 is required, the main features are

- DNA is made of two strands
- strands are antiparallel (5’ to 3’ and 3’ to 5’)
- strands are kept together by hydrogen bonds between the organic bases
- building blocks (monomers) of DNA are nucleotides
- nucleotides are linked together by covalent bonds
- covalent bonds are created by condensation reactions
- nucleotide consist of a deoxyribose sugar, a phosphate group and an organic base
- base is attached to C1, phosphate to C5
- organic base can be Adenine, Thymine, Cytosine, Guanine
- a base pair between the strands is always A-T or C-G
- 3 H-bonds between cytosine and guanine, 2 H-bonds between adenine and thymine
- double helix is twisted
- approx 10 nucleotides per full turn

12 (a) DNA gyrase supercoils the unwinding DNA to relieve the strain whileit is being unwound by helicase. It can cut the two sides of the DNA double helix, allow one chain to move to the other side and reseal. This relieves the strain and allows helicase to continue to separate the strands by breaking the H-bonds between the base pairs.

(b) Helicase unwinds the DNA double helix and breaks the hydrogen bonds between the strands which separates the strands

(c) Single Strand Binding proteins prevent the single DNA strands from pairing up with their complementary strand again (i.e. the most stable state). They attach to and stabilise the single DNA strand and prevent the strand from being digested by nucleases.

(d) RNA primase will form covalent bonds between the RNA nucleotides to form the RNA primer. One RNA primer will be formed on the leading strand but the discontinuous replication on

the lagging strand requires an RNA primer on each Okazaki fragment.

(e) DNA polymerase III will form covalent bonds between the DNA nucleotides and the growing strand. It works only in a 5' to 3' direction.

(f) DNA polymerase I removes the RNA primers (most are from Okazaki fragments) and replace RNA nucleotides with DNA nucleotides

(g) DNA ligase will attach the DNA fragments that were the Okazaki fragments to form a complete strand

13. Both: need energy and grow in the same direction: 5' to 3'

Transcription	Translation
DNA to RNA	RNA to protein
more limited number of mRNA is made each time.	many protein molecules are made almost at the same time
enzymes needed	enzymes and ribosomes and tRNA needed
in nucleus	in cytoplasm

14 (a) mRNA is an RNA copy of the sense strand of the DNA, made by complementary base-pairing during transcription of the non-sense section of DNA. The sequence of the mRNA codons determines the sequence of the amino acids in the polypeptide.

(b) ribosomes are needed for the tRNA anticodon to bind to the mRNA codon so that the amino acid of the tRNA can be attached to the growing polypeptide chain.

(c) a codon is a sequence of 3 organic bases on mRNA that codes for a specific

amino acid; an anticodon is a sequence of three organic bases(found on tRNA) complementary to the codon.

(d) each tRNA has a specific anticodon. Related to this anticodon, tRNA also carries a particular amino acid so that the same amino acid is always found with the same anticodon. tRNA takes the amino acid to the ribosome and allows it to attach to the growing polypeptide chain.

15 Primary structure: covalent bonds, the covalent bond between one amino acid and the next is called a peptide linkage or peptide bond. It is created by a condensation reaction between the -NH2 group and a -COOH group; the peptide linkage is the resulting covalent bond as shown in Figure 259.

Secondary structure: hydrogen bonds stabilise the secondary structures such as alpha helix and beta pleated sheet.

Tertiary structure: further folds the polypeptide chain and involves interactions between the R groups of the amino acids : hydrophobic interactions (non-polar R groups will group together), disulfide bonds, hydrogen bonds and ionic bonds

Quaternary structure; combines 2 or more polypeptide chains by hydrogen bonds, electrostatic attraction forces, hydrophobic forces, disulfide bridges.

for more information see <http://en.wikipedia.org/wiki/Protein_structure>

16. Functions include

• enzymes e.g. maltase which breaks down maltose into glucose and fructose

• hormones e.g. insulin

• defense e.g. antibodies/immunoglobins

• structure e.g. spindle fibre in cell division

• transport e.g. hemoglobin for oxygen transport

17 Reasons include:

• they are used to keep the protein in its place : polar amino acids interact with water on either side of the membrane, non-polar amino acids interact with the non-polar phospholipid bilayer in the centre of the membrane

• a hollow tube can be created, using polar amino acids at the ends, interacting with the water on either side of the membrane. In the centre, the inside of the cylinder is made of non-polar acids, creating a hydrophilic channel through the membrane.

• polar and non-polar amino acids can help create the shape of the active site of an enzyme and help provide the forces that keep the substrate in the active site and make sure that other substrate do not fit well and do not stay there.

18 This is a computer generated model showing some important secondary structures in a protein molecule: the pink sections indicate alpha (α) helices and the green sections indicate beta (β) pleated sheets.

The α helix is a secondary structure; polypeptide is coiled/ spiralled into a right-handed helix: β (pleated) sheet is a secondary structure; polypeptide folds back on itself (several times) to form a pleated sheet. Both α helix and β (pleated) sheet secondary structures are held together by hydrogen bonds; hydrogen bonds form between C=O and N-H groups/oxygen of carbonyl group and hydrogen of amine group; hydrogen bonds at regular spacing/ each turn has 3 complete amino acid residues and two atoms from the next one; dimensions of secondary structures are virtually constant; not all of a polypeptide forms secondary structures (in most proteins) they are random coil.

Chapter 8

Metabolism, Cell Respiration and Photosynthesis

Section 1

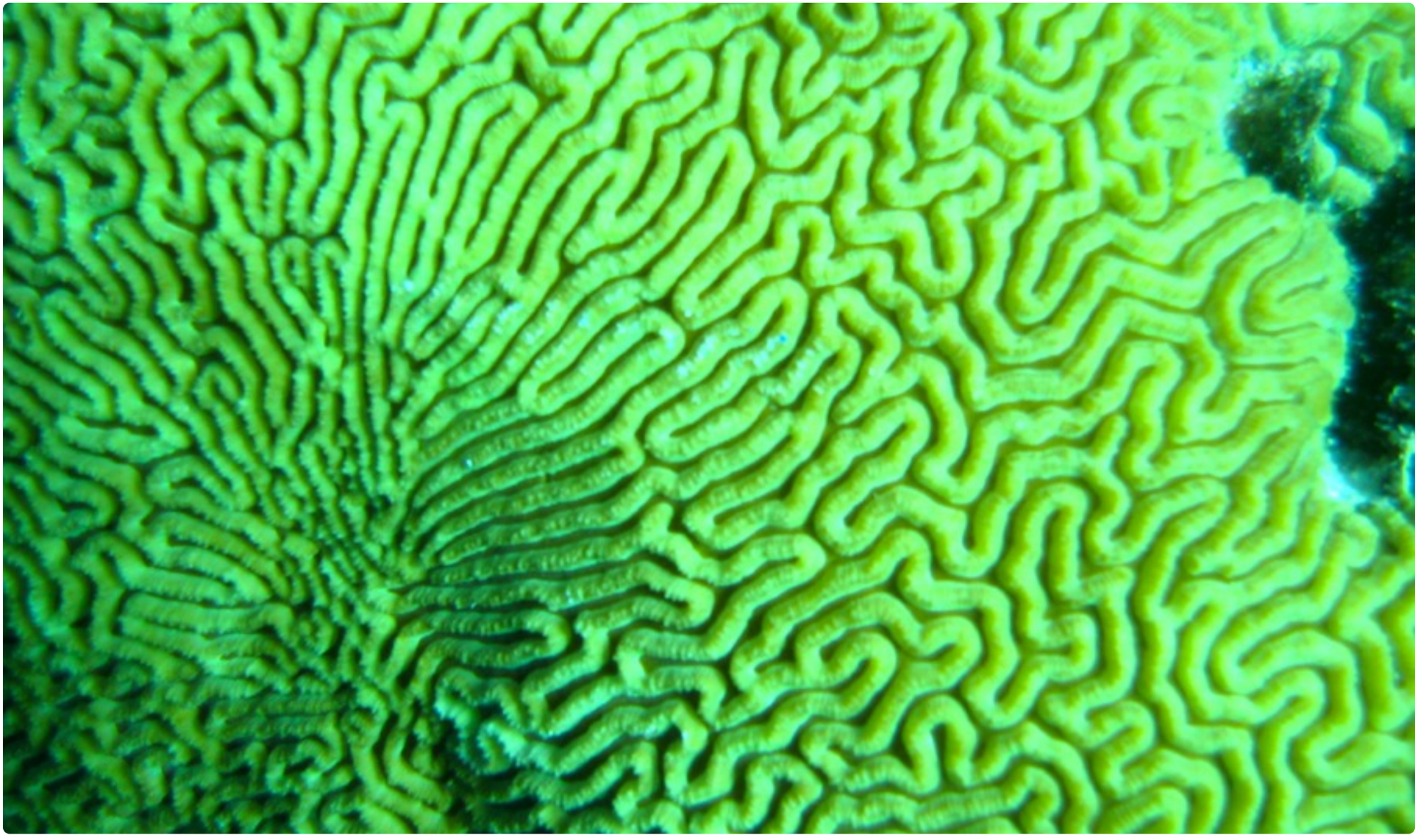
Metabolism, Cell Respiration and Photosynthesis

CONTENTS

Metabolism in plant cells involves both photosynthesis and respiration.

Additional material

Gallery 8.1 Photosynthesisers



Corals are animals. Many live in a symbiosis with small plants called Zooxanthellae.

Enlarged diagrams

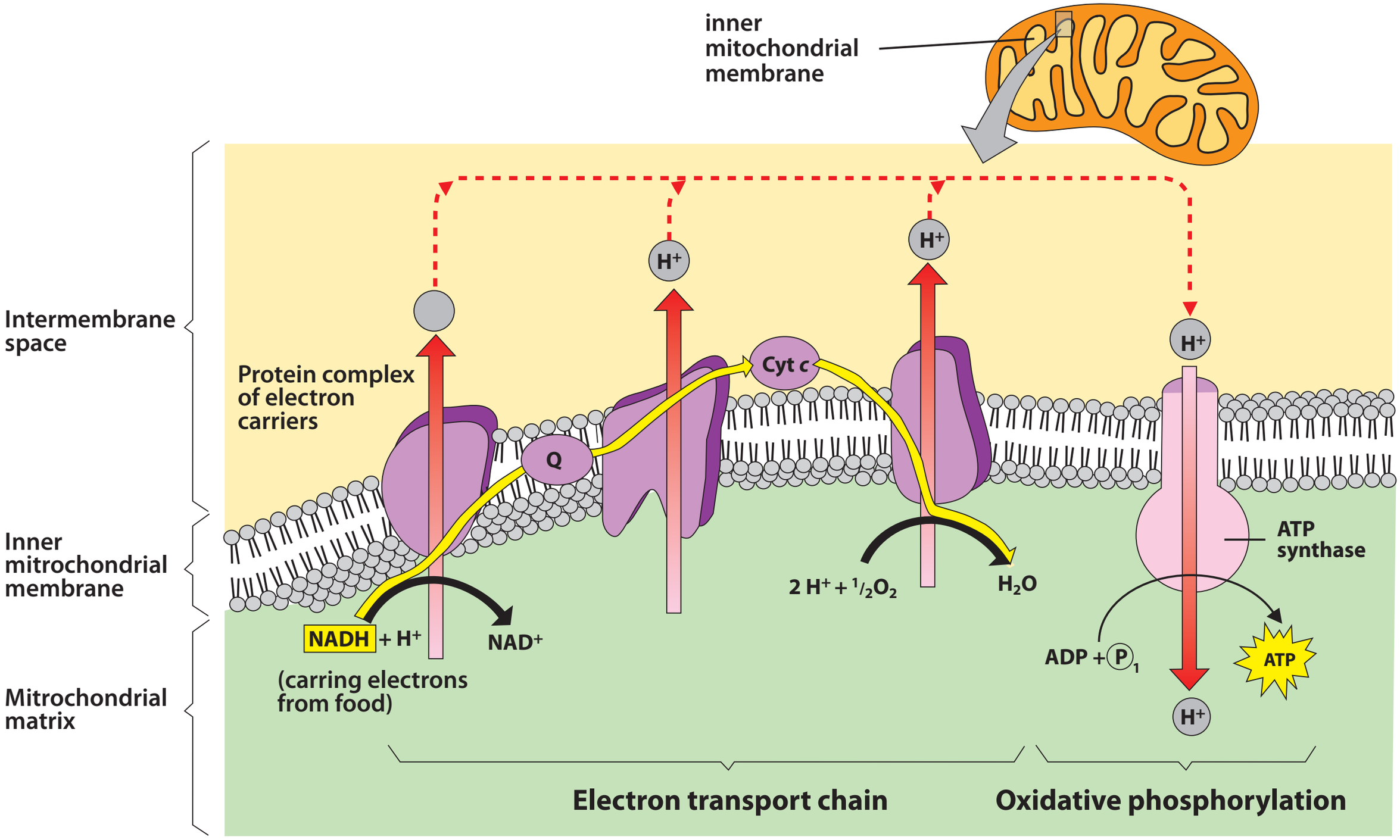


Figure 820 Pathways of oxidation and reduction

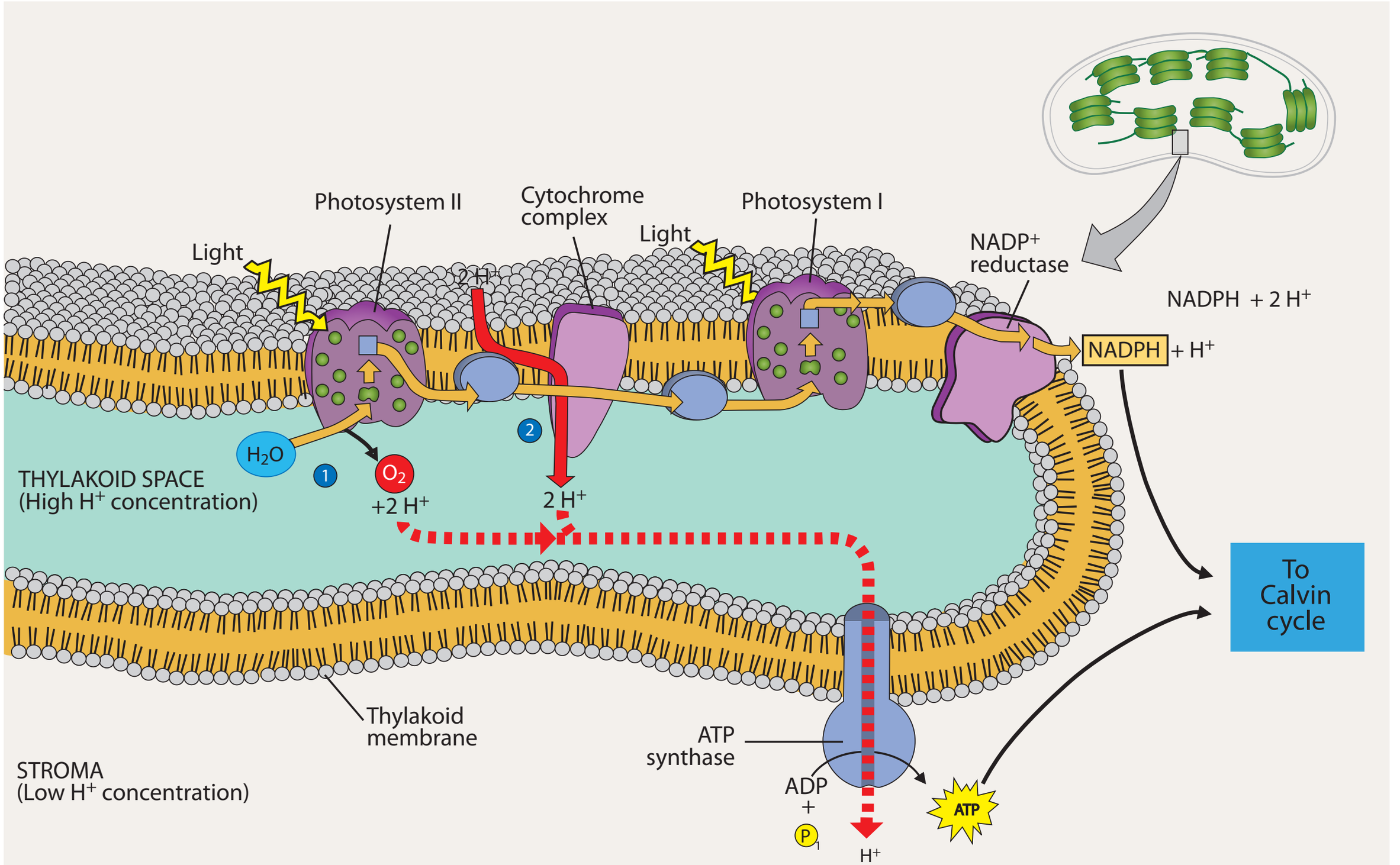


Figure 836 The process of photolysis

Internet resources

A simple animation of the electron transport chain is found on

http://www.science.smith.edu/departments/Biology/Bio231/etc.html

and on

http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter9/animations.html#

also on

http://www.youtube.com/watch?v=xbJ0nbzt5Kw

This excellent youtube animation very clearly explains the movement of electrons and protons but only refers to ATP production.

Electron tomography uses a beam of electrons to create the pictures of e.g. a mitochondrion.

http://www.sci.sdsu.edu/TFrey/MitoMovie.htm

This site takes you through the steps and shows how this 3D image develops.

An introduction animation of the light-independent reactions can be found on

http://legacy.hopkinsville.kctcs.edu/instructors/Jason-Arnold/VLI/Module%202/m2cellfunctionandenergetics/m2cellfunctionandenergetics10.html

Other useful sites for Photosynthesis are

http://www.springerimages.com/Images/LifeSciences/1-10.1007_s11120-010-9570-8-3

http://macromol.sbcs.qmul.ac.uk/resources/AllComplexes_25Nov2011_1800px.gif

Calvin's experiments: matured in years 1950-1951
e.g. http://www.jbc.org/content/185/2/781.full.pdf
but had been developing, with many other key co-authors e.g. Bassham, Benson, in the 1940s:
http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1961/calvin-lecture.pdf

Answers to exercises

Multiple Choice Questions

1C, 2A, 3D, 4A, 5B, 6A, 7D, 8D, 9D, 10D.

Short Answer Questions

11 Similarities:

Both reduce the rate of an enzyme controlled reaction.

Both affect the working of the enzyme.

Differences:

	Competitive inhibition	Non-competitive inhibition
inhibitor similar to substrate?	yes	no
binds to	active site of enzyme	enzyme but outside the active site
effect of adding more substrate	reduce effect of inhibitor	no effect
V_{max} achieved	with increased amount of substrate, V_{max} approached	V_{max} cannot be achieved in the presence of non-competitive inhibitor

Refer also to Figure 805

12 (a) in the cytoplasm

(b) in the matrix of the mitochondria

(c) on the cristae (inner membranes of the mitochondria)

13. Refer to Figure 822.

14 (a) The site for the Krebs cycle is the matrix of the mitochondria. It is a watery fluid contaning all the enzymes and compounds needed for the Krebs cycle to proceed.

(b) The site for the electron transport chain is the cristae (folded inner membrane) of the mitochondrion. It has a large surface area so there is a large surface area for many ATP synthase molecules. It is also impermeable to protons (except where there are ATP synthase molecules).

(c) Then it would not be possible to build up a higher concentration of protons and chemiosmosis would not occur. As a result, no ATP would be produced.

15 Refer to Figure 832.

16 Refer to Figure 833.

The light dependent stage produces ATP and NADPH which are needed to drive the Calvin cycle in the light independent stage. The light independent stage fixes carbon dioxide to produce a triose. This process requires ATP and NADPH, made in the light

dependent stage: ATP is needed to phosphorylate GP and to change TP into RuBP. NADPH is needed to reduce glycerate diphosphate into another triose.

17 (a) they provide the energy and the reducing power to drive the Calvin cycle in the light independent stage.

(b) it is a simple method of producing ATP

(c) non-cyclic photophosphorylation produces NADPH which is needed to drive the light independent stage. The advantage of the light independent stage is that it makes carbohydrates which can be used for long term energy storage but also as building materials for new cells so that the plant can grow and reproduce.

(d) in the Calvin cycle, 3 molecules of carbon dioxide are combined to form a triose molecule; 2 triose molecules will be combined to form glucose.

18 The grana thylakoid provide a large surface for absorbing light the membrane of the grana allows the electron carriers needed for photophosphorylation to be kept in the right order, helping the reaction to proceed.

The volume inside the grana is small so that a relatively small number of protons will cause a large difference in concentration across the membrane and the stroma is a watery fluid which contains all enzymes and intermediates needed for the Calvin cycle

19 Similarities :

- both use chemiosmosis
- both involve transport of electrons and protons
- both use ATP synthase to produce ATP from ADP and Pi
- both take place across a membrane which is impermeable to protons
- both build up a proton gradient across the membrane
- both transport protons into a small volume

	Chloroplasts	Mitochondria
site	membrane of granum	membrane of crista
organelle	chloroplast	mitochondrion
source of electrons	water (photolysis)	NADH + H+
ultipmate electron acceptor	NADP	oxygen
protons are pumped into	lumen of the grana	intermembrane space
protons diffuse via ATP synthase into:	stroma	matrix

20 (a) at the active site

(b) anywhere on the enzyme as long as it is away from the active site

(c) competitive inhibitor: prontosil

non-competitive inhibitor: cyanide ions

21 End product inhibition includes the following:

- ♦ allostery is non-competitive inhibition
- ♦ end product is the inhibitor
- ♦ end product will attach to the enzyme
- ♦ of an reaction earlier in the metabolic reactions
- ♦ at a place which is NOT the active site
- ♦ will change the shape of the active site
- ♦ enzyme no longer works
- ♦ no more product produced
- ♦ when product runs out
- ♦ then no more product to act as allosteric inhibitor
- ♦ so reaction proceeds
- ♦ new product formed.

22

	Krebs cycle	Calvin cycle
Occurrence	Occurs in animals and plants.	Only occurs in plants.
Site	Matrix of the mitochondrion.	Stroma of the chloroplast.
Electron/hydrogen carrier(s) utilised	NAD and FAD	NADP
Carbon dioxide production/ consumption	Two molecules lost per molecule of pyruvate.	One molecule is used to combine with RuBP.
ATP synthesis/ consumption	Twenty four molecules of ATP are produced per molecule of glucose.	ATP is consumed.

23 Main points:

• The light energy absorbed by the plant is converted into electrical energy and then stored as chemical energy.

- The plant achieves this by chlorophyll molecules capturing the light energy and raising the potential energy of the outer electrons until a flow of electrons occurs in photosystem II: Chlor a → Chlor $a^+ + e^-$

- Photosystem II is a complex of protein and chlorophyll a molecules whose absorption maximum is at a wavelength of 680 nanometres.

- Photosystem II has an active centre that is capable of dissociating water molecules into oxygen molecules, electrons and hydrogen ions. Chlorophyll a becomes chlorophyll a+ in PSII in light. Chl a+ is the strongest biological oxidiser and this will "steal" an electron from water causing it to break apart. See 8.3.4

- The electrons flow into photosystem II to convert the unstable chlorophyll positive ions back into chlorophyll a molecules: Chlor $a^+ + e^-$ → Chlor a

- The electrons produced in photosystem II by ionisation of chlorophyll will move down a series of electron carriers, producing ATP and reduced NADP (NADP+) that will be used in the Calvin Cycle for eventually synthesising carbohydrate, for the long-term storage of chemical energy. This process of ATP production is known as non-cyclic phosphorylation.

- ATP is also produced when light energy with a wavelength of 700 nanometres is absorbed by chlorophyll molecules in photosystem I. ATP is indeed produced in cyclic photo-phosphorylation but also when electrons move from PS II via carriers to PSI. However, the flow of electrons is recycled via the electron transport system to reform chlorophyll molecules. This process of ATP production is known as cyclic phosphorylation.

24 Refer to Figure 816. Main points:

- Glucose is phosphorylated by a phosphate ion formed from the enzyme controlled hydrolysis of ATP. Fructose phosphate is produced, which is phosphorylated to produce fructose biphosphate that undergoes lysis or decomposition into two molecules of a three carbon compound known as glyceraldehyde-3-phosphate.

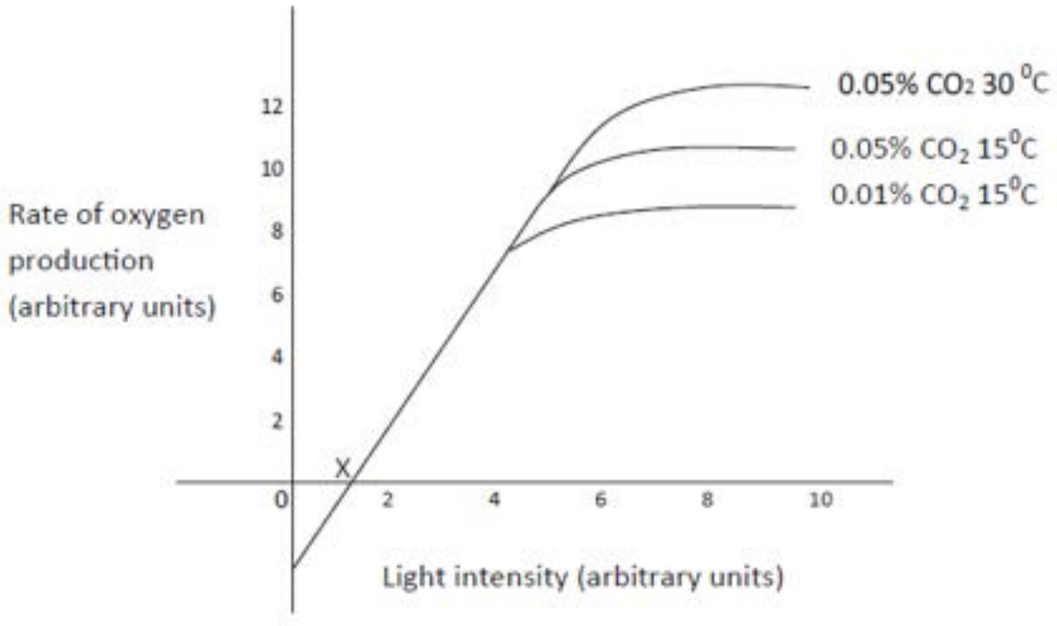
- The two glyceraldehyde-3-phosphate molecules are phosphorylated and undergo oxidation or dehydrogenation to produce two molecules of glycerate-1,3-biphosphate (a three carbon compound) and two pairs of hydrogen atoms (which are accepted by NAD+).

- The two glycerate-1,3-biphosphate molecules each lose a phosphate ion to produce two molecules of glycerate-3-phosphate (pyruvate), synthesising two ATP molecules.

25 In oxidative phosphorylation, the role of oxygen molecules is to act as the final acceptor of hydrogen ions (protons) and

electrons at the end of the electron transport chain. Without oxygen, the H+ would accumulate in the mitochondrial matrix. There would not be a gradient of H+ (protons) across the membrane of the cristae. Without this gradient, no movement of H+ through ATP synthase and no synthesis of ATP. Due to a build up of intermediates, the Krebs cycle would no longer occur and only glycolysis would generate a small amount of ATP. This is exactly what happens in anaerobic respiration. Oxygen (in the presence of cytochrome c oxidase) combines with the hydrogen ions (protons) and electrons to form water. Oxygen thus plays a vital role in the aerobic respiration of glucose.

26 (a) Line joined to 0.05% CO_2 15 °C line; line levels off to a plateau above 0.05% CO_2 15 °C (as shown below).



(b) Increased CO_2 concentration increases the rate of photosynthesis and hence rate of glucose production; plants show increased growth/yield. The key point is that all other factors are already at or near optimum levels so CO_2 is the limiting factor.

(c) Low light intensity; Low rate of photosynthesis/production of O_2 same as rate of respiration/use of O_2; Compensation point

(d) Some other factor is limiting the rate of photosynthesis, e.g. amount of chlorophyll, water supply, temperature {see (a)}

Chapter 9

Plant Biology

Section 1

Plant Biology

CONTENTS

There is enormous diversity in plant life.

Additional material

Gallery 9.1 Flowers

Flowers are reproductive organs.

Internet resources

http://www.ib.bioninja.com.au/additional-resources/biology-songs/transpiration-stream.html

has an animated song about the transpiration pull.

Good drawings of cross sections of plants

http://www.bio.miami.edu/dana/dox/stem.html

and also Wikimedia Commons

http://commons.wikimedia.org/w/index.php?search=plant+stem+sections&title=Special%3ASearch&go=Go&uselang=en-gb

Photos

Vascular system for drawing skill

Microprop of plants in sterile conditions

Coul;d usepPhotos of different flower structures

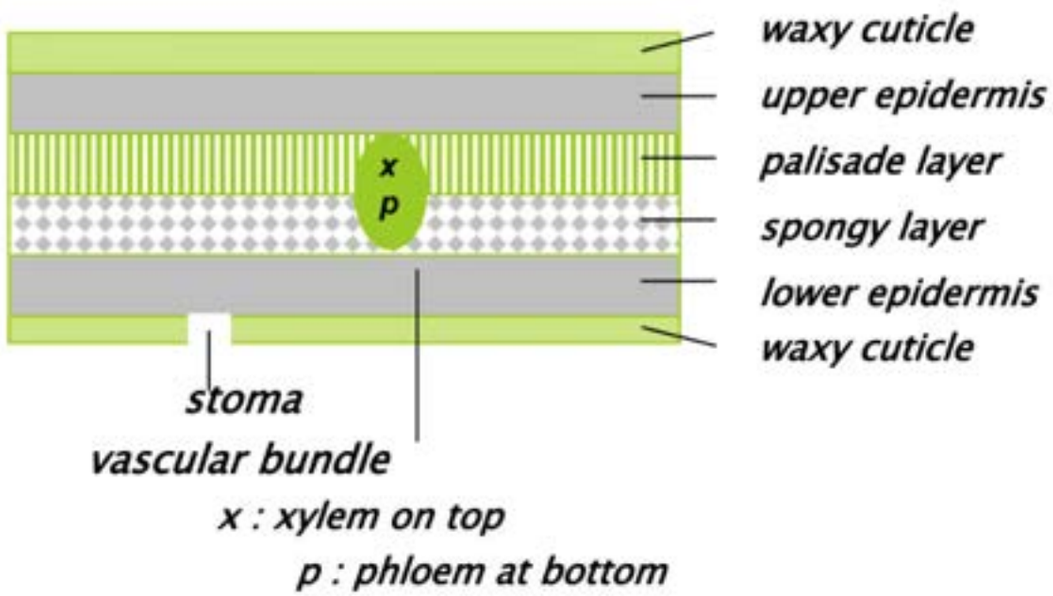
Answers to exercises

Multiple Choice Questions

1C, 2A, 3C, 4D, 5A, 6D, 7A.

Short Answer Questions

8 (a) A labelled diagram something like this or refer to Figure 903



(b)

upper epidermis	reduces water loss
	prevent gas exchange
	allows light to pass
	secretes cuticle
	barrier against infection
palisade layer	photosynthesis
spongy layer	allows rapid diffusion of oxygen and carbon dioxide through moist air spaces
	photosynthesis
lower epidermis	stomata open/close to allow gas exchange but reduce water loss
	secrete cuticle
	barrier against infection
vascular tissue	xylem transports water and mineral from roots to leaves
	phloem transports sucrose and amino acids from source to sink

(c)

upper epidermis

cells close together - no space between for pathogens to enter or water to evaporate

transparent (no chloroplasts) - light can pass easily

palisade layer

tighly packed, contain chloroplasts, narrow end to top - maximum exposure to light

spongy layer

air spaces allow rapid diffusion of respiratory gases

chloroplasts for photosynthesis

lower epidermis

cells close together - no space between for pathogens to enter or water to evaporate

few chloroplasts because insufficient light

stomata allows rapid gas exchange

vascular tissue

xylem

dead cells - no cross walls - facilitates transport of water and minerals

phloem

living cells - active transport of sucrose and amino acids

9

	Monocotyledenous plants	Dicotyledenous plants
veins in leaf	parallel	reticulate (net-like)
distribution of vascular tissue	scattered	in a ring
number of cotyledons in seed	one	two
floral organs	multiples of three	four or five
roots	unbranched	branched
examples	grass, onion, lily and tulip	daisy, oak tree and rose

10 Include:

- auxin is group of plant hormones
- auxin is produced by the apical bud of a plant
- auxin is transported down the stem as needed
- auxin stimulates growth
- by promoting cell division and cell wall stretching

♦ auxin accumulates on the shaded side of the stem

♦ which makes the shaded side grow faster

♦ so the plant grows towards the light

♦ this increases the amount of light on the leaves

♦ which increases photosynthesis

11 (a) Include:

• water is taken up by osmosis

• because the concentration of dissolved particles in the root hair cell is greater than that outside the plant

• roots take up minerals by active transport

• this increases the concentration of dissolved particles in the root hair cells

• root hairs increase surface area

• roots need a large surface area to allow a lot of water uptake at the same time

• water is taken from roots by xylem

• transpiration pull moves water up the xylem

• cohesion is the attraction between water molecules

• cohesion is the force needed for transpiration pull

• adhesion makes the water creep up the sides of a capillary tube and supports the flow of water in the plant

(b) Include:

• root hairs increase surface area

• to improve uptake of minerals

• carrier proteins found in membrane

• which take up minerals through active transport

• against the concentration gradient

• requires energy so mitochondria found in cells

12 Include:

• phloem transports sugars and amino acids

• by pressure flow hypothesis

• from source (area of production/storage) e.g. leaves or roots

• to sink (area of use/storage) e.g.fruits/growing points or roots

• so carbohydrates/amino acids may go up or down stem at different times

• phloem is made of living cells

• transport involves active transport i.e. energy is needed

• energy is supplied by companion cells

13 Refer to Figure 960

14

• correct temperature allows enzymatic activity

• oxygen is absorbed and used to release energy (cell respiration)

• water is absorbed

• water is used to dissolve and transport materials

• gibberelins are made in the cotyledons

• amylase is made

• starch broken down to maltose

• maltose used to release energy

• growth

15 (a) oxygen, water, suitable temperature

(b) oxygen : respiration requires energy and oxygen is needed to release energy

water : seeds swell up after taking up water which bursts the testa

presence of water activates enzymes which hydrolyses large molecules

suitable temperature : germination requires enzymes which need to have a temperature suitable for them to function effectively

16 Main points

• there are long day plants, e.g.carnations and clover, and short day plants, e.g. coffee and strawberries

• long day plants flower in summer, short day plants in autumn (and spring)

• long day plants only flower when nights are short

• short day plants only flower when nights are long

• phytochrome regulates the flowering of plants

• two states : Pr and Pfr

- Pr becomes Pfr quickly when exposed to red light
- Pfr becomes Pr slowly in darkness
- long day plants need Pfr to flower
- short day plants only flower when Pfr is absent

17 Main points

- During transpiration, the evaporation of water from the mesophyll cells to the sub-stomatal air space and its diffusion via the stomatal pore to the atmosphere helps to cool the leaves of the plant. Evaporation is an endothermic process and heat is absorbed from the surroundings.
- Since dissolved mineral salts flow with the water, transpiration is needed for the uptake of minerals salts from the soil and distribution via the xylem throughout the plant.
- Transpiration generates transpiration pull, that provides tension within the xylem cells for drawing up a continuous, cohesive column of water within the xylem vessels. This will supply water to cells and help them maintain their turgidity and thereby help support the plant.
- Transpiration is needed to ensure the uptake of water via the roots and stems until it reaches the leaves of a plant, where it acts as a reactant during photosynthesis.
- The water located on the surface of the mesopyll cells inside the leaf that evaporates during transpiration helps to maintain moistness inside the leaf facilitating gaseous exchange of oxygen and carbon dioxide.

18 Main points

- The xylem vessels are joined end to end without cross walls, this long tubular structure allows an unimpeded flow of water in a continuous column from the roots to the leaves.
- Pits present in the lignified cell walls allow the lateral flow of water, where necessary, such as in the case of overcoming blockages and air pockets.
- The various patterns of lignin deposits in the side walls strengthen the cell walls in resisting compression and prevent them from collapsing under the large tension forces exerted by the transpirational pull of water.
- The lumen is relatively narrow so that capillarity is maximised thereby helping to raise the water to great heights.
- Lignification of the cellulose cell walls also increases the adhesion of water molecules to the sides of the xylem vessel, which again increases the capillarity effect.

19 Factors are

The availability of soil water

Mechanism	Adaptation	Notes
Reduction of transpiration	Thick cuticle	Reduces transpiration through the cuticle, often shiny thereby reflecting the Sun's rays and therefore decreasing transpiration.
	Depression of stomata	Lengthen gas diffusion path and therefore reduces the diffusion pressure gradient; may trap still, moist air.
	Rolled leaves	The folding lengthens the diffusion path and traps moist air.
	Protective hairs	Traps moist air.
	Leaves small or absent	Small and circular in cross section to give a low surface area to volume ratio and reduction in mass prevents wilting.
	Variations in leaf position	Leaf positions adjusted so that the sun strikes them obliquely; the temperature and therefore the transpiration rate.
	High concentration of solutes in cytoplasm	Reduces evaporation from cell walls.
	Reduction in number of stomata.	Reduces the transpiration rate.
	Succulent stem and possibly leaves	Stores water.
Succulence (increased water storage)	Diurnal closing of stomata	Reduces transpiration.
	Shallow, wide root system near the soil surface	Maximum benefit from light rain.
	Vegetative or asexual propagation well developed	Seed germination requires liquid water.
Extensive root systems		To maximise water absorption.
Resistance to desiccation (drying out)	Increased lignification and reduction in leaves, allows resistance to wilting	Flattened stem is photosynthetic; leaves reduced to spines
	Reduced cell size	Wilting reduced.

The rate of transpiration will be reduced when there is a reduction in the availability of water in the soil for the plant to absorb. A reduction in the amount of water in the soil will decrease the concentration gradient or difference between the soil and the leaf, thereby slowing down the transpiration rate.

Humidity

When the humidity of the air is high, the concentration gradient or difference between the air inside the leaf and the air outside the leaf is reduced. Hence, less water will evaporate and the rate of transpiration is decreased.

Light intensity

During the day time when the light intensity increases, the stomata of many plants will be open due to water entering the guard cells via a process of osmosis down a concentration gradient or difference. The opening of the stomata and the increase in the size of the stomatal pore leads to an increase in the rate of transpiration. In the evening when it is dark, the stomata will close and the rate of transpiration is reduced.

Wind speed

When the speed increased, the water vapour that diffuses out via the stomata is more rapidly removed and this will increase the concentration gradient or difference between the moist air within the leaf and the dry air outside the stomata. Consequently, the rate of transpiration increases. If the wind speed decreases then water vapour will accumulate near the surface of the leaf, hence lowering the concentration gradient or difference. Hence, the rate of transpiration will decrease.

Temperature

As the temperature increases the average kinetic energy and hence speed of the water molecules increases, thereby increasing the rate of evaporation. A greater proportion of the molecules will have speeds equal to or in excess of the escape velocity and form water vapour.

21 Effects on Photosynthesis

Condition	Low level causes transpiration to	High level causes transpiration to	Mechanism by which change occurs
Light intensity	Decrease	Increase	Affects stomatal opening and closing
Humidity	Increase	Decrease	Affects diffusion gradient
Air movement	Decrease	Increase	Affects diffusion gradient. Removes saturated air from stomata. May also cool leaf.
Temperature	Decrease	Increase	Affects kinetic energy and hence movement of water molecules. May affect rate of photosynthesis and therefore have an indirect effect on opening of stomata

Chapter 10

Genetics and Evolution

Section 1

Genetics and Evolution

CONTENTS

Additional material

Gallery 10.1 Images of Evolution (4)

A ‘Darwinian icon’ - the marine iguana (Galapagos islands). All structural and behaviour adaptations of all organisms have evolved by natural selection.

Movie 10.1 The Blue footed booby mating ritual

There are some bizarre behavioral adaptations - disco time!

Movie 10.2 The Flightless Cormorant

This animal is thought to be evolving from cormorant towards a penguin form. Sometimes flightlessness is an advantage!

Internet resources

Under 10.3.2

Real examples of these types of selection are found on

http://wps.pearsoncustom.com/wps/media/objects/3014/3087289/Web_Tutorials/17_A02.swf

A more interactive example which, unfortunately, uses an imaginary species is found on

http://bcs.whfreeman.com/thelifewire/content/chp23/2302001.html

Both sites include some simple test questions and are quite useful to apply the principles explained above.

Answers to exercises

Multiple Choice Questions

1B, 2D, 3C, 4C, 5C, 6A, 7B, 8A.

Short Answer Questions

9 Refer carefully to Figure 1005

Interphase: * DNA replication.

Prophase I: Chromosomes condense.

Nucleolus becomes invisible.

Spindle formation.

Synapsis : homologous chromosomes side by side. (the pair is now called a bivalent, the crossover points are called chiasmata).

Nuclear membrane disappears (sometimes considered as early metaphase).

Metaphase I: Bivalents move to the equator.

Anaphase I: Homologous pairs split up, one chromosome of each pair goes to each pole.

Telophase I: Chromosomes arrive at poles.

Spindle disappears.

Prophase II: New spindle is formed at right angles to the previous spindle.

Metaphase I: Chromosomes move to the equator.

Anaphase II: Chromosomes separate, chromatids move to opposite poles.

Telophase II: * Chromosomes have arrived at poles.

* Spindle disappears.

* Nuclear membrane reappears.

* Nucleolus becomes visible.

* Chromosomes become chromatin.

10 (a) Mendel's second law : law of independent assortment.

Any one of a pair of characteristics may combine with either one of another pair.

(b) Mendel's second law does not apply to linked genes. They inherit together except for those cases where crossing over occurs.

11 (a) wild type colour, wild type wings

(b) All possible phenotypes and genotypes are :

r^+ is red eyes, r is white eyes

w^+ is normal wings, w is vestigial wings

possible phenotypes	corresponding genotypes
red normal	$r^+r^+w^+w^+$, $r^+r\ w^+w^+$, $r^+r^+w^+w$, $r^+r\ w^+w$
red vestigial	r^+r^+ww, $r^+r\ ww$
white normal	$rr\ w^+w^+$, $rr\ w^+w$
white vestigial	$rr\ ww$

Possible genotypes of the parents:

parent	phenotype	possible genotypes
1	white eyes, vestigial wings	$rr\ ww$
2	red eyes, normal wings	$r^+r^+w^+w^+$, $r^+r\ w^+w^+$, $r^+r^+w^+w$, $r^+r\ w^+w$

(c) If both parents are homozygous, that means that parent 1 is rr ww and parent 2 is $r^+r^+w^+w^+$.

The first cross is then simple :

P : white, vestigial x red, normal phenotype

rr ww $r^+r^+w^+w^+$ genotype

rw r^+w^+ gametes

F1 : r^+r w^+w genotype

red, normal phenotype

r^+w^+ r^+w rw^+ rw possible gametes

A Punnett square is needed for the second cross.

PUNNET SQUARE		Red, normal				phenotype parent
		r^+w^+	**r^+w**	**rw^+**	**rw**	gametes
Red, normal	**r^+w^+**	$r^+r^+\ w^+w^+$ red, normal	$r^+r^+\ w^+w$ red, normal	$r^+r\ w^+w^+$ red, normal	$r^+r\ w^+w$ red, normal	
	r^+w	$r^+r^+\ w^+w$ red, normal	$r^+r^+\ ww$ red, vestigial	$r^+r\ w^+w$ red, normal	$r^+r\ ww$ red, vestigial	
	rw^+	$r^+r\ w^+w^+$ red, normal	$r^+r\ w^+w$ red, normal	$rr\ w^+w^+$ white, normal	$rr\ w^+w$ white, normal	
	rw	$r^+r\ w^+w$ red, normal	$r^+r\ ww$ red, vestigial	$rr\ w^+w$ white, normal	$rr\ ww$ white, vestigial	
phenotype parent	gametes					

(d) Genotypes of the F2 :

$r^+r^+\ w^+w^+$: 1 $r^+r\ w^+w^+$: 2 $rr\ w^+w^+$: 1

$r^+r^+\ w^+w$: 2 $r^+r\ ^{w+w}$: 4 $rr\ w^+w$: 2

$r^+r^+\ ww$: 1 $r^+r\ ww$: 2 $rr\ ww$: 1

Phenotypes of the F2 :

red, normal : 9

red, vestigial : 3

white, normal 3

white, vestigial : 1

12 Since haemophilia is a sex-linked trait, boys either display the disease or do not possess the allele. Girls may be carriers, i.e. appear healthy but be able to pass on the trait.

Edward VII was Queen Victoria's oldest son. He did not display hemophilia so did not possess the trait so could not pass it on to his children. Several of Victoria's daughters probably were carriers and passed the trait on to their offspring. Males would display the trait, e.g. Alexis, son of Nicolas II of Russia and Alexandra (granddaughter of Queen Victoria). Daughters could be carriers.

13 (a)

possible phenotypes	corresponding genotypes
grey, straight	$g^+g^+s^+s^+$, $g^+g\ s^+s^+$, $g^+g^+s^+s$, $g^+g\ s^+s$
grey, curly	g^+g^+ss, $g^+g\ ss$
black, straight	$gg\ s^+s^+$, $gg\ s^+s$
black, curly	$gg\ ss$

A heterozygous grey, straight winged fly has genotype $g^+g\ s^+s$.

A black, curly winged fly has genotype gg ss.

P :	grey, straight		black, curly	phenotype
	$g^+g\ s^+s$	x	$gg\ ss$	genotype
	g^+s^+, g^+s, gs^+,		$gs\ gs$	possible gametes

F1	$g^+g\ s^+s$	$g^+g\ ss$	$gg\ s^+s$	$gg\ ss$	genotypes
	grey straight	grey curly	black straight	black curly	phenotypes

(b) The expected ratios for the phenotypes would be

grey straight : grey curly : black straight : black curly = 1 : 1 : 1 : 1

(c) As the ratios found show a much higher occurrence of the parental phenotypes, it suggests that the Law of independent assortment did not apply here, which suggests that the traits are linked.

14 (a). C = coloured, c = albino; G = grey, g = black

possible phenotypes	corresponding genotypes
coloured grey	CCGG, CCGg, CcGG, CcGg
coloured black	CCgg, Ccgg
albino	ccGG, ccGg, ccgg

Parent 1 : homozygous recessive albino : ccgg

Parent 2 : homozygous grey : CCGG

P:	albino	x	grey	phenotype
	ccgg		CCGG	genotype
	cg		CG	gametes
F1:		CcGg		genotype
		grey phenotype		
	CG Cg cG cg			gametes

All F1 have the phenotype grey and the genotype CcGg.

(b) and (c) The predicted ratios of the genotypes of the F2 can be found using a Punnett square. The results will be

CCGG : 1 CcGG : 2 ccGG : 1

CCGg : 2 CcGG : 4 ccGg : 2

CCgg : 1 CcGG : 2 ccgg : 1

(d) and (e). The predicted ratios of the phenotype of the F2 can be found by using a Punnett square. They are grey : black : albino = 9 : 3 : 4

Normally, the phenotypic ratio of this kind of dihybrid cross is 9:3:3:1 but in this case the "albino grey" and "albino black" are both albino and therefore have the same phenotype. Hence the numbers are added, giving the above ratio.

15 Main Points

• The Hardy Weinberg principle can be applied to a population where evolution does not occur. It measures the frequency of each of 2 alleles of a specific gene.

• In humans, albinism is a recessive allele. A person is either homozygous dominant (AA), heterozygous (Aa or aA) or homozygous recessive (aa). If the frequency of allele A is p and the frequency of allele a is q, then the frequency of the homozygous dominant is p2, the heterozygous is 2pq and the homozygous recessive is q2 and p2 + 2pq + q2 = 1.

• When the frequency of the homozygous dominant and homozygous recessive individuals in an interbreeding population are known, then the allele frequency can be calculated.

• If this process is repeated after a suitable interval, then a change in the allele frequency is evidence of evolution.

16. **Directional selection** takes place when one side of the continuum is favoured over the other. Example: Ground finches

on the Galapagos Islands have slightly different sizes beaks. During a drought, the birds with the biggest beaks are able to crack even the hardest nuts to get food. The others will starve sooner because their beaks are not strong enough to crack these nuts so they will have less to eat. After a drought, the average size of the ground finches beaks will have increased.

Stabilising selection is when both extremes are at a disadvantage. Considering skin colour in humans world wide, extremely pale skin and extremely dark skin are at a disadvantage (increased risk of skin cancer and potential lack of vitamin D respectively). The frequency of the extremes will be much lower than that in the middle.

Disruptive selection is the rarest form of selection. It favours the extremes, usually for different reasons. An example could be the length of the bill in a species of duck. Ducks with longer bills can feed from the bottom more effectively while the shortest billed ducks were more effective at scooping food from the surface. Ducks with average sized bills would be less effective in both ways of feeding.

Another example could be in the size of an individual. In times of shortage, the biggest might survive because they are strong enough to ensure they obtain enough food. The smallest would need the least food so might also survive but the average sized individuals may not. Disruptive selection could lead to speciation.

Chapter 11

Animal Physiology

Section 1

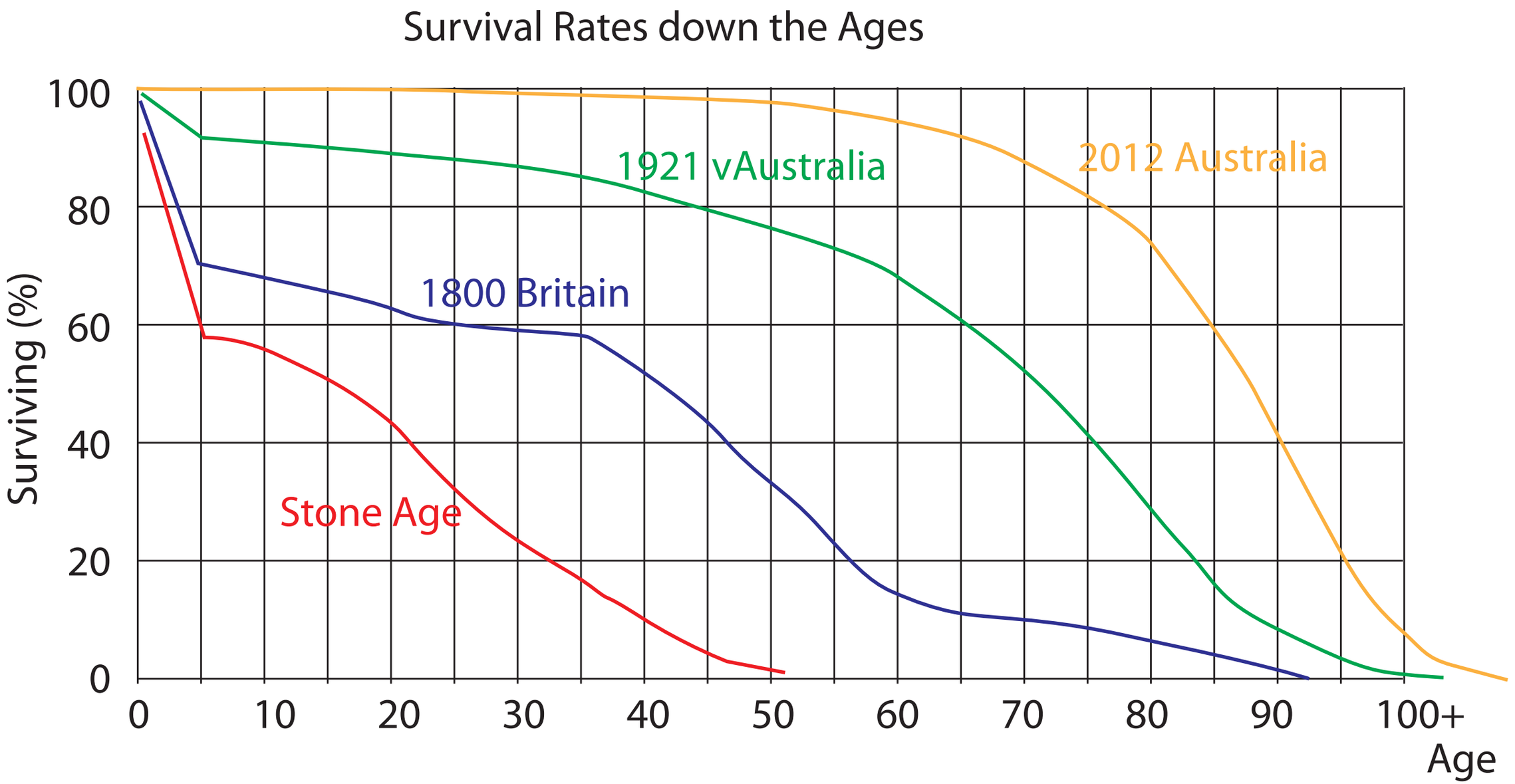
Animal Physiology

CONTENTS

Additional material

Gallery 11.1 Animals Great and Small

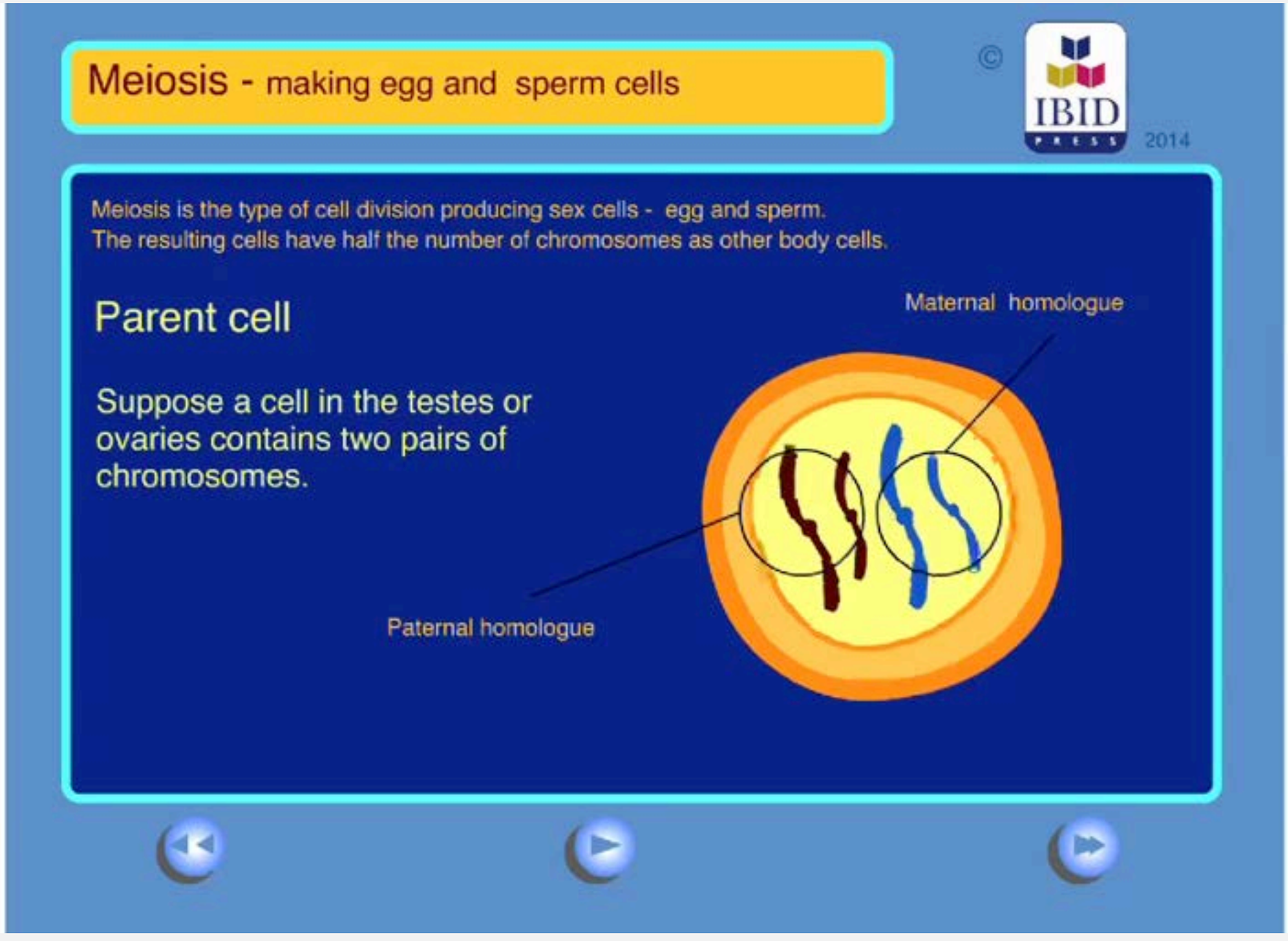
This is a species of 'Darter', sometimes called a 'snake bird'. Do some research and try to explain this unusual behavioural adaptaion.



Source: Foundation for Infinite Survival (Ca); Human Mortality Database; ABS

How well does this graph apply to members of your family, living and deceased?

Movie 11.1 Meiosis



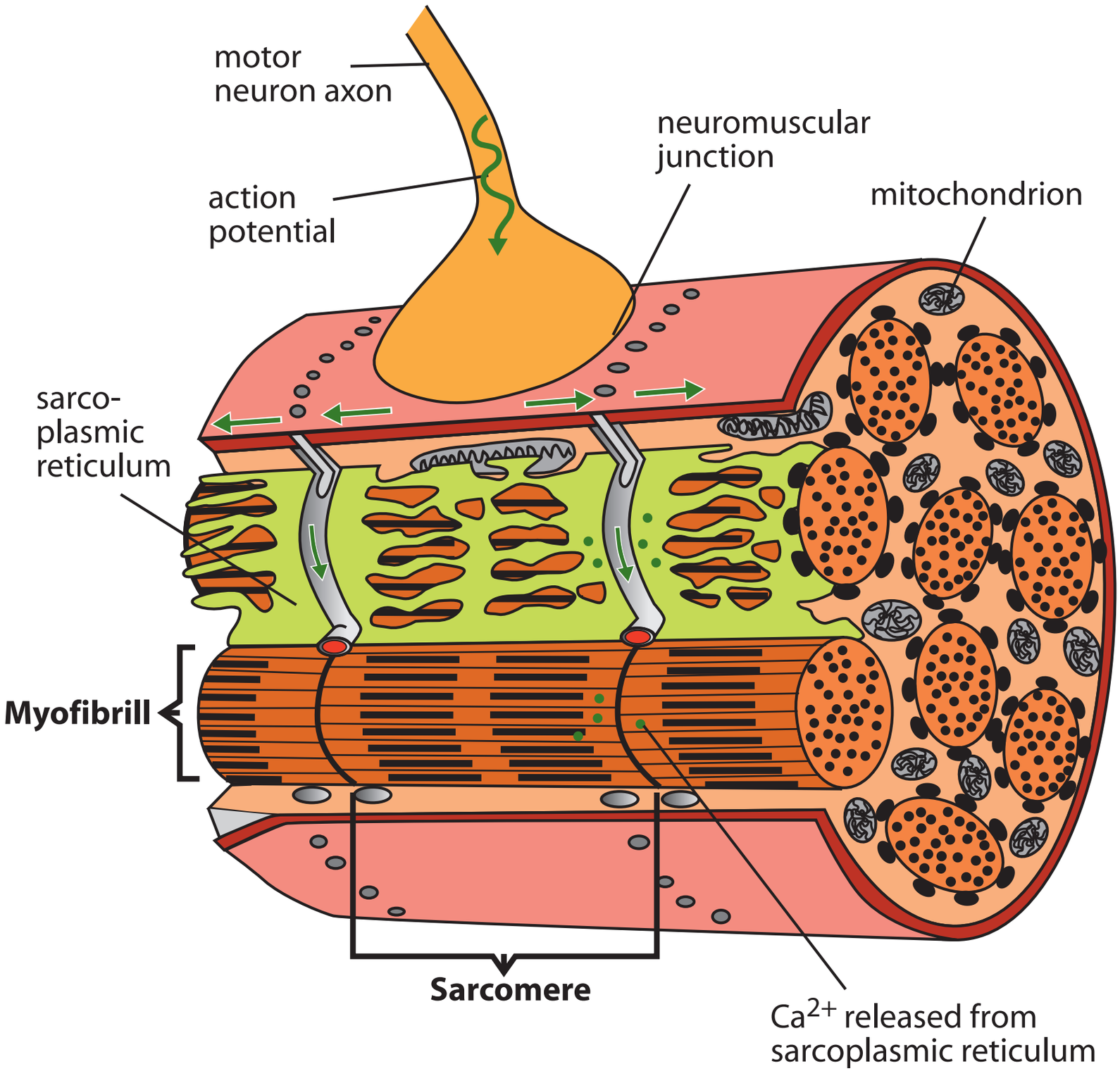


Figure 1135 The structure of a muscle cell

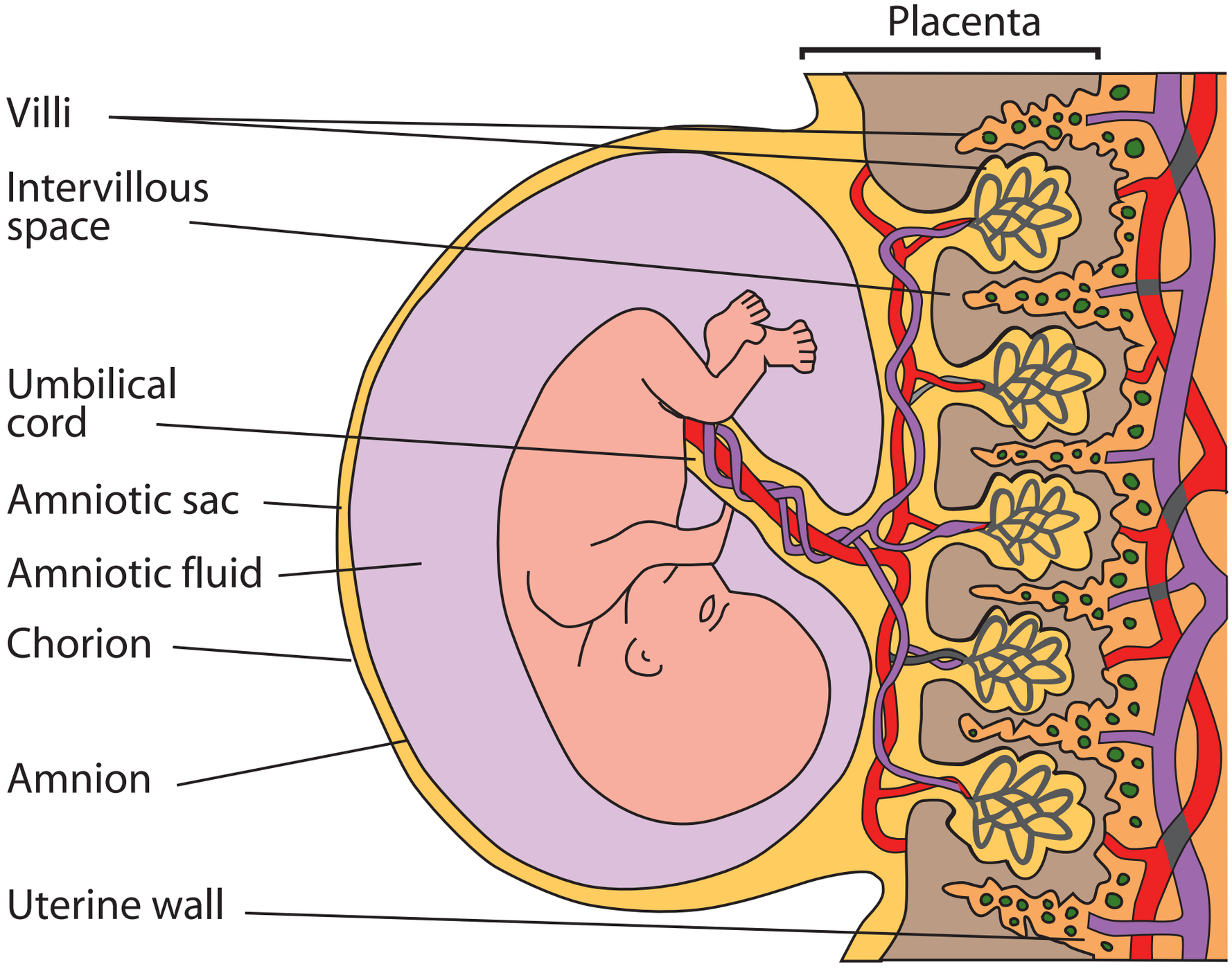
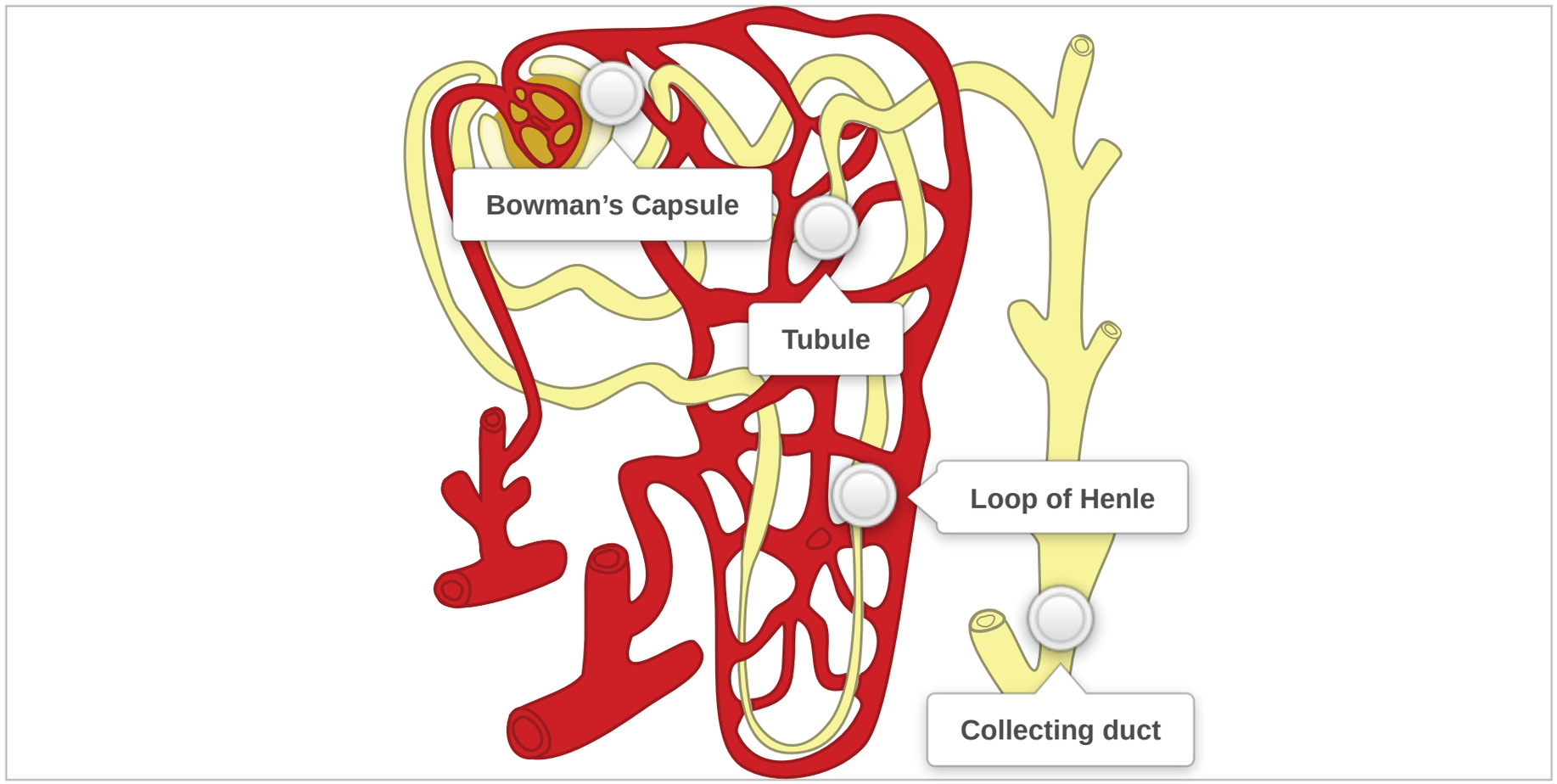


Figure 1193 The structure of the human placenta

Labelling exercise

Review 11.1 The structure of a nephron

Drag the labels to the correct locations



Loop of Henle

Bowman’s Capsule

Collecting duct

Tubule

Check Answer

Internet resources

The history of vaccinations and their effectiveness can be found on

http://www.historyofvaccines.org/content/articles/disease-eradication

Pregnancy tests

A few different techniques exist to create the colour. One is described above. Another is described in the short video below.

http://www.sumanasinc.com/webcontent/animations/content/pregtest.html

Altricial : species whose young need care for some time e.g. human, cats, dogs

Precocial : species whose young are able to feed, walk etc soon after birth e.g. horses, ducks.

http://www.frontiersin.org/neuroanatomy/10.3389/fnana.2011.00004/full

investigates growth of brain

This video shows the contractile vacuole.

http://www.youtube.com/watch?v=vk5NFSvp8lY

Hormones involved in birth are explained at

http://education-portal.com/academy/lesson/childbirth-the-role-of-hormones-in-labor-and-delivery.html

NOTES : not part of the book but possibly relevant

Answers to exercises

Multiple Choice Questions

1D, 2B, 3C, 4A, 5B, 6C, 7C, 8A, 9B, 10D, 11B, 12B, 13A, 14C, 15C, 16D, 17C, 18D, 19B, 20A, 21D, 22B, 23C, 24D.

Short Answer Questions

25 (a) Helper T cells will form a clone and select and activate the correct B cells.

(b) B cells divide to form clones which produce plasma cells and memory cells. Plasma cells produce antibodies against the antigen detected. Memory cells remain present after the infection has passed in order to speed up the production of antibodies in case the antigen is detected again.

26. (a) Benefits :

- total elimination of the disease (e.g. smallpox)
- prevention of pandemics and epidemics
- decrease health care costs
- prevent harmful side effects of diseases (e.g. paralysis after polio or problems with eyesight of the child after rubella infection of the mother.

(b) Dangers :

- some vaccines used to contain the preservative Thimerosal which contains mercury which, at high levels, causes damage to the brain, especially in babies and infants. The preservative was needed to make sure that no other pathogens would grow in the solution with the vaccine. No evidence was found of harmful effects of mercury in vaccinations but as a precaution, it has been phased out of almost all vaccins in the US and Europe. Statistically, the number of people diagnosed with conditions on the autistic spectrum has increased since the 1970 when vaccination became more common. This is a typical example of two events occuring simultaneously without there being clear proof that one is the cause of the other. Studies exist to show a link between the two as well as studies which disprove this connection.
- it is possible to have an allergic reaction to one or more of the components of the vaccine wich can cause swelling.
- vaccines have possible side effects which depend on the vaccine. It is wise to consider these before deciding on vaccination.

27 When a nerve impulse arrives at the muscle, the depolarisation of the motor end plate is passed on to the sarcoplasmic reticulum which causes it to release calcium ions (Ca^{2+}) into the

sacroplasm. The calcium ions attach to the troponin which is attached to the tropomyosin. This uncovers the binding sites on the actin for the myosin hooks. The muscle will now contract.

(a) Ca^{2+} is released from the sarcoplasmic reticulum into the sarcoplasm. The calcium ions attach to the troponin which is attached to the tropomyosin.

(b) When troponin binds to calcium ions, it changes its shape. As troponin is attached to tropomyosin, this then makes the tropomyosin move and uncovers the binding sites on actin for the myosin hooks.

(c) Hooks on myosin will attach to the binding sites on actin. The hooks will then release and repeat the action further down the actin. This is called the ratchet mechanism.

(d) ATP is hydrolysed to ADP. In this process, energy is released which drives the ratchet mechanism.

28 How nerves, muscles and bones work together to cause movement.

- muscles only contract when they receive an impulse from a nerve
- nerve cells carry depolarisations to muscles
- impulse causes release of calcium in the muscle
- muscle contracts
- muscle is attached to at least 2 bones via tendons
- bones are attached to each other via joint and ligaments
- leverage of bone will make the distance of movement of the bone more than the distance the muscle contracted
- bones move relative to each other (using joints)
- different joints allow different kinds of movement
- antagonistic muscles cause opposite movement

29 Comparing the composition of blood in the renal artery with that of the renal vein.

Similarities :

All blood cells and proteins should remain in the blood.

Since glucose and proteins will not be excreted, the amounts should remain the same. However, it is possible that the concentration has increased if water has been removed.

Differences :

	renal artery	renal vein
urea	more	less
oxygen	more	less
carbon dioxide	less	more
salt	usually more	usually less
hormones	more	less
toxins (i.e. poisons)	more	less

30 (a) Oogenesis is the process of forming ova (egg cells).

(b) Mitosis occurs in the germination epithelium. One cell mitotically divides into two, one of them proceeds with oogenesis (the primary oocyte), the other remains as germination cell and can have another mitotic division.

(c) Meiosis reduces the number of chromosomes in the gamete. Since a gamete needs to fuse with another gamete to start a new individual, each gamete must have half the number of chromosomes so that the new organism has the same number as either parent.

(d) Spermatozoa are very small and the 4 spermatids that result from Meiosis I and II can all become spermatozoa. Ova are very large since they need to contain reserve nutrients for the zygote. If each of the cells produced in Meiosis I and II would be an ovum, then each ovum would only contain one quarter of the reserve nutrients of the original primary oocyte. As it is, two or three polar bodies are produced to reduce the amount of genetic material but almost all the cell material goes to one ovum, giving it the best chance to grow out to a new individual if it is fertilised.

31 (a) The process of ultrafiltration is passive, that is, it requires no energy, and involves the forced removal of substances with relatively small molecules and ions from the blood into the Bowman's capsule. These substances are forced through the endothelial pores of the fenestrated capillaries due to the high blood pressure generated due to the diameter of the afferent arteriole being larger than the diameter of the efferent arteriole. The small molecules and ions are forced across to the basement membrane and into the Bowman's capsule to form the glomerular filtrate. The substances that form the glomerular filtrate include amino acids, glucose, water-soluble vitamins, urea and some small hormones. The substances remaining in the glomerular capillary are red and white blood cells, platelets and plasma proteins, for example, albumin, that are too large to undergo ultrafiltration.

(b) Selective reabsorption occurs in the kidney tubule via combination of diffusion and active transport of useful substances from the glomerular filtrate back into the blood. A high degree of selective reabsorption occurs in the proximal

convoluted tubule, which has numerous microvilli to increase the surface area for absorption and a relatively large number of mitochondria to provide ATP required for the active uptake of substances. Chemicals such as glucose, amino acids and ions diffuse from the glomerular filtrate in the lumen to the cells of the tubule. Then, these soluble substances are actively transported from the cells of the tubule and then diffuse into the surrounding capillaries. The constant removal of the substances from the cells of the tubule helps to maintain the concentration gradient for diffusion to continue. Furthermore, as sodium ions are actively transported water molecules are taken up by osmosis.

(c) Kidney dialysis machines operate by the use of a thin and partially permeable membrane where the patient's blood is pumped through in flow direction that is opposite to the flow of dialysate to produce a counter-current effect that ensures an efficient exchange of substances across the membrane. The dialysate has a composition similar to blood plasma, so that useful substances, such as glucose and mineral salts, are prevented from diffusing out into the dialysate. Instead, waste products, such as urea, diffuse out of the blood across the thin membrane into the dialysate down a concentration gradient. This is due to the relatively low urea concentration in the dialysate compared to the blood.

(d) Dialysis differs from ultrafiltration in the kidney, as the dialysate's composition is the same as normal blood to prevent useful substances, such as glucose, from diffusing out of the patient's blood into the dialysate. It allows waste products, predominately urea, to diffuse from the patient's blood into the dialysate down a concentration gradient. However, in ultrafiltration, glucose and urea filter across the basement membrane into the Bowman's capsule down a pressure gradient. In addition, the selection of substances to enter the Bowman's capsule is only according to molar mass (molecular mass) and not due to the presence of a concentration gradient.

Part of nephron	Relation of structure to function
Renal artery	Efferent branch wider than afferent therefore pressure of ultrafiltration is produced.
Glomerulus	Large surface area for filtration
Bowman's capsule	Funnels filtrate into tubule
Podocytes	Reduce resistant to filtrate
Proximal convoluted tubule	Large surface area for absorption of minerals, glucose and amino acids
Loop of Henle	Counter-current multiplier to increase water absorption because of hairpin shape. Sodium pump occurs
Distal convoluted tubule	Large surface area of absorption
Collecting duct	Makes counter-current multiplier possible because urine in it runs opposite way to ascending limb of loop of Henle
Epithelial cells in tubules	Many mitochondria for energy for active transport, e.g. sodium-potassium pump. Microvilli to give large surface area for absorption.

33 (a) HCG is secreted by the trophoblastic cells of the developing embryo

(b) HCG maintains the corpus luteum which produces progesterone

(c) At a later stage, the placenta will start to produce progesterone so the corpus luteum no longer is needed.

(d) Obtain monoclonal antibodies against the HCG (human chorionic gonadotropin). Fix them in place on a testing stick/strip. Add urine to the testing stick/strip. If the HCG is present in the urine (as it will be if the woman is pregnant), it will attach to the antibodies. The test has been so designed that this will give a colour showing a positive test.

34 Main points

- The placenta allows the exchange of soluble substances between the mother and the developing fetus without the two bloods coming into physical contact and mixing. This prevents blood, which may be immunologically incompatible from mixing and clotting. This would lead to blockage inside the vital organs of the fetus.
- Oxygen, water, amino acids, fatty acids, glucose and essential minerals, for example, calcium and iron, and vitamins are transferred from the mother's blood to the fetal blood to nourish the developing fetus.
- Carbon dioxide, urea, bilirubin and other metabolic waste are transferred from the fetal to maternal blood for excretion, thereby preventing harmful and damaging accumulation in the tissues of the fetus.
- The placenta permits certain maternal antibodies (IgG) to be transferred to the fetus, thereby providing the fetus with a degree of immunity. This form of immunity is termed passive natural immunity and is lost following birth.
- The placenta acts as a barrier for the fetus against certain pathogens and the toxins they may possess. However, some viruses, for example, HIV and rubella, and bacteria can cross the placenta and enter the fetal blood stream.
- The placenta prevents the entry of maternal hormones and other substances in the blood that may be harmful to the fetus. However, some harmful substances, for example, alcohol (ethanol), cocaine, thalidomide and nicotine, readily pass through the placenta.
- The placenta permits the maternal and fetal blood systems to function at significantly different pressures, without harming either the mother or the fetus.
- In the later stages of pregnancy the placenta produces several hormones: progesterone to prevent ovulation and menstruation, as well as human chorionic gonadotrophin (HCG) which ensures

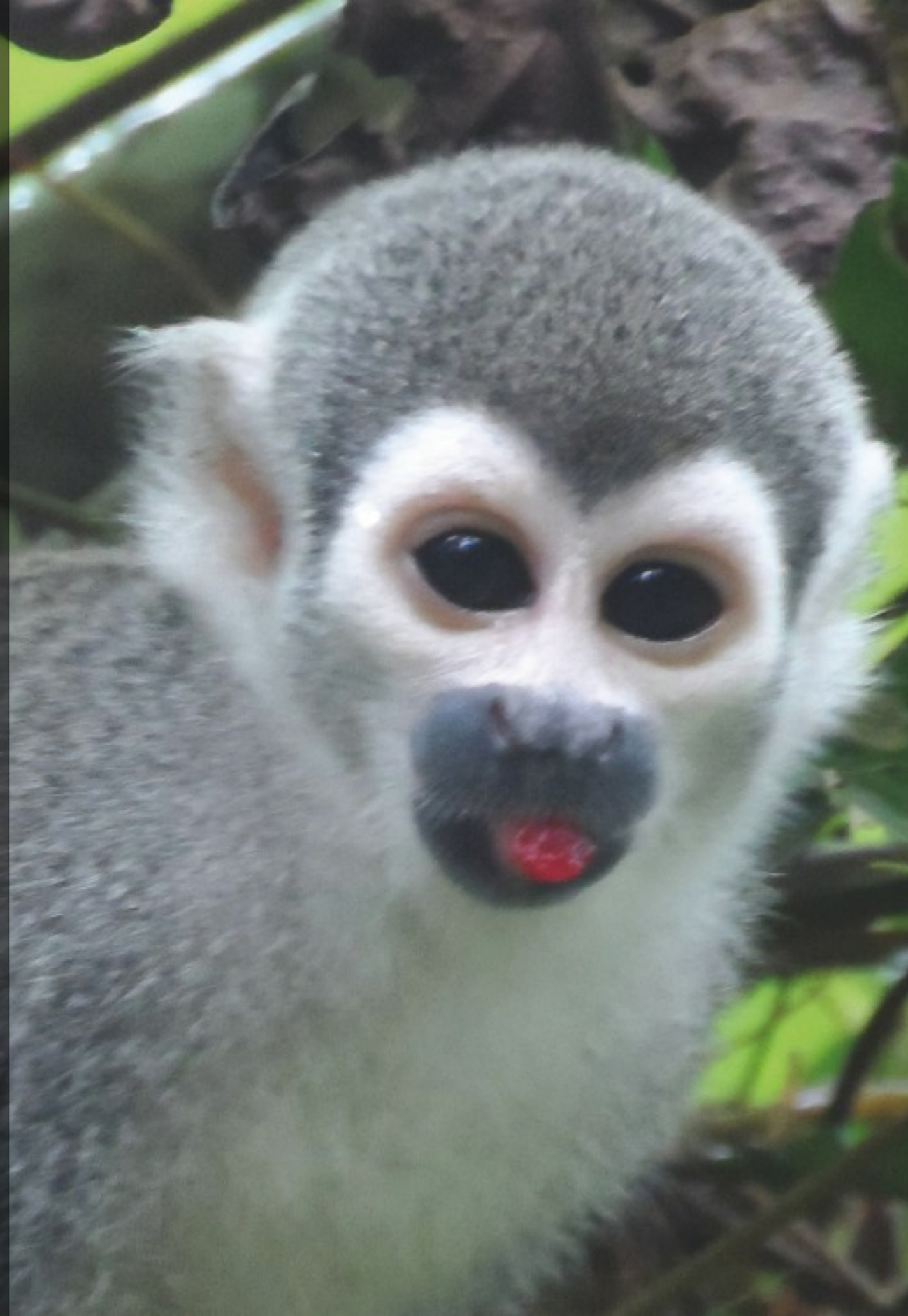
that the corpus luteum continues to produce estrogen and progesterone during the first three months of pregnancy.

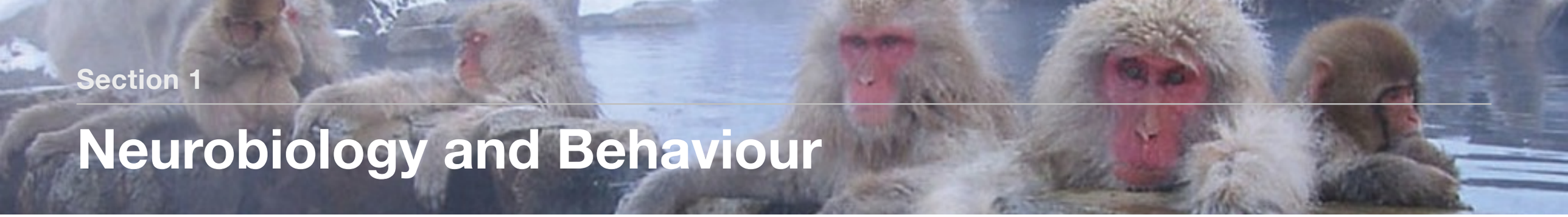
	Male gamete - sperm	Female gamete - ovum
Shape	Composed of three major regions: head containing the nucleus; a mid piece containing mitochondria and a tail (flagellum) concerned with movement.	Spherical shape. Enclosed by an inner plasma membrane and protected by an outer protein coat (vitelline layer).
Relative size	Significantly smaller than the ovum.	Significantly larger than the sperm.
Relative size of nucleus and cytoplasm	Small nucleus and little cytoplasm.	Large nucleus surrounded by a large volume of cytoplasm.
Number produced	Millions of sperm produced each day.	Usually one ovum is released every 28 days.
Mobility	Motile. Able to move due to ATP generation by mitochondria.	Immotile – cannot move. Moved along the oviduct by the sweeping action of cilia and the peristaltic contractions of the wall of the oviduct.

36. Calcium ions from the endoplasmic reticulum cause small vesicles, termed cortical granules, in the cortex of the cytoplasm of the fertilised ovum to releases their contents of enzymes and solutes into the space between plasma membrane and the vitelline layer. The cortical reaction causes the cross-linking of glycoproteins in the *zona pellucida* preventing further sperm entry.

Chapter 12

Neurobiology and Behaviour





Section 1

Neurobiology and Behaviour

CONTENTS

Meerkats are sometimes thought to show 'intelligent' behavior, what does this mean?

Additional material

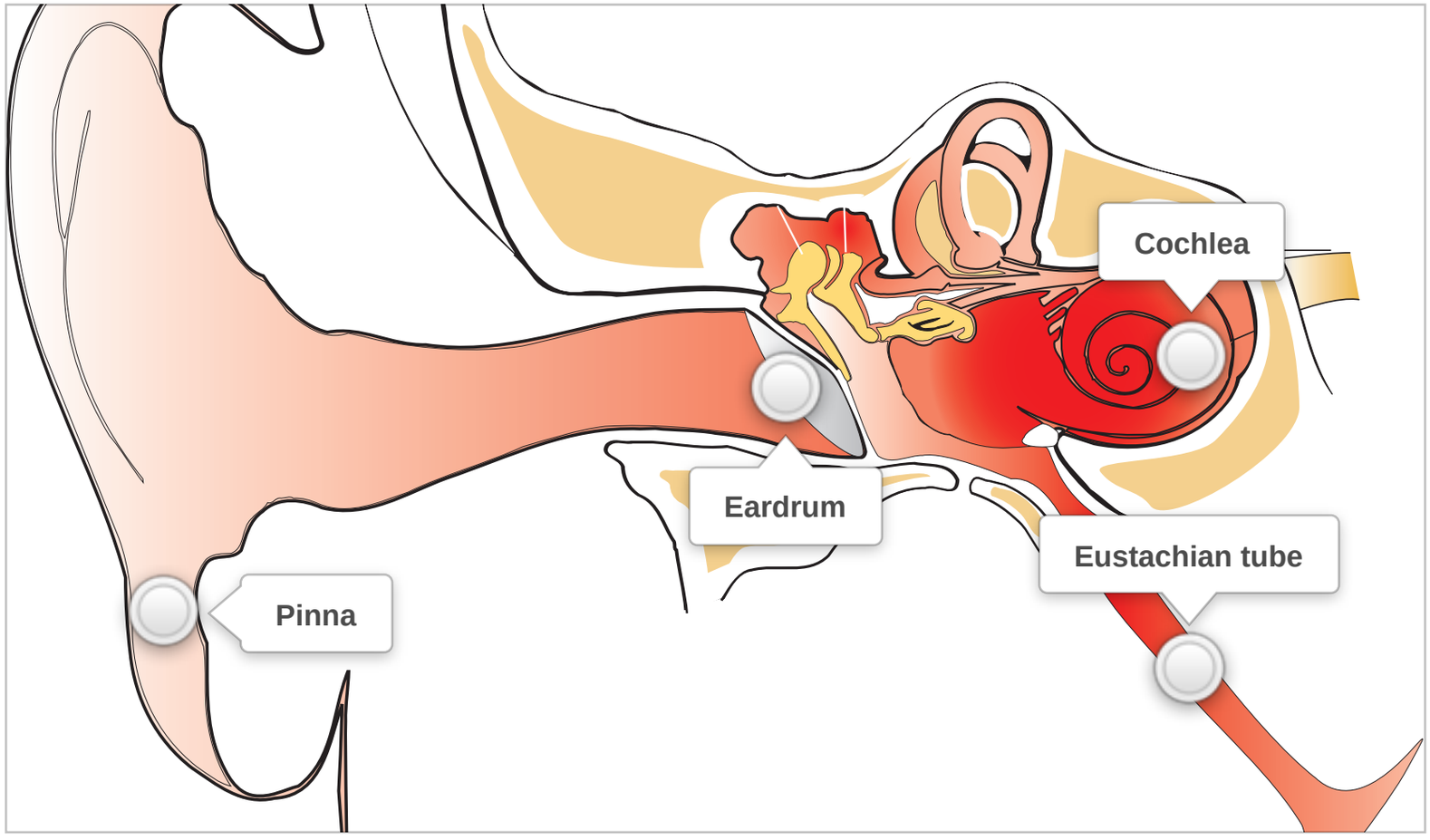
Gallery 12.1 The conflicting need for camouflage and sexual display

Seen in Zambia - an interesting effect in dappled light.

Labelling exercises

Review 12.1 The Ear

Drag the labels to the correct locations



Pinna

Eardrum

Eustachian tube

Cochlea

Check Answer

Internet resources

A1

http://thebrain.mcgill.ca/flash/i/i_03/i_03_m/i_03_m_par/i_03_m_par_alcool.html

http://outreach.mcb.harvard.edu/animations/synapse.swf

Answers to exercises

CORE SUB-TOPICS

A.1 Neural development

1. (a) incomplete closure of the neural tube during embryonic development/failure of convergent extension;

(b) spinal cord

2. Main functions

• formation of myelin and hence formation of white matter;

• formation of the blood-brain barrier;

• guiding growing axons to their destinations within the developing brain;

• secretion of growth factor;

• immune function;

• maintain the chemical environment for neurons;

3. (a) neural tube

(b) ectoderm or ectodermal cells

4. The axon grows from a developing or immature neuron in response to chemical stimuli which is sensed by the pioneer section of the growing axon, called the growth cone; this could be positive or negative chemo-attraction;

the axon growth is guided by radial glial cells which act as 'scaffolds';

5. (a) degeneration and death of unwanted neurons during post-birth neural development;

loss of little used/under used synaptic connections/synapses;

(b) to increase the efficiency of the brain/response to learning;

6. (a) changes in the number of neurons and their synaptic connections.

(b) a stroke or disability e.g. loss of sight, motor neuron disease, learning

7. (a) acts as a relay centre for many reflex actions; acts as conduit for sensory signals from the periphery to the brain and motor signals from the brain to muscles

(b) unable to breathe/ paralysis/unable to move one or more limbs

(c) Possibilities include

• injection of stem cells;

• injection of neuronal growth factors;

• injection of glial cells;

• injection of Schwann cells;

• injection of erythropoietin;

A.2 The human brain

1. (a) sympathetic and parasympathetic;

(b) heart /arteries/digestive system /smooth muscles /salivary glands /iris/bladder;

(c) release of urine from bladder/relaxation of anus;

2. Main points:

• Antagonistic/have opposite or complementary effects or coordinated and reciprocal effects; (right) vagus nerve is parasympathetic; accelerator nerve is sympathetic; vagus nerve and accelerator nerve /both systems lead to the sino-artrial node/ pacemaker and AV node (atrio-ventricular node);

• vagus nerve/parasympathetic system slows the heart rate and accelerator /sympathetic system increases it;

• vagus nerve/parasympathetic system secretes acetylecholine; accelerator nerve/sympathetic system secretes (nor)adrenaline / (nor)epinephrine;

• rate of heart beat depends on relative amounts of stimuli from sympathetic and parasympathetic nervous systems/an increase in one system causes a decreases in the other;

3. Shine light in eye to see if the pupil constricts/becomes smaller;

pupil reflex is a cranial reflex/autonomic nervous system reflex/ controlled by the brainstem;

(if the pupil reflex is not present) the patient is most likely brain dead;

some drugs (barbiturates)/nerve damage may interfere with pupil reflex;

4. (a)

A cerebrum/(left) cerebral hemisphere/cerebral cortex/(left) frontal lobe;

B pituitary (gland); do not accept hypothalamus

C cerebellum; D medulla (oblongata);

(b) breathing control/heart rate control/reflex control/blood pressure control /swallowing/coughing/production of saliva/ vomiting reflex;

(c) the face; the heart; pupil; the neck;

5. (a) the human brain has a more folded cerebrum (neo-cortex);

the human brain has more neurons;

the human brain has more neuronal connections;

the human brain has a greater percentage by mass of the body mass;

the cerebral cortex is more highly developed;

the cerebral cortex forms a larger percentage by mass of the total brain mass;

(b) arboreal/tree living; co-ordination of movement more complex / chimpanzees perform more complicated tasks e.g. simple tool use; more neurons required; e.g. hand-eye co-ordination

6. (a) memory, conscious thought, long-term memory, personality, language

(b) corpus callosum;

7. (a) glucose (do not accept glycogen)

(b) high rate of protein/enzyme synthesis/high rate of active transport

8. Before birth:

• cell proliferation/cell division;

• connectivity/synapse formation;

• myelination

9. Methods of study:

• fMRI (functional magnetic resonance imaging);

• PET (positron emission tomography);

• brain lesions;

• brain injury and disease;

• CT scans

10. An EEG is a record of the electrical activity of the brain, derived from a machine called an electroencephalograph; which receives voltage information from the brain through electrodes attached to the scalp.

Used to diagnose epilepsy, Angelman syndrome and brain tumors, as well as brain death; speech production; lesion studies; patients with damage to this area have an inability to speak/ability to speak a very limited number of words.

11 (a) occipital, temporal

(b) parietal

12. Main points:

• it records changes in blood flow; metabolically active parts of the brain have increased blood flow;

• but not all brain activity is detected by fMRI; a subject is given a stimulus which is designed to stimulate brain activity;

• links stimulus with a certain part of the brain;

• brain activity visualized by coloured images;

• degree of activity can be represented (by different colours);

• temporal activities (i.e. differences in time) can be recorded as well;

• allowing sequential use of the brain to be visualized;

• collaboration between brain parts;

• non-invasive/non-surgical; uses low energy radio waves;

13. Main points

• it is a legal/medical definition of death;

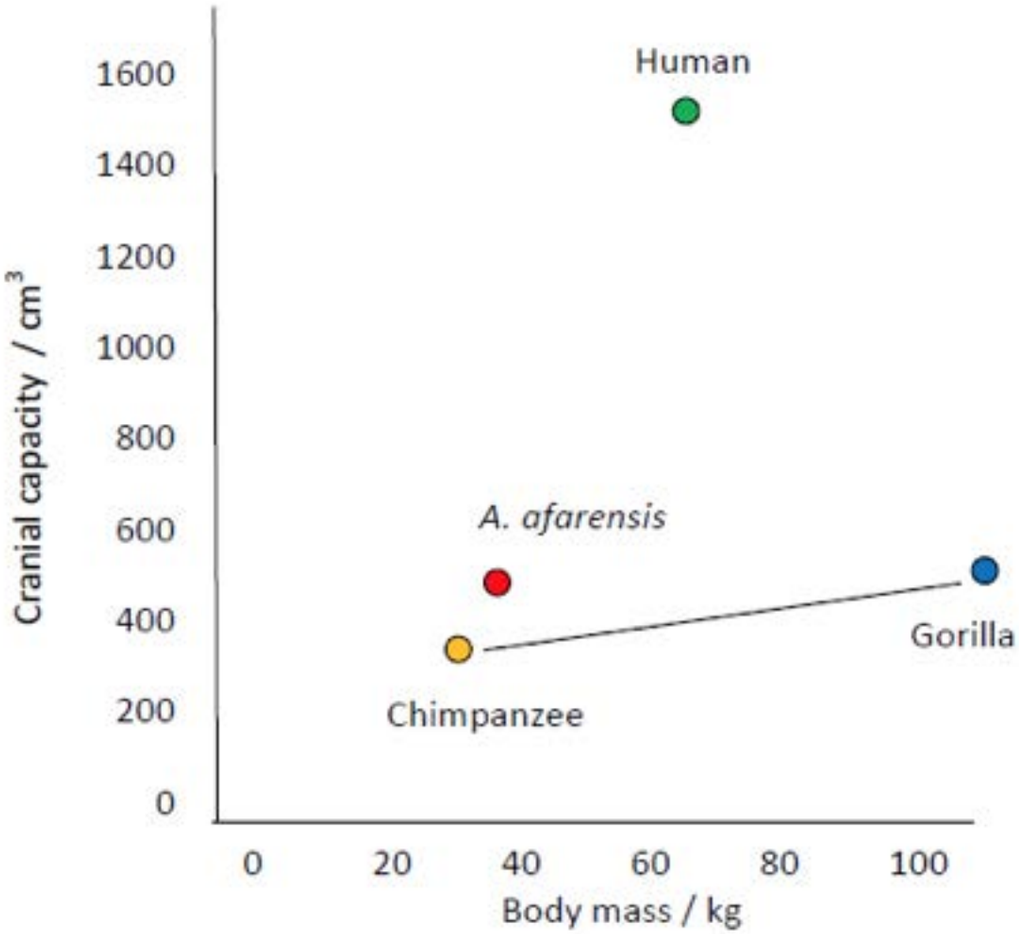
• loss of brain stem/medulla/medulla oblongata functions;

• apnoea/inability to breathe without life support machine;

• absence of brain stem reflexes, e.g. pupil reflex

14.

(a) and (b)



(c) A. afarensis is slightly above the trend line indicating its brain size is slightly larger than expected (compared to the living apes); the human is significantly above the trend line indicating its brain size is much larger than expected (compared to the living apes);

(d) this ratio does not take into the account the folding of the cortex and hence the number of neurons; this ratio does reflect the number of neuronal connections/synapses;

15. (i) occipital, temporal

(ii) parietal

16. Main points

• speech production;

• lesion studies;

• patients with damage to this area have an inability to speak/ ability to speak a very limited number of words;

A.3 Perception

1. (a) chemoreceptors/baroreceptors/thermoreceptors/ photoreceptors/propioreceptors /mechanoreceptors

(b) transform/convert/change energy; convert various types of stimuli into electrochemical energy;

(c) photoreceptor; receptor stimulated by light;

2. Both retinas receive action potentials /stimuli/impulses from left and right fields of vision;

left and right optic nerves cross in optic chiasma;

neurons from both eyes carrying impulses from left field of view go to right hemisphere / vice versa / right field of vision is processed in left side of brain / vice versa;

neurons from the optic nerve/optic tract synapse (in the lateral geniculate nucleus or body) with neurons to the (primary) visual cortex; allowing brain to generate perception of depth, distances and sizes;

3. Main points:

• light received by retinal cells/neurons/bipolar neurons/ photoreceptors;

• passed to optic nerve / cranial nerve II (via optic disc);

• to midbrain/relay neurons/internuncial neurons/intermediary neurons;

• out via motor neurons/cranial nerve III/effector neurons/ oculomotor nerve;

• sympathetic neurons cause radial muscles to contract / pupil to enlarge;

• parasympathetic neurons cause (via ciliary ganglion and ciliary nerves) circular muscles to contract / pupil to reduce;

4. Main points:

• rod cells absorb all wavelengths or frequencies of light/ monochromatic

• whereas cones absorb distinct wavelengths/red, green, blue;

• cones give greater visual sensitivity/acuity/higher spatial resolution than rods;

• rods are more dispersed in the retina than cones / give wider field of vision whereas cones are more concentrated in fovea;

• rod cells are more sensitive to dim light whereas cones function well in bright light; cones recover much faster from a flash of light than rods;

• a group of rod cells are connected to the same (sensory) neuron whereas cones each connect to one individual neuron (differences in convergence);

5. There are three different types of cone cell;

• there are three different forms of the visual pigment (iodopsin);

• each responds to a different (primary) colour /red, blue or green light;

• other colours are perceived by differential stimulation of these three types of cone cells;

6. Humans have three different types of cone cell (with iodopsin pigments);

• cones (with photopigments) can absorb red, green or blue light; (yellow light will result in) equal stimulation of red and green cones;

• which form synapses with bipolar cells;

• which synapse with neurons of the optic nerve;

• which transmit the signal to the visual cortex (in the cerebral hemispheres of the brain);

• where yellow colour is perceived;

7. (a) the blue-sensitive cones are stimulated by the blue light reflected from the cross.

(b) the blue-sensitive rhodopsin has become repeatedly bleached or decolourised; the blue-sensitive cone cells are unable to respond due to fatigue; the white light stimulates the other two types of cone cells present, namely, the red- and-green sensitive cone cells; this combination produces the yellow image, since red and green light (primary colours) form yellow light (secondary colour).

8. Main points:

• cilia on hair cells vary in length; each resonates (naturally vibrates) to a different frequency (energy) of sound;

• complex sounds are resolved into their components;

• inner hair cells send impulse/action potential to the brain/outer hair cells receive signals from the brain (via the auditory nerve);

9. Refer to Figure 1226.

(a) cornea and lens;

(b) choroid;

(c) the fovea;

(d) objects would look flat, i.e., not three-dimensional/not stereoscopic; inability to judge distances accurately;

10. (a) damage to the auditory nerve;

damage to the hair cells in the cochlea;

abnormal or incomplete embryological development;

(b) microphone; battery; magnet; transmitting radio-frequency antenna; microprocessor/computer;

(c) it increases the loudness/amplitude of the sound waves;

directs the sound down the ear canal/auditory canal;

11. (a) Refer to Figure 1238.

(b) (semicircular canals) filled with fluid; hair cells in, ampulla; cupula/gelatinous structure, moves as head moves; refer to inertia of fluid/hair cells/receptors, respond to position of cupula; three, ampullae/semicircular canals, lie in different directions; impulses/action potentials pass to cerebellum/brain;

AHL SUB-TOPICS

A.4 Innate and learned behaviour

1.(a) Pain sensed by receptors/nerve ending in the skin;

impulse/ action potential transmitted/propagated along sensory neuron; to the spinal cord/CNS (cnentral nervous system);

passage through association or relay neuron/neurons; in grey matter;

impulse passed along motor neuron; to muscles;

contraction of muscle pulls limb away from the source of pain;

(b) sensory/receptor cells; sensory neuron with cell body; interneuron/association/realy neuron with cell body; motor neuron

with cell body; muscle/effector; dorsal root/ventral root/ neuron cell bodies;

(c) innate/instinctive/stereotypic; inherited/genetic/inborn; does not require, learning/conscious thought;

reflex/reflex action; searches for mother's breast/feeding bottle;

(d) Automatic; does not necessarily involve propagation to brain/ only spinal cord; same neural pathway used each time; higher brain centres/cerebrum not involved /no thinking;

Rapid:

Only involves three neurons/receptor, relay and effector neuron; myelination/ saltatory conduction between synapses; and two/a few synapses; chemical/synaptic transmission is slow or electrical/electrochemical / nervous transmission is fast;

2. (a) Taxis is a directional response to or away from a stimulus; kinesis involves a random changing directional movement to a stimulus

(b) (random) movement of wood lice to find a moist area;

(c) positive phototaxis / movement to light in honey bees;

(d) kinesis occurs when a simple animal is reacting to/ moving away from, an unpleasant or damaging stimulus; from no particular direction;

Increases speed of random movement/locomotion; increases rate of turning;

example e.g. woodlice in a choice chamber will move from dry to damp conditions; stays away from hostile environment so increases chance of survival and reproducing;

taxis is a directional locomotory response; stimulus from one direction; example e.g. Euglena will move towards light (positive phototaxis);

The animal moves toward a favourable environmental condition/ away from unpleasant stimulus so increase its chance of survival and reproducing;

3. (a) (type of learning) where young form an attachment/ association to an object/ parent shortly after birth;

(b) Lorenz took newly hatched ducklings/baby ducks and showed himself to them; crawled/moved around in front of the ducklings; made/imitated a quacking noise like an adult duck; found that the ducklings imprinted on him and followed him rather than their parents;

4. (unconditioned) stimulus of food/sight of food accompanied by bell ringing; salivation is the (unconditioned) response;

(conditioned) stimulus of bell ringing given before/without unconditioned stimulus/sight of food; salivation became the conditioned response (to the bell ringing)

5. A form of intelligent activity as a function of cognitive effort; in contrast to a more passive trial and error mode of learning; to learn by perceiving how we learn;

6. Rat investigates cage/box/tries to escape; presses lever in Skinner box by chance; food / reward, appears; (positive) reinforcement occurs; repetition; associative learning; trial and error learning

7. Pavlov investigated the alteration/changing of behaviour / conditioning of dogs; whereas Skinner investigated reinforcement of a particular behaviour / operant conditioning;

Pavlov worked with dogs, Skinner with rats (and pigeons);

Pavlov and Skinner investigated behaviour linked to associations;

Pavlov's experiments required two external stimuli, Skinner used one;

8. (a) a motor response that is initiated by an environmental stimulus; and will until continue without further stimuli;

(b) inherited/genetically influenced; performed by all members of a species; limited plasticity

(c) environmental stimulus or cue that initiates a fixed action pattern;

9. (a) habituation / associative learning

(b) no threat; no waste of energy; less physiological stress

A.5 Neuropharmocology

1. (a) Inhibitory psychoactive drug

include benzodiazepine/valium /diazepam/temazepam is an inhibitory psychoactive drug (and hypnotic); it may relax (skeletal) muscle; by enhancing the action of GABA/GABAA;

cannabis/THC causes relaxation / euphoria / enhanced awareness;

inhibitory psychoactive drugs may reduce anxiety/muscle tension;

inhibitory psychoactive drugs may be addictive;

(b) Psychoactive drugs

affect the mind/brain and personality; change/increase synaptic transmission;

(drugs) can block/similar in structure/inhibit breakdown of neurotransmitter;

cocaine/crack; stimulates synaptic transmission of noradrenergic synapses; increased energy/alertness/euphoria;

nicotine; stimulates synaptic transmission of cholinergic synapses; has a calming effect;

amphetamines/ecstasy; stimulates synaptic transmission of noradrenergic synapses; similar effects to cocaine; longer lasting effect /2 to 4 hours;

2. Main Points

- experiences may cause structural changes in neurons; when neural stimulus releases neurotransmitters; which attach to receptors of postsynaptic cell; causing uptake of calcium ions by postsynaptic cells;
- calcium ions activate enzymes; which change shape of dendrite; to allow more connections / more receptors; resulting in new neural 'wiring' of brain / allowing easier transmission of impulse/ action potential across synapse;
- experiences may also cause changes in brain biochemistry; when neural stimulus changes RNA in neurons; causing synthesis of specific memory proteins;
- storage of 'memory proteins' is associated with learned behaviour;
- since protein-synthesis inhibiting drugs can destroy memory;

3. Main points

- neurotransmitters released by pre-synaptic neurons; diffuse across synapse; bind to specific receptors on post-synaptic membranes;
- some neurotransmitters increase permeability of post-synaptic membrane to positive ions; causing localized depolarization; which helps an action potential to form / raises membrane above threshold; e.g. acetylcholine or other example;
- others cause negatively charged chloride ions to move across post-synaptic membrane into the cell / K^+ moves out of the post-synaptic nerve cell; e.g. GABA / other example; leading to hyper-polarization; which inhibits action potentials;

4. Endorphins

- are produced by the brain;
- they are neurotransmitters;
- their action is inhibitory;
- they act as pain killers;
- they have specific receptor sites / receptor sites which accept/ interact with opiates;
- they are produced at times of stress (e.g. labour/birth);

• they open K+ channels and close Ca^{2+} channels/cause a net positive outflow/ prevent reaching threshold on post-synaptic membrane;

• medical use: pain killer (analgesic)

5. (a) GABA glutamate/glutamic acid

(b) There are two types of neurotransmitter receptor: ligand gated ion channels which open almost instantaneously; and G-protein coupled receptors which exert their effects through intracellular signaling pathways; GABA activates $GABA_A$ and glutamate activates AMPA and NMDA receptors; the latter are excitatory, while $GABA_A$ receptor activation is inhibitory

6. (a) increased number of Ca^{2+} channels; change in voltage dependence of Ca^{2+} channels; increased number of vesicles; increased transmitter per vesicle;

(b) increased number of receptors; different kind of receptor with higher conductance; closing of K^+ channels to reduce hyperpolarization of the post-synaptic cell;

7. Addictive drugs trigger secretion of dopamine which causes feelings of pleasure/well-being/reward /users become dependent on feelings; genetic predisposition is most common with addiction to alcohol;

Social factors affect the incidence of addiction; it is not certain that a person who is genetically predisposed will develop addiction when exposed to the drug; although many drugs are (potentially) addictive, not every user becomes an addict.

Risk factors include:

e.g.cultural traditions/peer pressure; social deprivation /traumatic life experiences/mental problems

8. (a) to act as a control to ensure the results are solely due to phenserine;

(b) mean number of errors reduced in subsequent trials; in all trials rats with phenserine had fewer errors in maze navigation;

(c) main points

• improves short-term memory inhibits action of acetylcholinesterase in synapses;

• slows down decrease in acetylcholine concentration/retains some acetylcholine at synapses/slows breakdown of acetylcholine;

• in parts of brain associated with memory; improved short term memory;

9. Main points

• affects ability to concentrate;

• loss of motor/ muscle control;

• impairs perceptions / painkiller / loss of time sense;

• memory loss;

• relaxed attitude;

• increased appetite;

• depression;

10. (a) a local anaesthetic is a drug that results in the absence of sensation in a part of the body; there is no loss of consciousness a general anaesthetic is a drug that causes a reversible coma/loss of consciousness; there is complete absence of sensation/ reflexes;

(b) Novocaine; injection or cocaine; topical halothane/ketamine; inhaled or propofol; injected

(c) local anaesthetics prevent transmission of nerve impulses; they bind to sodium channels/fast sodium channels and block the open channel from the inside; general anaesthetics activate inhibitory CNS receptors and inactivate excitatory CNS receptors; activate GABA/GABAA/glycine receptors;

A.6 Ethology

1. Raise young geese/goslings away from their parents;

• if they migrate normally it is innate behaviour;

• if they migrate in a different way/do not migrate it is learned behaviour;

2. In response to a change in the environment;

• there is genetic variation and heritability in behavioural patterns; those that show the selected/favoured behaviour survive; pass on genes to offspring;

• trial and error learning not possible or limited; individuals live alone/have short life time and cannot learn from others; example: taxis, kinesis, courtship, etc.;

3. There must have been genetic variation in the memory skills of individuals; individuals that were better than average at remembering must have been able to pass on their abilities to their offspring via inheritance; birds that were better than average at remembering songs must have had more surviving offspring on average than the typical sparrow at that time;

4. It is about optimizing the trade-off between costs and benefits; with the assumption that evolution will have reached some sort of equilibrium that cannot be bettered; and that foraging profitability

is linearly correlated with lifetime reproductive success in terms of the number and quality of offspring produced.

5. This experimental design separates the effects of genetics and the parental environment;

6. The hybrid is consistent with an intermediate but non-dominant inheritance;

of one more alleles (multiple alleles);

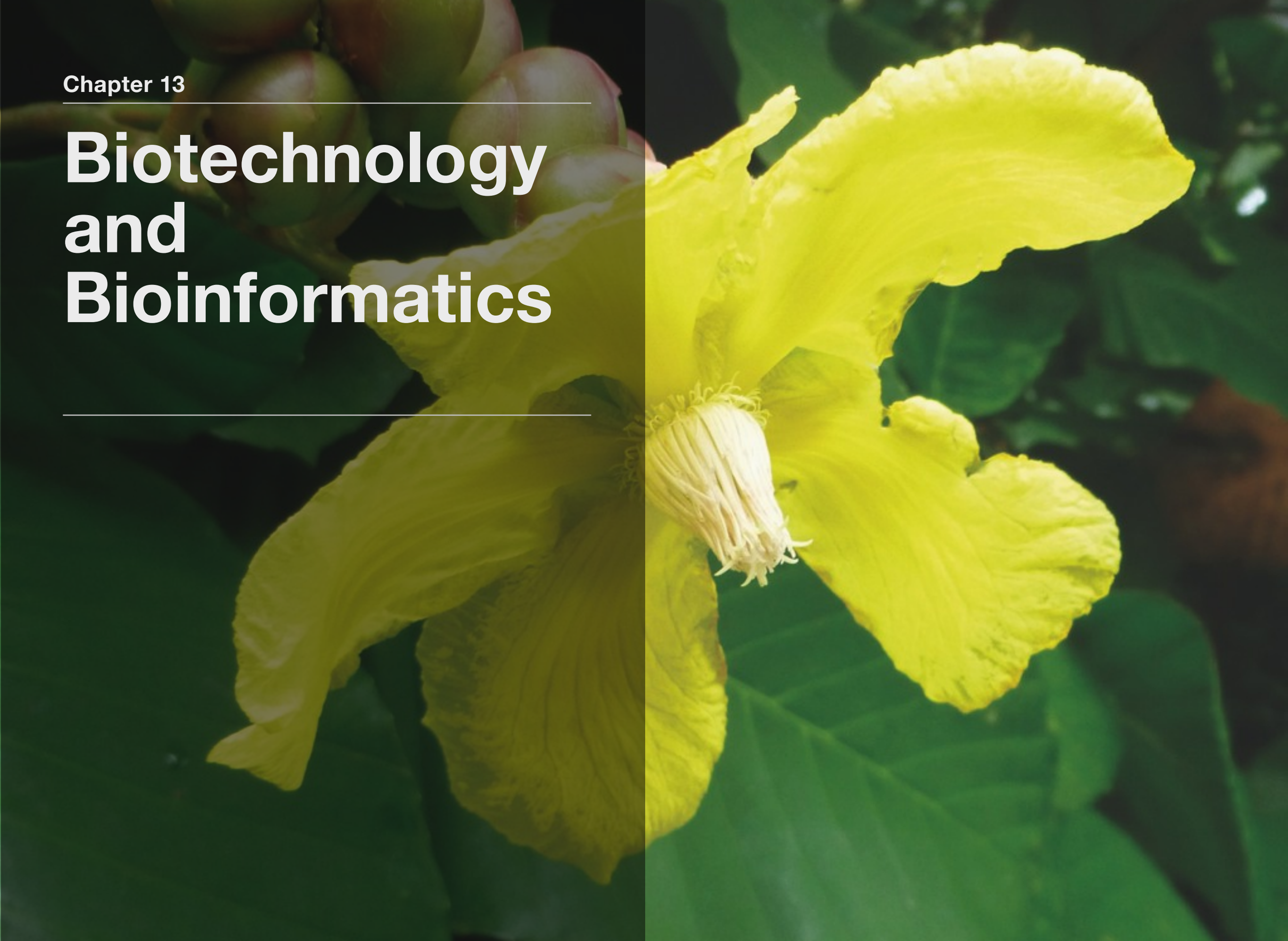
7. (a) Reciprocal altruism is a behaviour whereby an organism acts in manner that temporarily reduces its fitness; while increasing another organism's fitness; with the expectation that the other organism will act in a similar manner at a later time

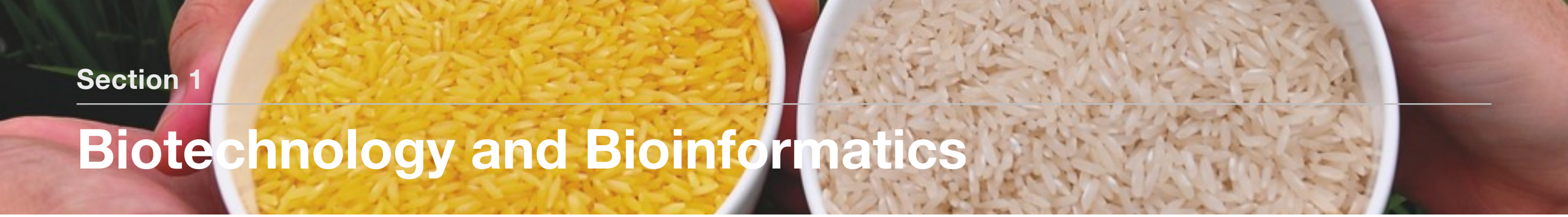
(b) 'Cheaters' must be detectable and refused cooperation; there must be many opportunities for unrelated organisms to interact repeatedly; individual recognition within the group;

8. Acts on mating success; individual advantage over others of same sex and species with regards to reproduction; subset of selection can lead to evolution traits that hinder survival, but improve overall fitness

Chapter 13

Biotechnology and Bioinformatics





Section 1

Biotechnology and Bioinformatics

CONTENTS

The use of domestic animals to produce drugs is called 'biopharming'

Additional material

Breweries and wineries.

Both industries now use bio-technology to enhance quality and quantity of the products.

Internet resources

This is a very new topic so not much here apart from the websites listed

- Recent research in to producing stem cells from somatic cells by acid shock can be found at http://www.genengnews.com/gen-news-highlights/acid-shock-converts-adult-b-cells-b-to-b-stem-b-b-cells-b/81249434/

-

- Quite a few Company/University websites are mentioned in the chapter

Clustal Omega

https://www.ebi.ac.uk/Tools/msa/clustalo/

ORF Finder

http://www.ncbi.nlm.nih.gov/projects/gorf/

Swiss Prot

http://web.expasy.org/docs/swiss-prot_guideline.html

Genbank

https://www.ncbi.nlm.nih.gov/genbank/

BLAST

http://blast.ncbi.nlm.nih.gov/Blast.cgi

Ensemble

http://www.ensembl.org/index.html

CORE SUB-TOPICS

B.1 Microbiology: organisms in industry

1. The cell envelope of Gram negative bacteria consists of three layers: inner (or cell) membrane, a single peptidoglycan (murein) layer and outer membrane;

The cell envelope of Gram positive bacteria consists of an inner membrane and multiple layers of peptidoglycan (murein);

2. The cell envelope of Gram negative bacteria contains a single layer of peptidoglycan (murein); during the de-staining step of the Gram procedure, bacteria are treated with alcohol; that dissolves the outer membrane and also disrupts the single layer of peptidoglycan (murein), removing the crystal violet bound to it;

3. Main points:

- removal of feedback inhibition by amino acids on key enzymes in the pathway;
- overexpression of similar enzymes that are not feedback inhibited; removal of competing metabolic pathways;
- enhanced carbon production from the biosynthetic pathways involved in central metabolism;
- removal of any transcriptional repression (negative regulation) of the genes involved in the pathway;
- add more copies of the genes that need high levels of expression;

4. Use of living organisms/biological agents/animals/plants/cells/enzymes/fungi/microorganisms; e.g. to produce useful products/produce foods/produce medicines/produce chemicals/process other materials/treat waste; in fermenter/culture vessel

5. methanobacterium /methanococcus/methanothrix;

(anaerobic) respiration / fermentation; (produces) methane and carbon dioxide; with traces of H2S/H2O/H2;

6. Refer to Figure 1345

activated sludge/trickling filter; aerobic bacteria digest organic matter; aerobic bacteria respire/metabolise organic matter; insect larvae/protists (protozoa), feed on bacteria insect larvae/protists (protozoa), form a layer/biofilm on surface of stones

7. A and E; the original strain of the bacterium requires only amino acid 1 because it has all the functional enzymes (A to E) that can convert the amino acid into the other essential amino acids (2 to 6); since the mutant strain of bacterium can only survive when provided with amino acids, 1, 2 and 5, it means that it does not

have enzymes A and E that could convert amino acid 1 to 2, and amino acid 4 to 5

8. (a) Continuous culture is not suitable because:

• (penicillin) is secondary metabolite; produced at start of /during stationary phase/end of growth phase;

• production (at maximum) when kept short of nutrients

• depleting factors limiting growth;

• continuous culture maintains in, log /rapid growth, phase;

(b) will affect enzyme activity/metabolic rate; addition of buffer/ acid/ alkali/base

B.2 Biotechnology in agriculture

1. (a) micro-injection/peri-nuclear injection

(b) liposome

2. It naturally transfers part of its tumour-inducing (Ti) plasmid to dicot plant cells;

the Ti plasmid contains virulence genes and the transfer DNA (T-DNA);

the only regions of the T-DNA that are required for transfer are the border sequences and the region in between the border sequences can be replaced by any required DNA sequence without interfering with T-DNA transfer;

3. Overcoming the species barrier between plants; the precise introduction of a single gene; the simultaneous introduction of multiple genes from a metabolic cycle; tissue-specific expression

4. Main reasons:

• Farmers can choose the optimal time to spray/only need to spray once; less glyphosate is needed; compared with selective weed killers; using fewer chemicals is beneficial for the environment;

• reduces/saves energy;

• lower/less use of farm machinery;

• higher crop yield;

• improved crop quality;

• increased efficiency in terms of less manpower;

5. (a) initial/starting levels, normal higher than genetically modified plant;

• normal/unmodified has a more rapid rise from 0-4 days;

• normal/unmodified reaches much higher level at 4/8 days;

• normal stays same level from (approximately) 4-8 days/while genetically modified plant rises slightly;

• normal/unmodified drops again after 7/8 days/ genetically modified plant continues to rise after 7/8 days;

(b) start later; happen more slowly;

(c) not ripe/green when picked; long shelf life; will not over-ripen; do not ripen too quickly; do not become squashy or soft/firmer;

B.3 Environmental protection

1. Two of these methods:

• plate the bacteria on agar with benzene present as the sole carbon source, look for growth;

• use an enzyme assay to look for the presence of an enzyme that is known to degrade benzene;

• use a lab test in a closed flask, add radiolabeled benzene, look for radioactive 14CO2 production; compare to control of killed bacteria

2. Two of these reasons:

• Bioremediation is often much cheaper than physical or chemical methods; some bioremediation methods have the ability to degrade pollutants in situ (on site) without major disruption; may improve soil fertility and structure compared to physical and chemical methods which may damage the soil;

• bioremediation uses non-toxic and naturally occurring agents;

• bioremediation is theoretically useful for the permanent elimination of pollutants by mineralisation to carbon dioxide and water; physical and chemical methods often involve transporting or converting the pollutant into another form

3. Extracting samples of the contaminated soil (or groundwater); extracting the pollutant using a solvent and measuring it using a chemical or analytical technique (e.g. infra-red spectroscopy (IR) or gas chromatography (GC); this should be done at two different times and the results compared;

4. (a) bacterium obtains energy; for synthesis of chemical substances; for, growth / division/binary division; does not need to use carbon compounds for release of energy;

(b) takes up large surface area; unsightly/spoils view; requires large amount of water /continuous water supply; contamination of water /pollution due to acid ; copper, Cu /iron, Fe, toxic/ poisonous to plants;

(c) low level technology/no sophisticated machinery/requires less maintenance; low energy consumption/less fossil fuels used; few safety hazards/safer; no hazards; organism easy to obtain/culture; self replicating/multiplies; waste less hazardous; disposal of waste, costs less/is easier; low grade/low purity ores/scrap iron; less workers needed; use in situ;

5. (a) Refer to Figure 1344

(b) Bacteriophage has only one type of nucleic acid/DNA, bacteria has both DNA and RNA; bacteriophage has protein outer covering/ bacteria has cell wall/ peptidoglycan (murein) outer surface; bacteriophage has no membrane organelles/cytoplasm/ membranes; bacteria have ribosomes/organelles/cytoplasm/cell (or surface) membrane;

(c)To infect and lyse harmful water-borne bacteria;

AHL SUB-TOPICS

B.4 Medicine

1. Refer to Figure 1350. Quantifies the amount of mRNA; measures expression levels of thousands of genes simultaneously;

2. (a) denature; anneal/hybridise; extension; repeat; electrophorese/electrophoresis

(b) DNA strands are separated; free nucleotides are used; DNA polymerase enzymes are required;

3. (a) viral DNA carries normal allele/gene/ recombinant DNA; virus binds and fuses (with lung cells); viral DNA put into/ incorporated/integrated, (lung) cells/host DNA;

(b) translation will not occur normally; no amino acid added to chain when stop codon reached; protein chain not completed / protein only partially made/truncated protein;

(c)

Drug	Gene therapy
can be taken orally/ by mouth	delivered (by vector) into respiratory tract
self administered	requires medical treatment
is readily taken up by cells	poor take up by cells
no vectors needed / fewer, lesser no side effects	possibility of side effects (from vectors) / named side effect
only needs to enter cytoplasm of target cell	difficulty in integrating gene into host DNA
no need to switch on gene	difficulty in switching on gene

4. Variation of DNA sequences between diseased or mutant allele and the normal allele results in the formation (or deletion) of a restriction site; after DNA is digested (with DNAases) from the patient (with disorder or disease), different lengths of restriction fragment are produced; after gel electrophoresis (and Southern blotting), the patient and normal individual will show different band patterns (on photographic film);

5. Genetic, testing / screening; for inherited disease/disorder; (test to see if) individual is carrier; premarital testing / predict if (potential) offspring may inherit the disease/disorder; prenatal testing before birth with possibility of termination; embryo selection (to ensure embryo healthy/viable); (test for genes that contribute to) diseases that develop later in life; those with genes given, advice to limit effects/counselling;

faster/earlier, diagnosis; develop more, effective/efficient, drugs (to reduce symptoms of disease/disorder); drugs have direct effect, on genes/protein made from specific gene / gene therapy / replace with functioning gene; use of gene probes/biopsy; allows targeting of drug treatment;

6. Antibodies are produced by body/immune system; during immune response to infection/pathogen; antibodies can be linked/covalently bonded to enzymes; when body recognizes antigen (in blood sample or other tissue) it binds to it/interacts with it; the attached enzyme brings about a colour change (or other observable or measurable effect) detecting bacteria, virus e.g. HIV or antigens.

B.5 Bioinformatics

1. DNA, RNA, protein sequences, molecular structures, gene expression data

2. Increasing rapidly, doubling, increasing exponentially

3. (a) A query sequence (of DNA or protein) is entered; it scans the query for ‘hits’ in various databases; it carries out alignment/ basic alignment; displays similar sequences

(b) Identify an unknown sequence; build a phylogram or cladogram; establish likely functions of a protein; map a sequence in a genome

4. (a) Arrangement of two or more DNA or protein sequences; that minimises the number of differences between them

(b) Determine how pathogens harm host/determine mechanisms of virulence; determine evolutionary relationships between organisms/protein or DNA sequences;

5. (a) insertions; deletions

(b) conserved

6. BLASTn is used for comparing nucleotide sequences; BLASTp is used for comparing protein sequences;

7. (a) A partial sequence; of a cDNA or complementary DNA sequence

(b) Gene structure prediction; gene discovery; genome mapping; evolutionary studies

8. (a) Homologous;

(b) They are both derived from a common ancestral sequence;

9. (a) A technique for selectively inactivating a gene by replacing it with a mutant in an otherwise normal organism

(b) A mouse and a human have similar DNA sequences in their genomes; the genes are often homologous and have similar functions;

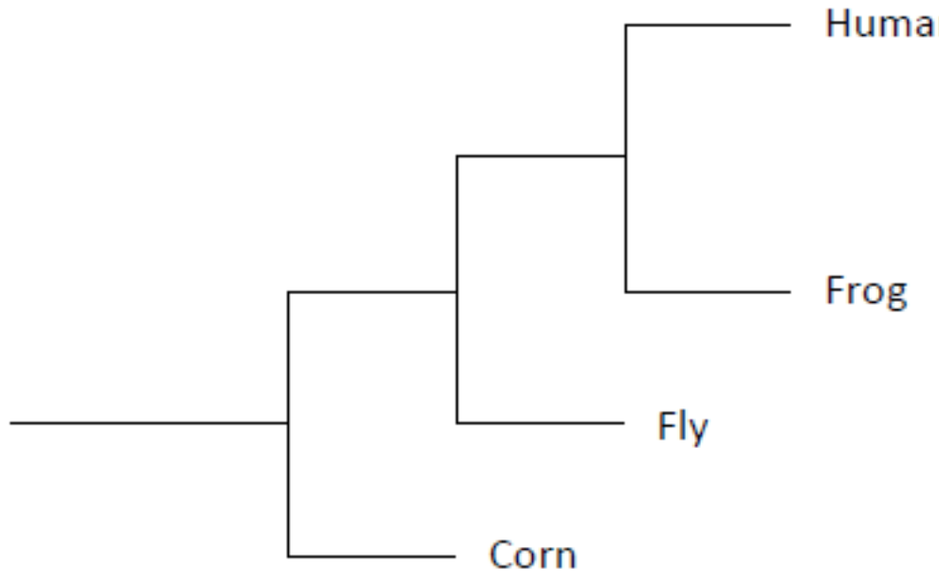
(c) Mutant alleles are introduced by homologous recombination into mouse embryonic stem cells; embryonic stem cells containing a knockout mutation in one allele of the gene being studied are introduced into early mouse embryos to produce chimeras; chimeric mice are mated to establish whether the mutation is incorporated into the gametes/germ line; mice heterozygous for the knockout mutation are mated to produce homozygous knockout mice;

10. (a) non-template strand:
5′GCCATTACATGGTGCACTCCACCTAGGACTCACTC

template strand:
3’CGGTAATGTACCACGTGAGGTGGATCCTGAGTGAG

(b) the DNA would contain introns separating the exons (segments of coding sequence) that are spliced out of the mRNA during processing

11.



12. Main reasons are:

- humans are eukaryotes/Escherichia coli is a prokaryote;
- humans/eukaryotes have larger proteins/genes/presence of introns; ‘junk’ DNA /non-coding DNA;
- repeating sequences/ repetitive DNA; centromeres (for chromosome pairing)/telomeres (at ends of chromosomes); fossil genes;
- E. coli cell much smaller; more intense natural selection for less waste of space within cell/ more compact genome;

Chapter 14

Ecology and Conservation

Section 1

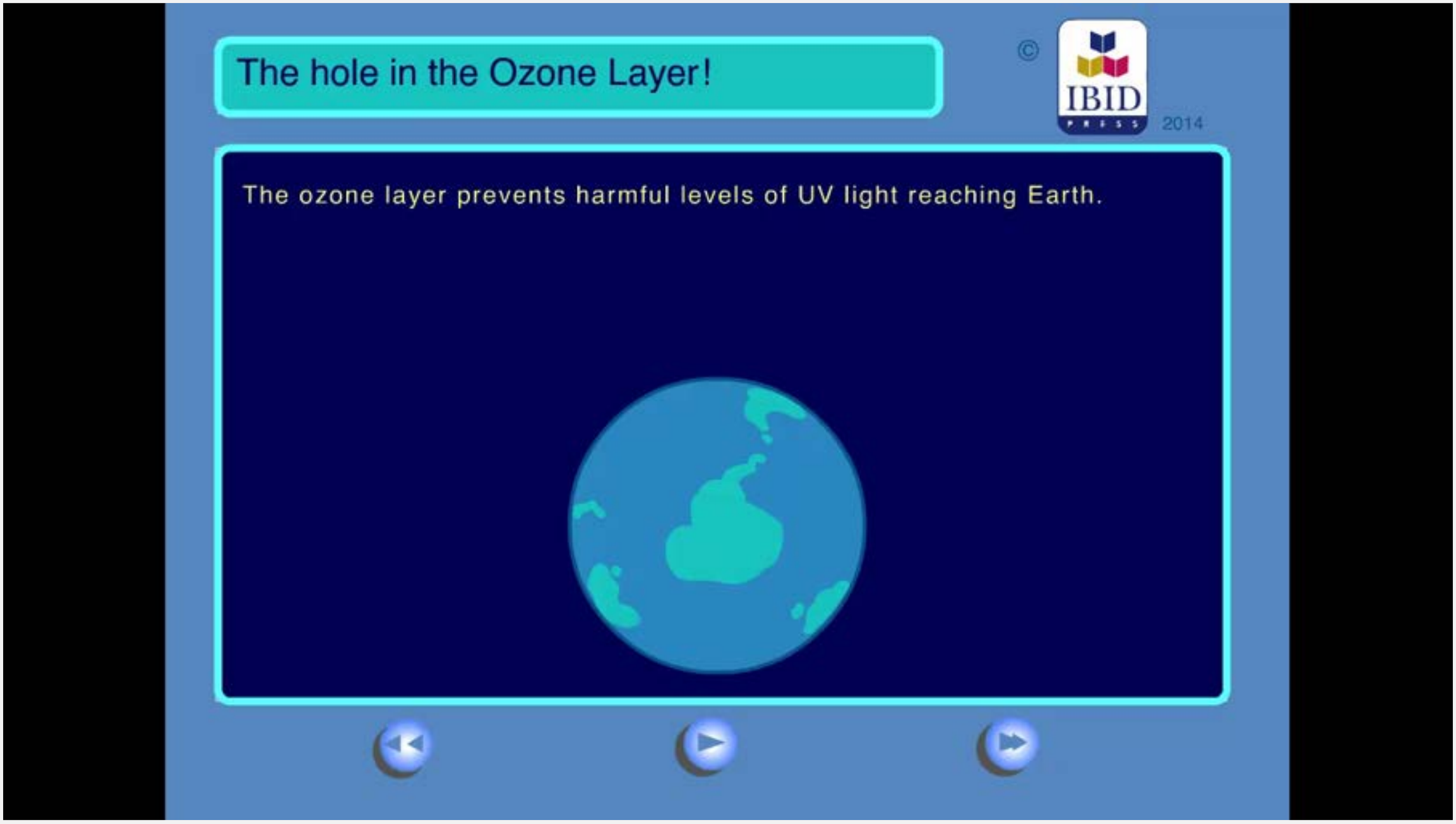
Ecology and Conservation

CONTENTS

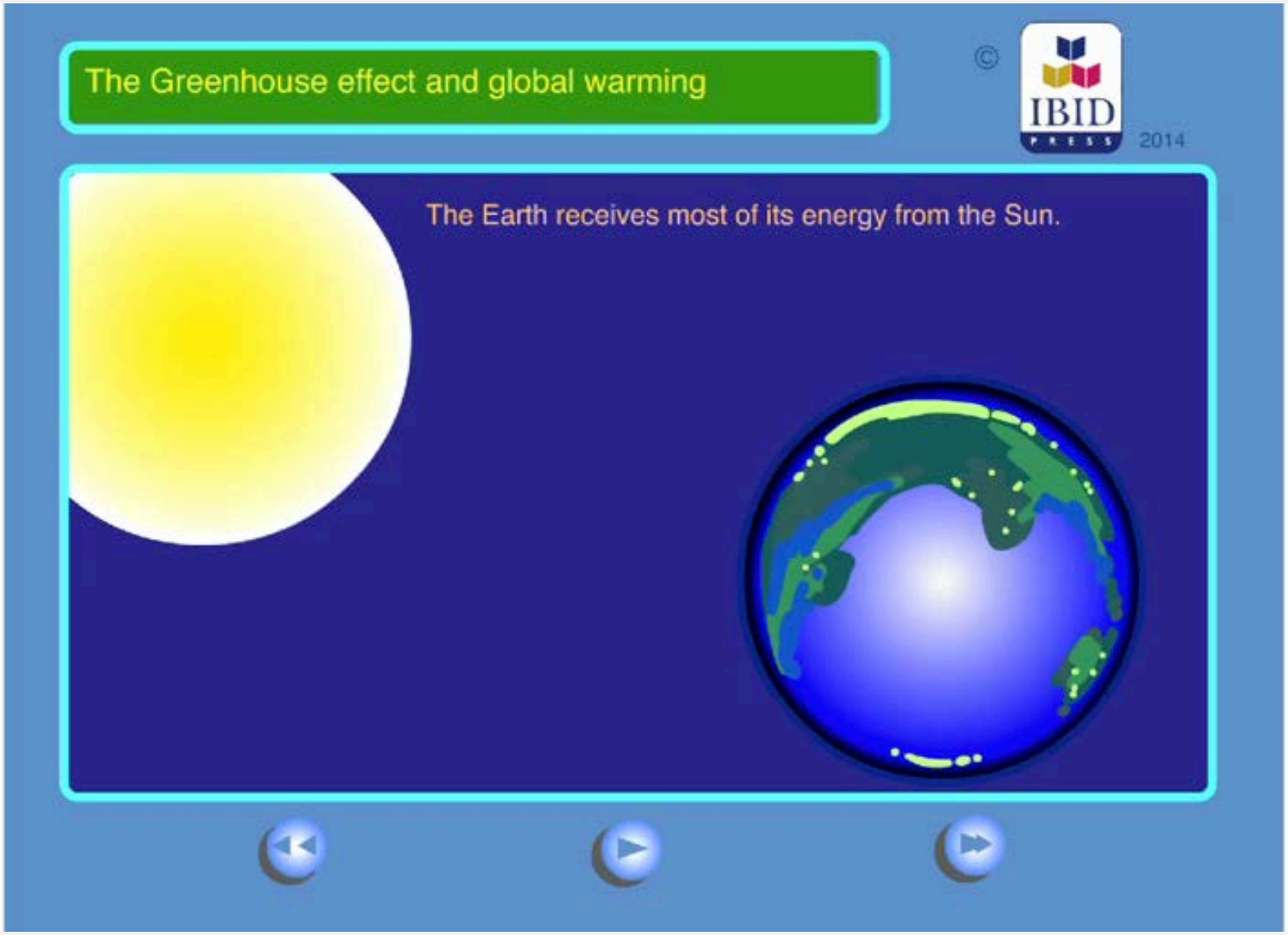
The otter is an example of a 'Keystone Species' (see Figure 1407 in the Textbook)

Additional material

Movie 14.1 Ozone Hole



Movie 14.2 The Greenhouse Effect



Gallery 14.1 The Galapagos

This is one place where Charles Darwin gathered information to develop his theory of Natural Selection and is now a popular tourist destination. Suggest why it is tightly regulated.

Internet resources

Some information about kelp forests can be found on

http://www.sci.sdsu.edu/cmi/wp-content/uploads/2012/09/kelpforest_final_Flat.jpg

and on

http://theminuteafter.blogspot.ch/2011/11/kelp-forest.html

This site also provides data and a number of questions and answers on primary succession.

http://wps.prenhall.com/esm_freeman_biosci_1/0,6452,501374-,00.html

The Great Barrier Reef is often cited as ‘in danger’. It is extensively monitored and ‘zoned’:

http://www.gbrmpa.gov.au/zoning-permits-and-plans/zoning/zoning-maps

Several websites may be of interest:

http://www.regional.org.au/au/asa/2004/poster/2/5/1/1185_hilln.htm

http://vro.dpi.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_waterlogging

US Govt site http://phil.cdc.gov/phil/home.asp

Answers to exercises

CORE SUB-TOPICS

1. Similarities

Both

- ♦ are long term relationships
- ♦ between organisms of different species
- ♦ where at least one of them benefits

Differences

Parasitism	Mutualism
one organism benefits, the other is harmed	both organisms benefit
e.g. athlete's foot : fungus growing on damp skin; fungus obtains nutrients from host which loses nutrients	e.g. algae and fungus in lichen algae photosynthesis, fungus takes up water and minerals
e.g. fleas on a dog fleas suck blood from dog	sea anemone and clown fish clown fish chases away fish that eat anemones; tentacles of anemone protect clownfish

2. (a) A keystone species is a species which has a bigger impact on its environment that would be expected considering the number of individuals of the species.

(b) The starfish Pisaster is a keystone species. It will eat the mussel Mytilus californianus, keeping down the numbers and allowing other species of mussels to exist in the community. Without Pisaster, M. californianus will cause the disappearance of many other species of mussel.

(c).The fundamental niche is the potential niche or the niche where the organism would be able to survive. The realised niche is the actual niche where the organism is found and is able to compete with other species.

The realised niche is usually smaller than the fundamental niche because the species cannot successfully compete with other species in all parts of its fundamental niche and/or successfully deal with predation

3. (a) Calculations

	Site 1		
	n	n-1	n(n-1)
water beetle	19	18	342
water snail	66	65	4290
mosquito fish	19	18	342
leech	11	10	110
diptera larvae	11	10	110
bivalve	786	785	617010
Ostracada	5	4	20
tadpoles	8	7	56
true worms	74	73	5402
	999		**627682**

	Site 2		
	n	n-1	n(n-1)
Ostracada	16	15	240
tadpoles	32	31	992
true worms	39	38	1482
water hoglouse	157	156	24492
swimming mayfly nymph	102	101	10302
dusky mayfly nymph	16	15	240
non biting midge larva	614	613	376382
Hawker' dragon fly	16	15	240
	992		**414370**

Summary

	Site 1	Site 2
total number of individuals at each site N	999	992
N-1	998	991
N(N-1)	997002	983072
sum of n(n-1) for all species at one site	627682	414370
Simpson's index	1.588	2.372

(b) Simpson's index for site 2 is bigger than for site 1. This means that the diversity at site 2 is greater than at site 1 despite the fact that site 2 has fewer species. The smaller divesity index at site 1 is caused by the fact that only one species is present in large numbers while in site 2 more species have a larger number of individuals.

(c). Site 1 could be more polluted than site 2. Only some species are capable of competing successfully in a polluted environment so the diversity of a polluted area is generally less than that of an unpolluted area. If both sites are from the same stream, it is likely that site 2 was higher upstream than site 1.

Another possibility is that succession has proceeded further at site 2 than at site 1, unless site 1 was the climax community.

4. (a) In situ : nature reserves e.g. Great Barrier Reef Marine Park in Australia and Yellowstone National Park in the USA.

Ex situ: zoos, e.g London Zoo, botanic gardens e.g. New Botanic Garden of the University of Helsinki at Kumpula Manor seed banks e.g. Millenium Seed Bank Project in Kew (UK)

(b) Benefits of *in-situ*

• some species are very hard to breed in captivity

• the population remains adapted to its original habitat, e.g. continues its natural diet

• individuals maintain their natural behaviour

• species interacts with others and fulfills its role in the ecosystem

• the habitat remains available for the endangered species (and others)

• it requires a larger gene pool but then conserves this variation between individuals

• species continues to evolve

• individuals can have more space, e.g. for a territory

• individuals may not need to be transported

Benefits of *ex-situ*

• protect individuals of a nearly extinct species

• captive breeding programmes can increase number of individuals and maintain some biodiversity

• increasing awareness about exotic or endanged species

5. The top trophic levels in a terrestrial food chain are often endothermic animals which require large amounts of food to maintain a constant body temperature. They have a high rate of cellular respiration to provide the energy needed to heat their bodies and hence a low conversion of ingested energy to biomass. This limits the length of the food chain. In aquatic environments, there are many more ectotherms which have a lower rate of cellular respiration and hence a higher conversion of ingested energy to biomass. This allows for longer food chains since a given amount of energy in one trophic level can sustain more organisms in the next.

6. The size of the arrow indicates the flow of nutrients between biomass, litter and soil. Due to the favourable conditions in a tropical rain forest, most nutrients are flowing between these deposits and very little is actually found in the litter or soil. On the taiga, the litter is often needles from coniferous trees which is slow to decompose. So, there is a fair amount of nutrients in biomass and litter but little in the soil. Transfer of nutrients is much slower than in the tropical rain forest due to different climatic conditions.

7 Rabbits were brought to Australia by Europeans for food and hunting. Some may have escaped, others were released deliberately. The mild climate, agriculture (edible plants within reach of the rabbit),and sandy soil and lack of any native predators caused a population explosion in a short time. Rabbits have caused the extinction of many plant species unique to Australia and are also the cause of significant erosion (due to the lack of plants keeping the soil in place with their roots).

8. (a) The eagle is both on the third and fourth trophic level. The plant is the producer, the butterfly the primary consumer, the lizard the secondary consumer and the eagle the tertiary consumer. Equally, the plant is the producer, the rabbit the primary consumer and the eagle the secondary consumer.

(b) Matter is recycled on Earth but energy is constantly received from the Sun and radiated out into space again.

9. Population size $N = (n_1 \times n_2)/_{n3} = 6474/8 = 809.25$

So the estimate of the total population size would be just over 800 woodlice. Note that if the numbers were the same but 9 of the woodlice had been marked, the estimated population size would have been just over 700.

AHL SUB-TOPICS

10. (a) The abiotic (non-living) factors likely to be important would include: temperature range, light intensity, rainfall, wind speed and direction, soil type, altitude. The biotic (living) factors would include; size of own population, competitors of other species, predators, parasites, other plants and animals that serve as food sources.

(b) Natality (birth rate) depends on fertility, clutch size and hatching time and will obviously influence the increase in the population. Mortality (death rate) will depend on a range of biotic and abitotic factors. Immigration (movement in) includes all individuals moving into the population and there may be several reason for this movement. Emigration (movement out) includes all individuals moving out the population and there may also be several reason for this movement.

Overall; Population change =Immigration + Natality – Emigration – Mortality

11 Refer to Figure 1493 showing the main parts of the nitrogen cycle. In particular note the roles of ‘nitrifying’ bacteria, (often present in root nodules of legumes) which convert nitrogen gas to nitrites and nitrates and also the role of ‘denitrifying’ bacteria which do virtually the opposite.

12. Refer to Figure 1497 showing the main parts of the phosphorus cycle. In particular note how the amount of phosphorous may be increased by the application of fertilizer and decreased by the removal of crops and run-off into larger water bodies caused by rainfall or irrigation.

Chapter 15

Human Physiology

Section 1

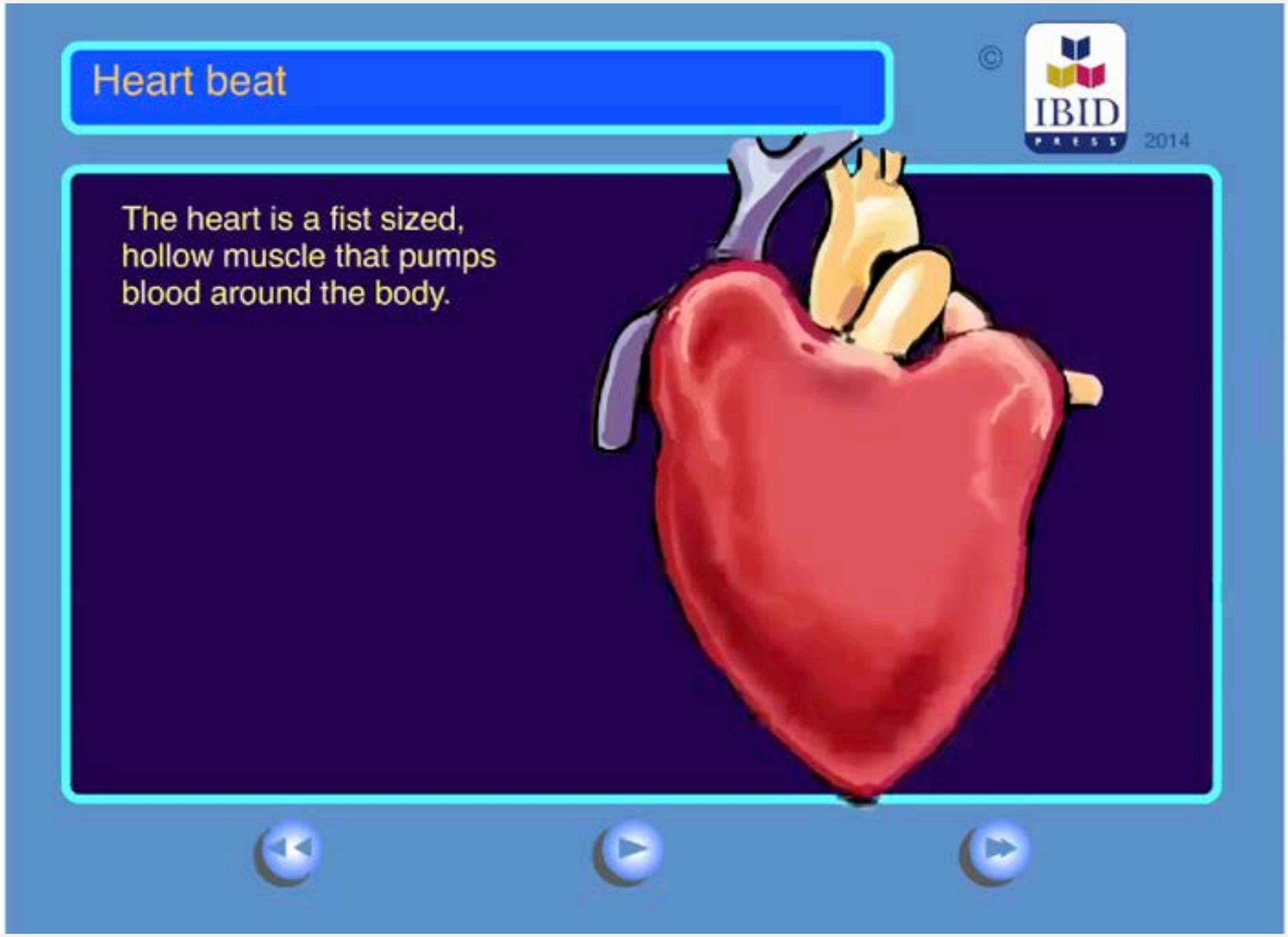
Human Physiology

CONTENTS

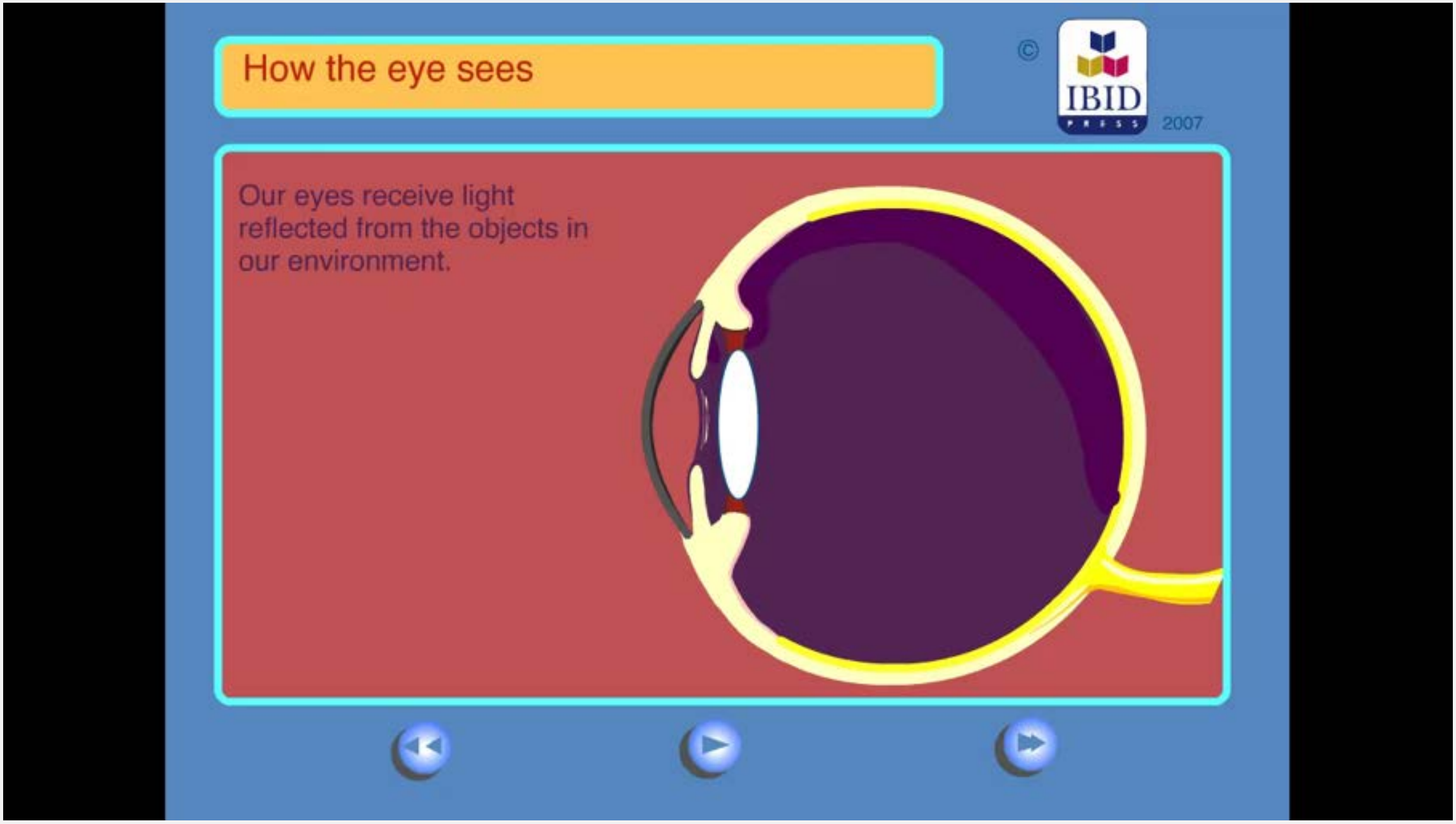
Two Australian scientists (Robin Warren and Barry Marshall) receive their Nobel Prizes in 2005 for discovering the cause of stomach ulcers.

Additional material

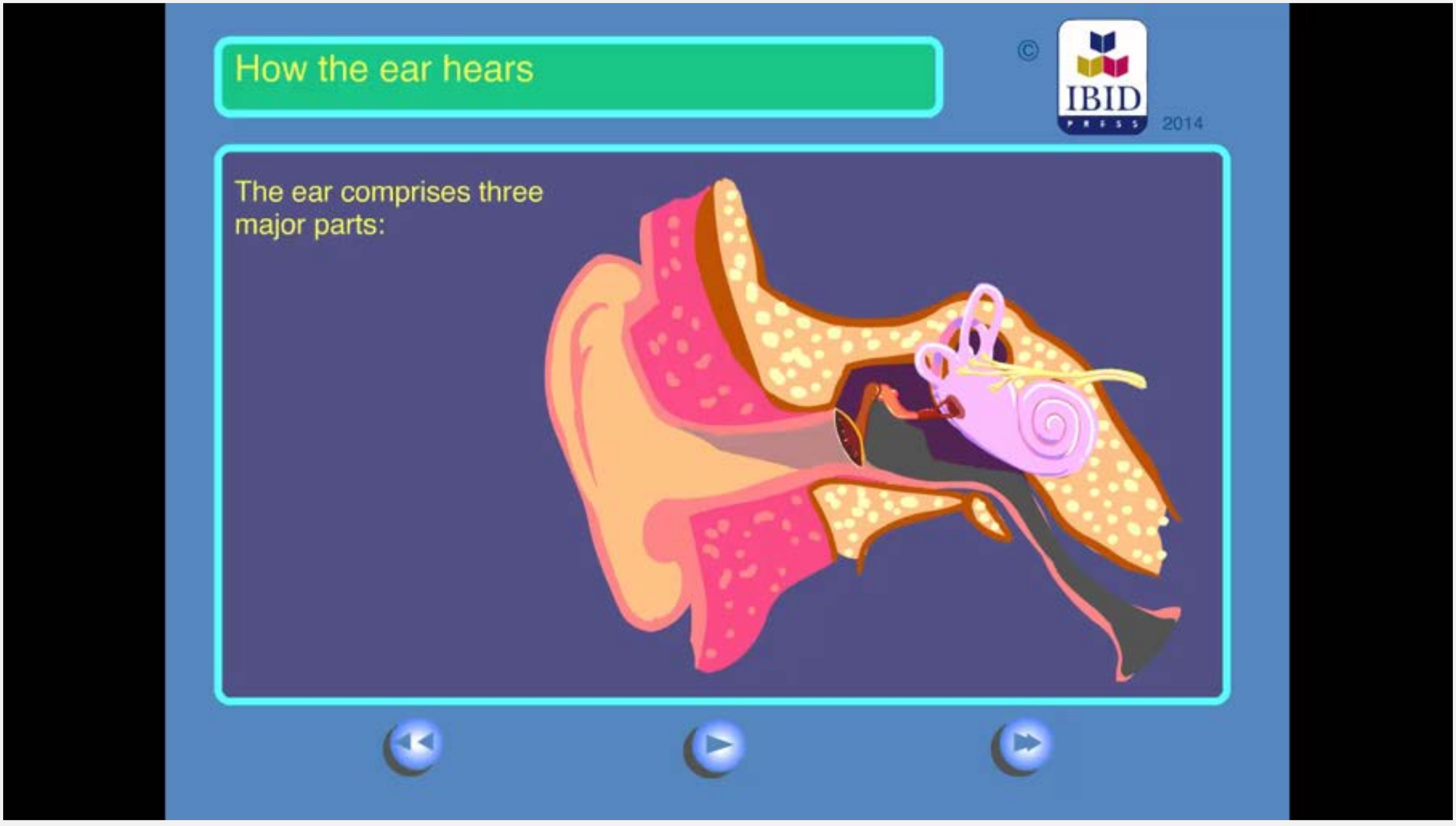
Movie 15.1 Heart beat



Movie 15.2 The Eye



Movie 15.3 The Ear



Internet resources

GAS EXCHANGE ANIMATION

An overview of the movement of oxygen and carbon dioxide and the changes in partial pressures are found on

http://highered.mcgraw-hill.com/sites/0072943696/student_view0/chapter15/animation__changes_in_the_partial_pressures_of_oxygen_and_carbon_dioxide.html

When the baby is nursing, nervous impulses to the hypothalamus cause the release of oxytocin which causes the milk to be released.

The first half of the video on this site explain some of the above.

http://education-portal.com/academy/lesson/the-neonatal-period-lactation-and-nursing.html#lesson

CORE SUB-TOPICS

1. (a) Phenylketonuria (PKU) is a genetic disorder. People who suffer from PKU cannot break down phenylalanine to tyrosine but will instead break it down into phenylpyruvic acid which usually causes physical and mental retardation.

(b) Most proteins will contain phenylalanine so a strict low protein diet is needed to avoid taking in phenylalanine. A special formula is needed to supplement this diet which, by necessity, will be deficient in many nutrients. In some cases, medication which will help breaking down phenylalanine is available. Gene therapy may be a future solution.

(c) Calcium is an essential component of the extracellular matrix that makes bone. Bone is constantly being broken down by osteoclasts and rebuilt by osteoblasts. Without sufficient calcium, the bones will lack strength. Calcium ions are absorbed by the small intestine. Vitamin D improves the amount of calcium that is taken up.

2. (a) Pepsin and trypsin are proteases and if produced in active form would digest the cell that produces them so they are made as pepsinogen and trypsinogen

(b) Pepsinogen (inactive precursor) is activated by HCl in the stomach (the stomach has a mucus layer lining it to protect the cells from pepsin) trypsinogen (inactive precursor) is activated by enterokinase in the small intestine HCl and enterokinase are made by different cells than those who make pepsinogen and trypsinogen.

3. (a) Microvilli, mitochondria, pinocytotic vesicles.

(b) Microvilli increase the surface area, allowing more nutrients to be absorbed at the same time mitochondria provide energy since some of the processes of absorption are active transport which requires energy pinocytotic vesicles as a result of endocytosis tight junctions to prevent particles from entering in between cells.

4. (a) Glucose, amino acids, hormones, vitamins, cholesterol,

(b) Glucose is taken up, converted to glycogen and stored amino acids are used to make (blood) proteins surplus amino acids are broken down for energy and urea produced as a waste product vitamins A and D are stored in the liver cholesterol levels are controlled.

(c) Main functions

• breakdown of hemoglobin into heme group (with iron) and protein (globin)

• separation of iron from heme, resulting in production of bile pigments

• detoxification (poison, alcohol, etc)

• making cholesterol

• making protein (for blood plasma)

• storage of some nutrients and vitamins

5. Main points

• genetic factors - if one or more family members have CHD, the risk is increased

• age - CHD is more common with increasing age

• gender - CHD is more common among males

• smoking - smoking increases the chance of CHD

• obesity - obesity increases the chance of CHD

• diet - a diet high in cholesterol and saturated fats increases the chances of CHD; there is evidence that trans fatty acids are particularly unhealthy

• lack of exercise - exercise seems to decrease levels of LDL cholesterol and reduces chances of CHD.

6. (a) Glucose is a relatively small molecule (half the size of lactose) and is able to readily diffuse across and into the villus; lactose is larger and less readily diffuses due to its large molecular or molar mass.

(b) The mucosa has folds; the lumen of the ileum is covered with finger-like projections termed villi; the surfaces of the absorptive cells of the villus are covered with microvilli.

(c) The glucose is converted to glycogen and stored; respired inside the liver or transported via the blood plasma to respiring body cells.

(d) Unabsorbed lactose prevents osmotic water flow across the mucosa; unabsorbed lactose enters the large intestine where is metabolised by bacteria. The resulting metabolites prevent osmotic water flow and stimulate fluids secretion in this gut region.

(e) The lactase would be digested in the stomach before reaching the ileum. Heating accelerates the activity of lactase by increasing the average kinetic energies and hence velocities of substrate and products. The collision rates and hence reaction rates would be increased.

7 The heart beat stimulus originates in a group of specialised cardiac muscle cells known as the sinoatrial nopde (SAN), commonly known as the pacemaker. The SAN produces a wave of excitation that spreads to both atria of the heart, causing atrial systole.

The wave of excitation from the SAN then reaches another group of specialised cardiac muscle cells known as the atrioventricular node (AVN). The AVN produces a new wave of excitation that is

transmitted along specialized nerve cells called Purkinje fibres, which collectively make up the bundle of His located in the ventricular walls.

The wave of excitation travels along these fibres in the interventricular septum to the apex of the ventricles and radiates upwards, causing contractions in both ventricles. This is the beginning of ventricular systole.

8 (i) 6, 3 and 4

(ii) 6

(iii) 4

(iv) 4 and 3

(v) 4

(vi) 8 and 4

(vii) 8 and 5

(viii) 4

(ix) 6, 3 and 4

(x) 1 and 3

(xi) 1 and 7

(xii) 2

(xiii) 6

(xiv) 7

(xv) 7

AHL SUB-TOPICS

9 Refer to Figure 1556 on page 500 for details of hormones and their actions in the body.

10 (a) (i) As the whale dives the pressure exerted by the surrounding water increases since the mass of water above the whale increases.

(ii) In the trachea and nasal cavity.

(b) If the demand for ATP remained constant, then the glucose consumption rate of a metabolically active tissue would rise by a factor of 19 times. This is due to the switch from aerobic to anaerobic respiration which would occur. Anaerobic respiration yields two ATP molecules per glucose molecule, compared to the thirty eight molecules formed during aerobic respiration.

(c) Oxy-hemoglobin and oxy-myoglobin.

(d) To act as a store of oxygen during the whale's dive and release oxygen when the partial pressure of oxygen becomes very low.

(e) (i) It implies that oxy-hemoglobin only releases its oxygen when the partial pressure of oxygen is very low.

(ii) To compensate whale oxy-hemoglobin is presumably very responsive to changes in carbon dioxide: a small increase in carbon dioxide levels will causes the dissociation of the whale hemoglobin.

(f) (i) It may lower the pH of the blood.

(ii) The whale's blood plasma is expected to be highly effective at buffering the blood from changes in pH.

(g) The chemoreceptors respond to levels of carbon dioxide via a change in pH.

(h) Larger whales have proportionally more bone and fat and less muscle. Muscle has a much higher demand for glucose and oxygen than fat and bone. Hence, larger whales have proportionally more oxygen available per unit mass of body tissue and hence can do longer and hence deeper dives.

Chapter 16

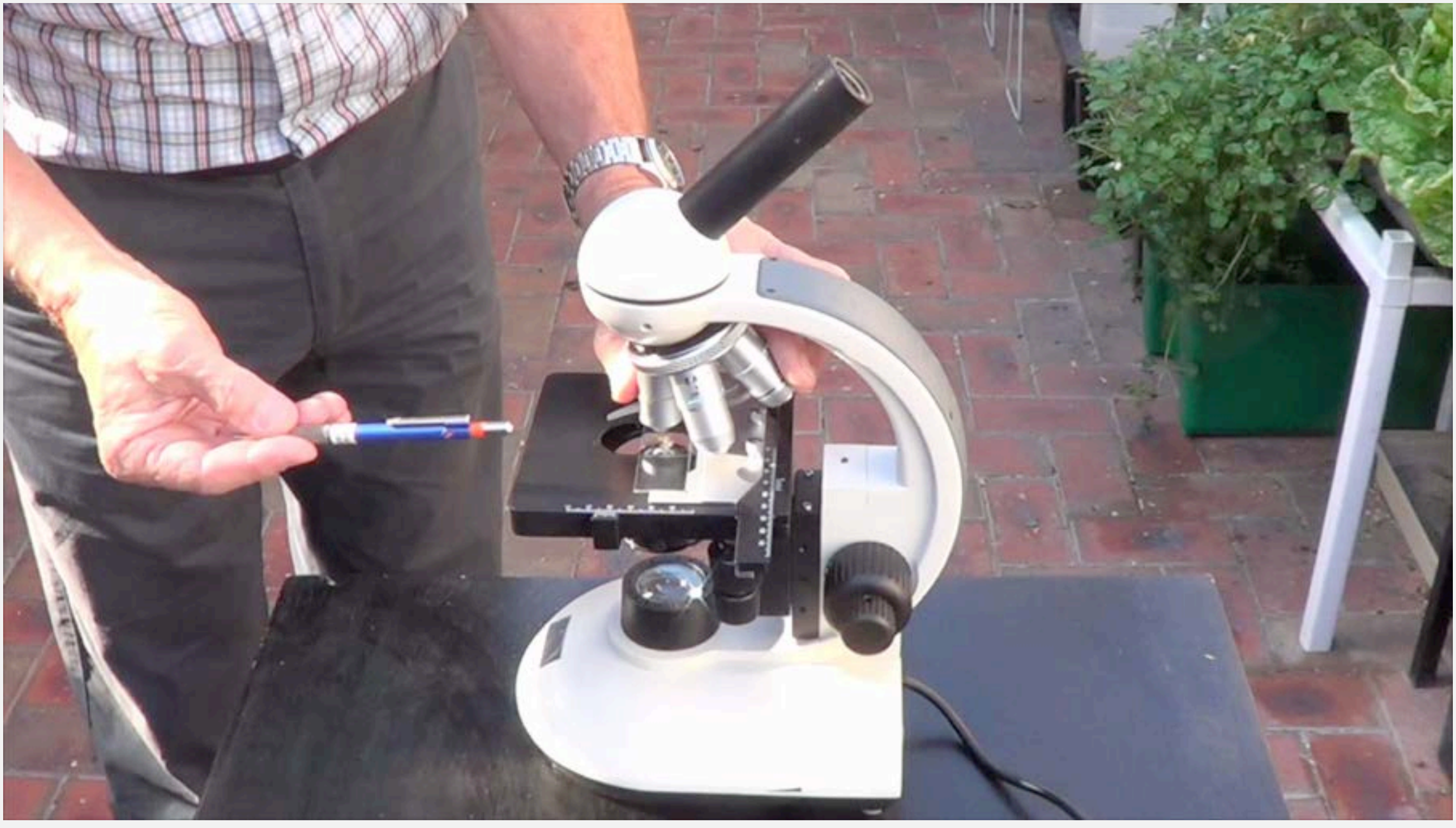
The Microscope

Section 1

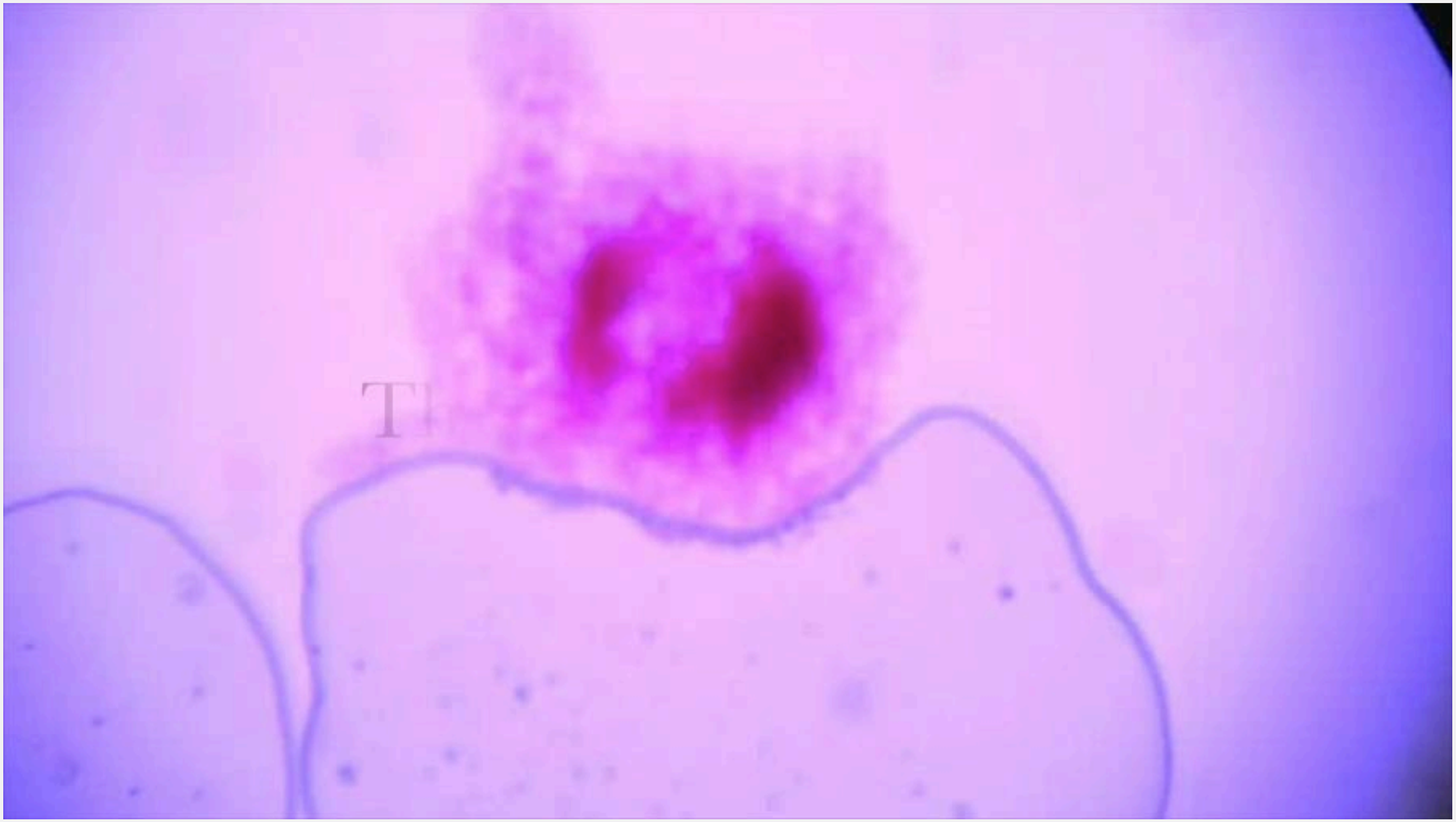
A few tips...

CONTENTS

Movie 16.1 The main controls of a light microscope



Movie 16.2 Looking into a light microscope



Movie 16.3 Looking for life

Chapter 17

Statistical Methods

An appendix that you may find useful when conducting investigations.

This has been provided by Paul Billiet to supplement his Investigations, also published by IBID Press.

Statistics are useful mathematical tools that are used to analyse data. Perhaps the best known statistic is the average. This is a single figure that is used to represent a set of data.

Averages

There are three types of average:

The **median** which is the middle value of a range of results.

The **mode** which is the value that appears the greatest number of times.

The **mean** which is the sum of all the results divided by the number of results.

Example: in the following set of data: 1; 3; 7; 10; 11; 12; 13; 13; 22; 23; 24

The median = 12 which is the 6th value when they are arranged in order.

The mode = 13

The mean = 139 ÷ 11 = 12.6

Note that if there is an even number of results the median is calculated by adding the middle two values and dividing by two.

Example: for the series 1; 2; 4; 5; 7; 9 the median = $\frac{4+5}{2} = 4.5$

If all three averages are approximately the same we can usually assume that the data shows a “normal distribution” and the following tests can be used even for comparatively small samples (n<30).

Sampling

Remember the mean of the sample you have selected is not necessarily the mean of the whole population. Nor is it necessarily true that if the sample means taken from two different populations are different then the population means of each must be different. There is bound to be a natural variation. The tests below determine whether the variation you obtain is actually greater than you might expect.

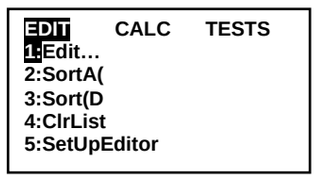
The range

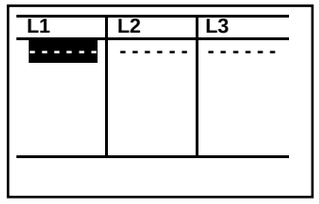
The range of the results can give a simple indication of the variation in the sample. Enter the data into a spread sheet on either a computer or a graphic calculator. Use the MAX and MIN

commands to determine the biggest and smallest values. The range = $Max - Min$: amplitude = $\frac{Max - Min}{2}$.

Standard deviation

The standard deviation is a measure of the variation of the results. For data that are evenly distributed each side of the mean (a normal distribution), 68% of the data lies within one standard deviation of the mean. Basically if you take another sample at random in the same population there is a 68% chance it will fall within 1 standard deviation either side of the mean (and a 95% chance that it will fall 2 standard deviations either side of the mean).





You can work this out on a TI calculator as follows:

Use the **STAT** key

Press **STAT**

This gives you the **STAT** menu.

You will already be in the **EDIT** menu. Press 1

This opens a spread sheet

You can see if there is anything stored in the columns of the spread sheet. Check this and if there are data you need to clear it.

- To clear the spread sheet

Press **STAT**

You will be in the **EDIT** menu. Press **4**

You will get "**ClrList**"

Press **2nd** then **L1**

ENTER

You have now cleared column **L1**

Repeat the process (**STAT**, **4**, **2nd**, **L2**, **ENTER** etc….) to clear the other columns

- To enter data

Press **STAT**

You will be in the **EDIT** menu.

Select 1

This opens a spread sheet

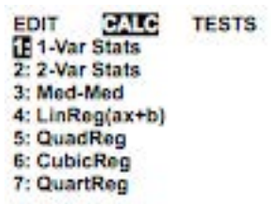
type in the first number, then **ENTER**

second number then **ENTER**

etc.

If you are comparing two sets of data, do the same thing in column **L2**

- To find out mean, median, standard deviation



Press **STAT**

Use the cursor to move across to the **CALC** menu

You will find a menu which permits you to calculate a large number of statistical parameters. Most of what we want is in 1:1-Var Stats. The first on the list.

Press **ENTER**

1-Var Stats appears

Press **2nd** then **L1** and **ENTER**

You will get:

$\bar{x}$ (the mean)

S_x (the standard deviation of the sample)

σ_x (the standard deviation of a population)

n (the number in the sample)

Scroll down for more.

minX (the minimum value)

Q1 (the first quartile)

Med (the median)

Q3 (the third quartile)

maxX (the maximum value)

Plotting a histogram to show a frequency distribution

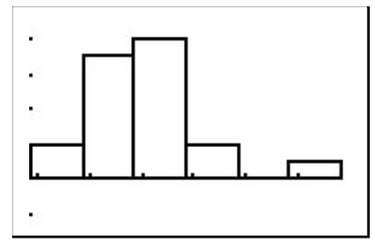
You will also find it useful to see the distribution of your data as a frequency histogram. This too can be carried out on the TI calculator.

Open **STAT PLOT** and select **Plot1**

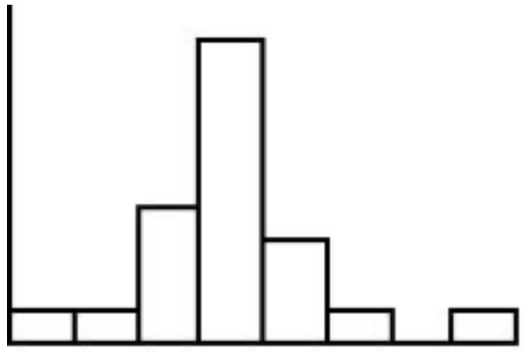
Switch it to On by pressing **ENTER**.

Under type: select the histogram type of presentation.

Scroll to Xlist: and select the list you want



to plot. Press **2nd** then **LIST** then scroll down to the list of data. Press **ENTER**.



There is no *Ylist* because the histogram plots the frequency of the different data in the *Xlist* in regular groups called class intervals. These are set automatically by the calculator.

Press **ZOOM** then **9** and the histogram will appear.

To adjust your histogram press **WINDOW** and enter the following information:

Xmin is the lower limit of the lowest class interval

Xmax is the upper limit of the highest class interval

Xscl is the width of the class intervals

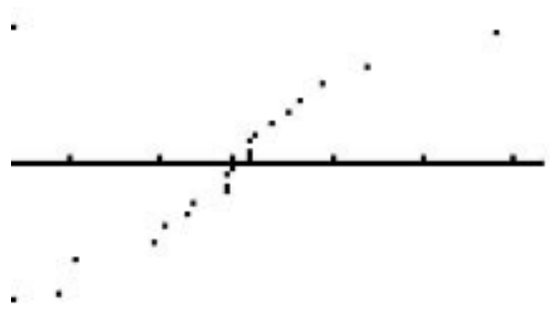
Ymin set zero

Ymax needs to be higher than the highest frequency

Yscl and *Xres* can be left as the default values

When these are set press **GRAPH** and inspect the histogram. If you want to adjust the histogram further press **WINDOW** again and change the values.

If you want to see if the histogram approaches a normal distribution you may test this using the normal probability graph. This is the last type of graph in the **STAT PLOT** series.



Return to **STAT PLOT** and **Plot 1**. Scroll to **Type**: Then scroll through the list to the last one and press **ENTER**.

Press **ZOOM** then **9**. The graph that appears now will be a scattergram of points. If they fall into a diagonal line, the distribution of the data follows a normal distribution.

Predicting the Population Mean

We can never be sure that our sample mean is equal to the population mean but we can produce a confidence interval i.e. two numbers between which we are 95% certain that the population mean lies.

The standard error of the mean

This statistic gives us an idea of how good our sample is. The narrower the limits are the closer the mean of the sample represents the mean of the population.

The standard error of the mean is given by $1.96\left(\frac{s}{\sqrt{n}}\right)$. Its size indicates how representative your mean is.

The sample mean $\pm 1.96\left(\frac{s}{\sqrt{n}}\right)$ gives the 95% confidence limits.

In other words, we are 95% sure that the mean of the population lies somewhere between:

$$\bar{X} \pm 1.96\left(\frac{s}{\sqrt{n}}\right)$$

NB We would only use this formula for $n>30$. If $n<30$ and we are fairly sure the population we are sampling from has normal distribution we replace 1.96 by the 95% point from our *t*-test tables with n-1 degrees of freedom.

- To calculate the 95% confidence limits on a TI calculator

Press **STAT**

Use the cursor to move to the **TESTS** menu

Press 8

This selects **TInterval**

You will probably find the data has already been entered for List: as **L1** but if you want to use another column of data change the Lists by pressing **2nd** then **LIST** and scrolling down to the list of data that you want.

Freq:1 can be left alone

C-Level: .95 sets the confidence limits at 95%

Scroll down further to select **Calculate**

Press **ENTER**

You will get the result for the 95% confidence limits for your data

Example:

TInterval

(20.926, 23.274) (the 95% confidence limits)

$= 22.1$ (the sample mean)

$S_x = 3.144$ (the sample standard deviation)

n=30 (the sample size)

Comparing the means of two samples

Are the means from two different samples significantly different from one another?

This can be estimated by finding the standard error of the differences between the two means and comparing this with probability levels that have already been calculated. We can use this test when the size of both samples are greater than 30.

1. First set up your "null hypothesis". This is the hypothesis that states there is no difference between the two populations.

2. Calculate your test statistic using $d = \frac{\left|\bar{x_1} - \bar{x_2}\right|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$

Table of probability values:

Probability (P)	0.1	0.05	0.02	0.01	0.001	0.0001	1E-05
Difference (d)	1.645	1.96	2.326	2.576	3.291	3.891	4.417
Confidence limits	90%	95%	98%	99%	99.9%	99.99%	99.999%

3. Compare your calculated value for "d" with the table

Example: $d_{calculated} = 2.67$

This value is larger than the value for the 0.01 probability level of $d = 2.576$. So we can say that we are over 99% certain that these two means are different.

Generally, we can accept differences at the 95% confidence limits or higher, as being significant differences (i.e. d>1.960).

Students t-test

This statistical test may be used if the size of your sample is small (<30). The degree of error in the sample will be larger (the sample mean will deviate more from the population mean). It assumes the populations you are drawing from are normally distributed.

You simply replace *d* by *t* in the above formula and look up the significant points in *t*-tables.

$$t = \frac{\left|\bar{x_1} - \bar{x_2}\right|}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Calculating the value of "*t*":

Where is the positive difference between the two means.

Calculating the degrees of freedom: $n_1 + n_2 - 2$

- To calculate the t-test on a TI calculator

Press **STAT**

Use the cursor to move to the **TESTS** menu

Press **4**

his selects 2-SampTTest

You will probably find the data has already been entered for L1 and L2 but if you want to use other columns of data change the Lists by pressing 2nd then LIST and scrolling down to the lists of data that you want.

Scroll down further to select **CALCULATE**

Press **ENTER**

You will get the result for the *t*-test on your data

t = ...

Now using the correct Degrees of Freedom and the probability table for the t-test, you can find if the t value you have calculated lies above or below the critical 5% probability level (p=0.05). You will either accept the Hypothesis or the Null Hypothesis.

- To determine whether or not there is a significant difference between the means of these two samples

Using the degrees of freedom look up the values for '*t*' in the table. What probability level corresponds to your calculated value for '*t*'?

Example:

For 14 degrees of freedom 't' has the following results for different probability levels:

Probability(*P*)	0.1	0.05	0.02	0.01	0.002	0.001
t value	1.761	2.145	2.624	2.977	3.787	4.14

If the calculated value for t is 2.78 it lies between the 0.02 and 0.01 probability levels. In other words if our null hypothesis is correct there is only a 1 to 2% chance of getting such a large difference between the means by chance. This is very unlikely. In general if the value calculated for '*t*' lies above *P* = 0.05 (the 95% level) we can accept that there is a significant difference between these means and so reject our null hypothesis.

- One tail or two tails?

It is also necessary to determine whether your hypothesis has a direction or not.

If your hypothesis has no direction e.g. “the treatment on sample A will have an effect on the growth of the plants compared to the control sample B” or ‘there is a significant difference between sample A and sample B” then the a two-tailed test is used.

If your hypothesis has a direction e.g. “sample A is greater than sample B” then you need a one-tailed test. This will change the critical value. Of course you have to be confident of the outcome for this. If the result of the test is below the critical value it supports the null hypothesis (“there is no difference between sample A and sample B”) it does not support a different hypothesis (“sample A is smaller than sample B”)

All this requires is that you are careful with the phrasing of your hypothesis and you use different columns on the t-test table to determine the critical value for one-tailed and two-tailed tests.

TABLE OF PROBABILITY LEVELS FOR STUDENT'S t-TEST

Degrees of freedom	Level of significance (*p*)						
	p = 0.05	*p* = 0.025	*p* = 0.01	*p* = 0.005	*p* = 0.001	*p* = 0.0005	One-tailed test
	p = 0.1	*p* = 0.05	*p* = 0.02	*p* = 0.01	*p* = 0.002	*p* = 0.001	Two-tailed test
1	6.314	12.706	31.821	63.657	318.31	636.62	
2	2.92	4.303	6.965	9.925	22.327	31.598	
3	2.353	3.182	4.541	5.841	10.214	12.924	
4	2.132	2.776	3.747	4.604	7.173	8.61	
5	2.015	2.571	3.365	4.032	5.893	6.869	
6	1.943	2.447	3.143	3.707	5.208	5.959	
7	1.895	2.365	2.998	3.499	4.785	5.408	
8	1.86	2.306	2.896	3.355	4.501	5.041	
9	1.833	2.262	2.821	3.25	4.297	4.781	
10	1.812	2.228	2.764	3.169	4.144	4.587	
11	1.796	2.201	2.718	3.106	4.025	4.437	
12	1.782	2.179	2.681	3.055	3.93	4.318	
13	1.771	2.16	2.65	3.012	3.852	4.221	
14	1.761	2.145	2.624	2.977	3.787	4.14	

Degrees of freedom	Level of significance (p)						
	$p = 0.05$	$p = 0.025$	$p = 0.01$	$p = 0.005$	$p = 0.001$	$p = 0.0005$	One-tailed test
	$p = 0.1$	$p = 0.05$	$p = 0.02$	$p = 0.01$	$p = 0.002$	$p = 0.001$	Two-tailed test
15	1.753	2.131	2.602	2.947	3.733	4.073	
16	1.746	2.12	2.583	2.921	3.686	4.015	
17	1.74	2.11	2.567	2.898	3.646	3.965	
18	1.734	2.101	2.552	2.878	3.61	3.922	
19	1.729	2.093	2.539	2.861	3.579	3.883	
20	1.725	2.086	2.528	2.845	3.552	3.85	
21	1.721	2.08	2.518	2.831	3.527	3.819	
22	1.717	2.074	2.508	2.819	3.505	3.792	
23	1.714	2.069	2.5	2.807	3.485	3.767	
24	1.711	2.064	2.492	2.797	3.467	3.745	
25	1.708	2.06	2.485	2.787	3.45	3.725	
26	1.706	2.056	2.479	2.779	3.435	3.707	
27	1.703	2.052	2.473	2.771	3.421	3.69	
28	1.701	2.048	2.467	2.763	3.408	3.674	
29	1.699	2.045	2.462	2.756	3.396	3.659	

Degrees of freedom	Level of significance (p)						
	$p = 0.05$	$p = 0.025$	$p = 0.01$	$p = 0.005$	$p = 0.001$	$p = 0.0005$	One-tailed test
	$p = 0.1$	$p = 0.05$	$p = 0.02$	$p = 0.01$	$p = 0.002$	$p = 0.001$	Two-tailed test
30	1.679	2.042	2.457	2.75	3.385	3.646	
31	1.696	2.04	2.453	2.744	3.375	3.634	
32	1.694	2.037	2.449	2.739	3.366	3.623	
33	1.693	2.034	2.445	2.733	3.356	3.611	
34	1.692	2.032	2.441	2.728	3.348	3.601	
35	1.689	2.03	2.437	2.723	3.34	3.591	
36	1.688	2.028	2.434	2.719	3.333	3.582	
37	1.687	2.026	2.431	2.715	3.326	3.574	
38	1.686	2.024	2.429	2.712	3.319	3.566	
39	1.685	2.022	2.426	2.708	3.313	3.558	
40	1.684	2.021	2.423	2.705	2.971	3.307	
41	1.683	2.02	2.421	2.701	2.967	3.301	
42	1.682	2.018	2.419	2.698	2.963	3.296	
43	1.681	2.017	2.416	2.695	2.959	3.291	
44	1.68	2.015	2.414	2.692	2.956	3.286	

Degrees of freedom	Level of significance (p)						
	$p = 0.05$	$p = 0.025$	$p = 0.01$	$p = 0.005$	$p = 0.001$	$p = 0.0005$	One-tailed test
	$p = 0.1$	$p = 0.05$	$p = 0.02$	$p = 0.01$	$p = 0.002$	$p = 0.001$	Two-tailed test
45	1.679	2.014	2.412	2.69	2.952	3.282	
46	1.679	2.013	2.41	2.687	2.949	3.277	
47	1.678	2.012	2.408	2.685	2.946	3.273	
48	1.677	2.011	2.407	2.682	2.943	3.269	
49	1.677	2.01	2.405	2.68	2.94	3.265	
50	1.676	2.009	2.403	2.678	2.937	3.261	
51	1.675	2.008	2.402	2.676	2.934	3.258	
52	1.675	2.007	2.4	2.674	2.932	3.255	
53	1.674	2.006	2.399	2.672	2.929	3.251	
54	1.674	2.005	2.397	2.67	2.927	3.248	
55	1.673	2.004	2.396	2.668	2.925	3.245	
56	1.673	2.003	2.395	2.667	2.923	3.242	
57	1.672	2.003	2.394	2.665	2.92	3.239	
58	1.672	2.002	2.392	2.663	2.918	3.237	
59	1.671	2.001	2.391	2.662	2.916	3.234	

Degrees of freedom	Level of significance (p)						
	$p = 0.05$	$p = 0.025$	$p = 0.01$	$p = 0.005$	$p = 0.001$	$p = 0.0005$	One-tailed test
	$p = 0.1$	$p = 0.05$	$p = 0.02$	$p = 0.01$	$p = 0.002$	$p = 0.001$	Two-tailed test
60	1.671	2	2.39	2.66	2.915	3.232	
61	1.67	2	2.389	2.659	2.913	3.229	
62	1.67	1.999	2.388	2.658	2.911	3.227	
63	1.669	1.998	2.387	2.656	2.909	3.225	
64	1.669	1.998	2.386	2.655	2.908	3.223	
65	1.669	1.997	2.385	2.654	2.906	3.22	
66	1.668	1.997	2.384	2.652	2.905	3.218	
67	1.668	1.996	2.383	2.651	2.903	3.216	
68	1.668	1.996	2.382	2.65	2.902	3.214	
69	1.667	1.995	2.382	2.649	2.9	3.213	
70	1.667	1.994	2.381	2.648	2.899	3.211	
71	1.667	1.994	2.38	2.647	2.897	3.209	
72	1.666	1.994	2.379	2.646	2.896	3.207	
73	1.666	1.993	2.379	2.645	2.895	3.206	
74	1.666	1.993	2.378	2.644	2.894	3.204	

Degrees of freedom	Level of significance (p)						
	$p = 0.05$	$p = 0.025$	$p = 0.01$	$p = 0.005$	$p = 0.001$	$p = 0.0005$	One-tailed test
	$p = 0.1$	$p = 0.05$	$p = 0.02$	$p = 0.01$	$p = 0.002$	$p = 0.001$	Two-tailed test
75	1.665	1.992	2.377	2.643	2.893	3.203	
76	1.665	1.992	2.376	2.642	2.891	3.201	
77	1.665	1.991	2.376	2.641	2.89	3.2	
78	1.665	1.991	2.375	2.64	2.889	3.198	
79	1.664	1.99	2.375	2.64	2.888	3.197	
80	1.664	1.99	2.374	2.639	2.887	3.195	
90	1.662	1.987	2.369	2.632	2.878	3.183	
100	1.66	1.984	2.364	2.626	2.871	3.174	

The Mann-Whitney U-Test

Sometimes distributions of variables do not show a normal distribution, or the samples taken are so small that one cannot tell if they are part of a normal distribution or not. Using the t-test to tell if there is a significant difference between samples is not appropriate here.

The Mann-Whitney U-test can be used in these situations. This test can be used for very small samples (between 5 and 20). It can also be used when the variable being recorded is measured using an arbitrary scale that cannot be measured accurately (e.g. a colour scale measured by eye or a behavioural trait such as aggression).

The following example will illustrate the method.

The size of leaves taken from bramble bushes (Rubus fruitocosus) were measured to see if there is a difference between the size of the leaves growing in full sunlight and those growing in the shade.

	Width of leaf / cm ± 0.1cm						
Sunlight	6.0	4.8	5.1	5.5	4.1	5.3	4.5
Shade	6.5	5.5	6.3	7.2	6.8	5.5	5.9

The Mann-Whitney U-test is chosen because the sample size is so small it is not clear if these are samples taken from normally distributed data.

1. Set up the Null Hypothesis: There is no difference between the leaves taken from the sunlit bramble and the shaded bramble.
   Alternative Hypothesis: There is a difference between the leaves taken from the sunlit bramble and the shade bramble.

2. Let n_1 be the size of the smallest sample and n_2 be the size of the biggest sample.
   In this example both are of the same size so it does not matter which you choose.
   $n_1 = 8$ and $n_2 = 8$

3. Rank all the values for both samples from the smallest (=1) to the largest. Set them up as shown in the table below.

Sunlight	Rank	Rank	Shade
4.1	1		
4.5	2		
4.8	3		
5.1	4.5		
5.1	4.5		
5.3	6		
5.5	8.5		
		8.5	5.5
		8.5	5.5
		8.5	5.5
		11	5.9
6	12		
		13	6.3
		14	6.5
		15	6.8
		16	7.2

$R_1 = 41.5$ $R_2 = 94.5$

Note: Where the values are the same and share the same rank, take an average of the rank values.

4. Total the ranks of each sample R1 and R2 (see the bottom of the table above).

5. Calculate the U values for both samples:

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 = 8 \times 8 + \frac{8 \times 9}{2} - 41.5 = 58.5$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2 = 8 \times 8 + \frac{8 \times 9}{2} - 94.5 = 5.5$$

6. Use the table to find the critical value for the U statistic at the 5% level for samples of this size (n_1 = 8 and n_2 = 8).

   $U_{crit} = 13$

7. Reject the Null Hypothesis if the smallest value of U_1 or U_2 is below U_{crit}. In this case U_2 is below 13 we can reject the Null Hypothesis and accept the Alternative Hypothesis. The difference between the size of the bramble leaves in the light and the dark is significant for P>0.05. Bramble leaves in the dark seem to be significantly bigger.

Critical Values for the Mann-Whitney U-Test. Level of significance: 5% (P = 0.05)

	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
3	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	10	10	11	11	12	13	13
4	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	14	15	16	17	17	18	19	20	21	22	23
5	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20	22	23	24	25	27	28	29	30	32	33
6		5	6	8	10	11	13	14	16	17	19	21	22	24	25	27	29	30	32	33	35	37	38	40	42	43
7			8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
8				13	15	17	19	22	24	26	29	31	34	36	38	41	43	45	48	50	53	55	57	60	62	65
9					17	20	23	26	28	31	34	37	39	42	45	48	50	53	56	59	62	64	67	70	73	76
10						23	26	29	33	36	39	42	45	48	52	55	58	61	64	67	71	74	77	80	83	87
11							30	33	37	40	44	47	51	55	58	62	65	69	73	76	80	83	87	90	94	98
12								37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	97	101	105	109
13									45	50	54	59	63	67	72	76	80	85	89	94	98	102	107	111	116	120
14										55	59	64	67	74	78	83	88	93	98	102	107	112	118	122	127	131
15											64	70	75	80	85	90	96	101	106	111	117	122	125	132	138	143
16												75	81	86	92	98	103	109	115	120	126	132	138	143	149	154
17													87	93	99	105	111	117	123	129	135	141	147	154	160	166
18														99	106	112	119	125	132	138	145	151	158	164	171	177
19															113	119	126	133	140	147	154	161	168	175	182	189
20																127	134	141	149	156	163	171	178	186	193	200
21																	142	150	157	165	173	181	188	196	204	212
22																		158	166	174	182	191	199	207	215	223
23																			175	183	192	200	209	218	226	235
24																				192	201	210	219	228	238	247
25																					211	220	230	239	249	258
26																						230	240	250	260	270
27																							250	261	271	282
28																								272	282	293
29																									294	305
30																										317

THE χ^2-TEST

When scientists make a prediction and carry out an experiment, they hope that their prediction is correct. Usually you can tell if the prediction is hopelessly wrong but what if it is almost right? This is often the case in biology where living systems are complex.

How can scientists be sure if their results fit in with their predictions? The answer is to use a statistical tool that compares the observed results with the expected ones. The one used here is called the χ^2-test (chi^2- test). It is used for data in categories (nominal data) i.e. counts of individuals such as numbers of seeds germinating in different conditions.

The simplest case is if there are two possible outcomes. For example toss a coin 10 times, you would expect 5 heads and 5 tails because the chance of a head or a tail is 50% for a fair coin. This does not mean you would get 5 heads every time. You would not be too surprised if you got 6 heads, or maybe even 7. If, though, you got 9 or 10 you might begin to question your initial assumption (often called the null hypothesis) that the coin is fair. This is because the difference between what you would 'expect' under the null hypothesis and what you actually 'observe' is too great.

The χ^2-test standardises this intuitive view. It considers the differences between observed values (O) and expected values (E) using the formula:

$$\sum \frac{(O-E)^2}{E}$$

Clearly the larger the differences between observed and expected values the larger the numerical value of χ^2 and the less likely it is that your original assumption, or null hypothesis, is true.

The χ^2-test works for counts for example numbers of individuals or beats or bubbles per minute.

A biological example

Gregor Mendel, the father of genetics, studied the inheritance of peas. One of the characteristics he investigated was flower colour. The coloured flower allele is dominant to the white flower allele.

The pure bred parents, one coloured the other white, are crossed. They produce the F1 which are all coloured. These F1 are then selfed to produce the F2.

Mendel's Law of Segregation predicts that there should be 75% coloured flower plants to 25% white flowered plants. How well did his results fit this?

Here we use the χ2 test as a test of goodness of fit.

Two possible hypotheses

NH The results agree with the prediction. Called the Null Hypothesis because we expect no difference.

AH The results disagree with the prediction. This is called the Alternative Hypothesis.

Which one is correct?

Calculating the χ2 statistic from the results

Set up a 1 x 2 table (1 row x 2 columns) to collect the observed data

	Type of flower	
	Coloured	White
Number of plants	705	224

Trait	Mendel's Results (Observed)	Mendel's Predictions (Expected)	Difference (O-E)	$(O-E)^2/E$
Coloured flowers	705	75% of 929 = 696.75	+ 8.25	0.0977
White flowers	224	25% of 929 = 232.25	-8.25	0.2931
Totals	929	929		0.3908 = χ^2

This calculated value for χ^2 needs to be compared with values for χ^2 found in probability tables. For this we need to know the number of Degrees of Freedom. This is worked out from the number of classes - 1. In this case there are two classes (coloured flowers and white flowers). So the number of degrees of freedom = 2 - 1 = 1

Probability levels (p) for χ2

Degrees of Freedom	0.95	0.9	0.5	0.100	0.050	0.010	0.001
1	0.0039	0.016	0.455	2.71	3.84	6.63	10.83
2	0.1	0.211	1.39	4.61	5.99	9.21	13.82
3	0.35	0.584	2.37	6.25	7.81	11.34	16.27
4	0.71	1.06	3.36	7.78	9.49	13.28	18.47
5	1.14	1.61	4.35	9.24	11.07	15.09	20.52
6	1.64	2.2	5.35	10.64	12.59	16.81	22.46
7	2.17	2.83	6.35	12.02	14.07	18.48	24.32
8	2.73	3.49	7.34	13.36	15.51	20.09	26.13
9	3.32	4.17	8.34	14.68	16.92	21.67	27.88
10	3.94	4.87	9.34	15.99	18.31	23.21	29.59

Results smaller than the 0.90 level look too good to be true.

The difference is not significant. The NULL hypothesis is accepted.

The difference is significant. The NULL hypothesis is rejected.

Having obtained our value for χ2 we need to compare it with the values in the tables for our particular number of “degrees of freedom”. The table lists various “significance levels” e.g. p = 0.05 and 0.01. These are often referred to as the 5% and the 1% significance levels. The value of 7.81 in the column headed by 0.05 when there are 3 degrees of freedom means there is a probability of only 0.05 of obtaining a value this large if our null hypothesis is true. As this is very unlikely we would reject the null hypothesis if our calculated value of χ^2 was this big or bigger. A common form of words is to say, “The result is significant where p = 0.05 so we reject the null hypothesis that…”

If our calculated value of χ2 was smaller than this “critical value” we would claim, “The result is not significant so there is no reason at p = 0.05 to reject the null hypothesis that....” Indeed if the value of χ2 is much smaller than the p = 0.05 critical value we could claim that the experimental results ‘support’ (they can never prove) the null hypothesis.

In our example the calculated value for χ2 is 0.3908, which is well below p = 0.05 on one degree of freedom, 3.84. There is clearly no reason to reject Mendel’s theory on this set of results.

Sometimes though the results can be just too good. If someone claimed to get 5 heads out of 10 tosses of a fair coin every time he did it you might question their veracity. With a χ2-test calculated results smaller than the 0.90 level and particularly below the 0.95 level might be regarded with suspicion.

Test of association

Quite often we do not have a hypothesis, like those derived from Mendel's laws, to work from. In these cases we are trying to establish if there is an association between different events. For example if seeds are treated in two different ways do they germinate or not.

Here a 2 x 2 table would be set up, two rows x two columns.

Result	Treatment A	Treatment B	Row total
Germinated			
Not germinated			
Column total			

Grand total

The expected values can be calculated by $\frac{\text{Row total x Column total}}{\text{total}}$

Our Null Hypothesis would be that there is no association.

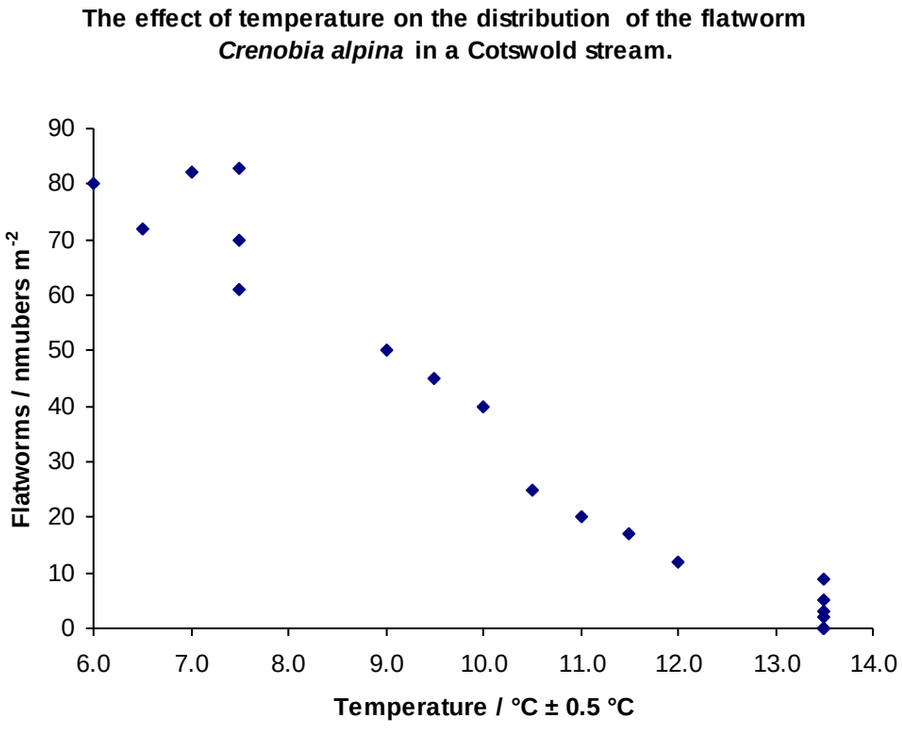
To calculate the degrees of freedom = (number of rows – 1) x (number of columns – 1)

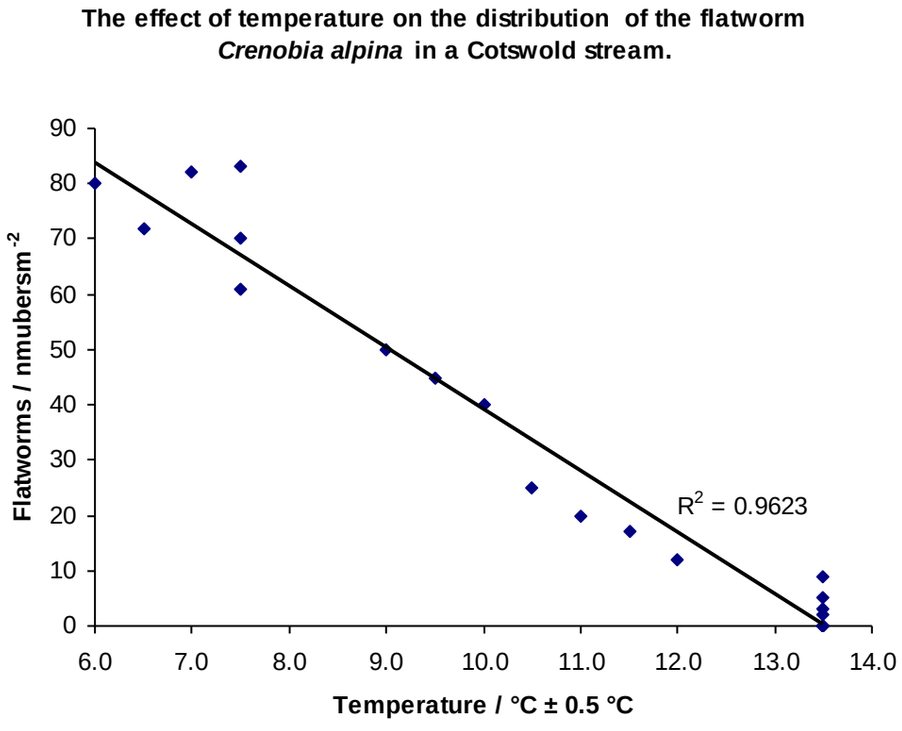
Correlation

Linear Correlation

The following results were observed for a flatworm, *Crenobia alpina*, living in a hill stream.

Temperature / °C ± 0.1°C	Flatworms / numbers m^{-2}
6.0	80
6.5	72
7.0	82
7.5	83
7.5	70
7.5	61
9.0	50
9.5	45
10.0	40
10.5	25
11.0	20
11.5	17
12.0	12
13.5	9
13.5	5
13.5	0
13.5	3
13.5	2
13.5	0
13.5	0
13.5	0





The scatter gram of the data reveals that there seems to be a strong linear relationship between the water temperature of the stream and the density of flatworms.

By adding a trend line it is possible to show the Coefficient of Determination (use options in the trend line menu of MSExcel). The value 0.9623 indicates that there is a strong linear correlation between the two variables (water temperature and numbers of Crenobia). Because the line falls from 6 to 13.5°C it is a negative correlation.

Note the Coefficient of Determination (R^2) is not the correlation coefficient it is a measure of how well the model (the trend line) fits the data and how likely another data point will lie on this model.

To find if there is a relationship between the two variables we use Spearman Rank Correlation (rs). This goes from +1, for a strong positive correlation, to 0, for no correlation, and -1, for a strong negative correlation.

Put the two variables in rank order. If two or more results are the same then give them the average of the rank they would normally occupy.

The difference between the ranks (*d*) is calculated then squared (d^2) (see next section).$r_s = 1 - \frac{6\Sigma d^2}{n(n^2 - 1)}$

The correlation coefficient (*r*) is calculated on a spread sheet, as follows:

T°C	Flatworms	Flatworms Rank	T°C Rank	d	d²
7.5	83	1	16	15	225
7	82	2	19	17	289
6	80	3	21	18	324
6.5	72	4	20	16	256
7.5	70	5	17.5	12.5	156.25
7.5	61	6	17.5	11.5	132.25
9	50	7	15	8	64
9.5	45	8	14	6	36
10	40	9	13	4	16
10.5	25	10	12	2	4
11	20	11	11	0	0
11.5	17	12	10	-2	4
12	12	13	9	-4	16
13.5	3	16	4.5	-11.5	132.25
13.5	2	17	4.5	-12.5	156.25
13.5	0	19.5	4.5	-15	225
13.5	0	19.5	4.5	-15	225
13.5	0	19.5	4.5	-15	225
13.5	0	19.5	4.5	-15	225

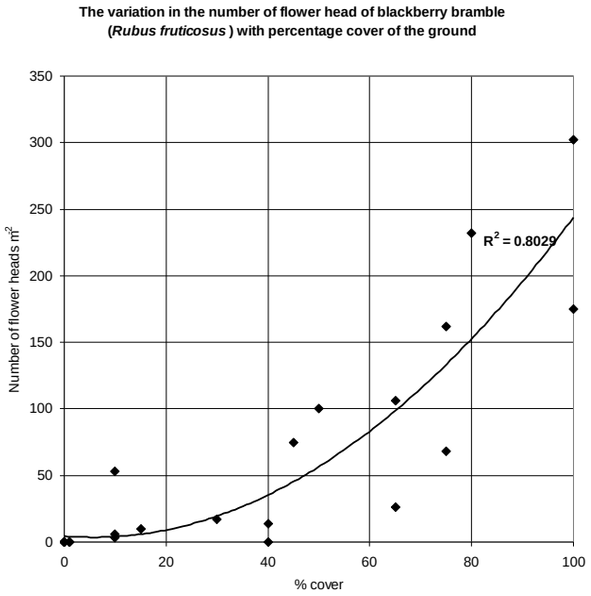
Sum=2911.5 6*Sum=17469 n=21 n(n^2-1)=9240 r_s=-0.8906

This indicates that there is a strong negative correlation between temperature and the density of *Crenobia alpine*.

Cause and effect

Just because there is a strong correlation does not mean that a low temperature causes a high density of *Crenobia* or that a high density of *Crenobia* causes a low temperature. The reason has to searched for elsewhere. For example the food or *Crenobia* grows better at a lower temperature, or the enzymes of *Crenobia* have a low optimum temperature.

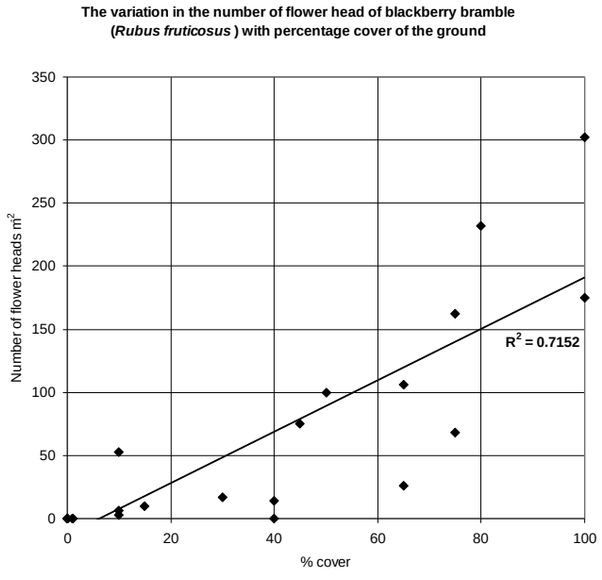
Relationships where there is a curve



In an investigation on the distribution of blackberry bramble plants (*Rubus fruiticosus*) and the numbers of flower heads we can see that there appears to be a linear relationship. This makes sense if there is a higher density of plants there should be a higher density of flower heads.

However if we try a curve we get a better fit. The R^2 value is a bit higher.

To find if there is a relationship between the two variables that are not directly proportional (not a straight line) we can still use Spearman Rank Correlation (r_s).



This a strong positive correlation between the percentage cover of the bramble plants and the density of the flower heads.

n	% cover ± 5%	Rank% cover	Number of flower heads m-2	Rank flower heads	Difference between the ranks (d)	d^2
1	0	3	0	5	-2	4
2	0	3	0	5	-2	4
3	0	3	0	5	-2	4
4	0	3	0	5	-2	4
5	0	3	0	5	-2	4
6	1	7	0	5	2	4
7	1	7	0	5	2	4
8	1	7	0	5	2	4
9	10	10	3	10	0	0
10	10	10	53	16	-6	36
11	10	10	6	11	-1	1
12	15	12	10	12	0	0
13	30	13	17	14	-1	1
14	40	14.5	0	5	9.5	90.25
15	40	14.5	14	13	1.5	2.25
16	45	16	75	18	-2	4
17	50	17	100	19	-2	4
18	65	18.5	26	15	3.5	12.25
19	65	18.5	106	20	-1.5	2.25
20	75	20.5	68	17	3.5	12.25
21	75	20.5	162	21	-0.5	0.25
22	80	22	232	23	-1	1
23	100	23.5	175	22	1.5	2.25
24	100	23.5	302	24	-0.5	0.25

$\Sigma d^2=201$ $r_s = 0.91$

Summary

- Establishing the variation in a sample (how consistent is a sample)

Range: Maximum value – Minimum value

Standard deviations: for sample > 5

- Confidence in a sample (how representative is a sample)

Standard error of the mean or the 95% confidence limits.

- Testing the relationships between variables

Spearman rank correlation coefficient.

- Comparing two samples

Choosing the right statistical test depends upon the kind of data you have.