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AREA OF STUDY 3 *Heinemann Biology 2 5th Edition ProductLink* provides extensive support material for Unit 4 Area of Study 3 Practical Investigation.

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How to use this book

Heinemann Biology 2 5th edition

Heinemann Biology 2 5th edition has been written to the new VCE Biology Study Design 2017–2021. The book covers Units 3 and 4 and is an easy-to-use resource. Explore how to use this book below.

Biology in Action

Biology in Action places biology in an applied situation or relevant context. Text and artwork refer to the nature and practice of biology, applications of biology and associated issues, and the historical development of biological concepts and ideas.

Chapter opener

Chapter opening pages link the Study Design to the chapter content. Key knowledge addressed in the chapter is clearly listed.

CHAPTER 05 Energy transformation in cells

Learning outcomes

Energy is vital for life. Whether growing, moving, reproducing, responding or excreting, living organisms are using energy. Using energy involves transforming energy from one form to another, and transferring it from one place to another. When a muscle contracts, for example, chemical energy in the muscle cells is being transformed into the kinetic energy of movement.

By the end of this chapter, you will have an understanding of the cellular organelles and biochemical pathways that provide living things with the energy they need to survive.

You will also learn how cells adjust their metabolism to account for changes in environmental conditions.

Key knowledge

- the purpose of photosynthesis
- chloroplasts as the site of photosynthesis, an overview of their structure and evidence of their bacterial origins
- inputs and outputs of the light-dependent and light-independent (Calvin cycle) stages of photosynthesis in C3 plants (details of the biochemical pathway mechanisms are not required)
- factors that affect the rate of photosynthesis, including light, temperature and carbon dioxide concentration
- the purpose of cellular respiration
- the location of, and the inputs and outputs of, glycolysis including ATP yield (details of the biochemical pathway mechanisms are not required)
- mitochondria as the site of aerobic cellular respiration, an overview of their structure and evidence of their bacterial origins
- the main inputs and outputs of the Krebs (citric acid) cycle and electron transport chain including ATP yield (details of the biochemical pathway mechanisms are not required)
- the location of anaerobic cellular respiration, its inputs and the difference in outputs between animals and yeasts including ATP yield
- factors that affect the rate of cellular respiration, including temperature, glucose availability and oxygen concentration.

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BIOFILE

Acromegaly
Acromegaly is a hormonal disorder in which the pituitary gland produces too much of the growth hormone somatotrophin. Sometimes the overproduction of the hormone is caused by a tumour of the anterior pituitary gland. The tumour can be treated with drugs or surgically removed.

Acromegaly normally develops during adulthood and results in an increase in the size of hands, feet and face, and can result in severe degenerative and fatal complications. When acromegaly occurs during childhood, the excess growth hormone can cause a condition known as gigantism. These children can have exaggerated bone growth and an abnormal increase in height.

BIOLOGY IN ACTION

Building strong bones

You are probably aware that if you break your arm, the broken bone becomes thinner and weaker during the period in which it is in plaster and out of action (Figure 6.1.7). For people suffering from osteoporosis, weight-bearing exercises are recommended to build up bone strength. Both of these situations relate to the ability of bone cells to detect and respond to physical stress. Physical stress on bones causes them to become thicker. Removal of stress causes bone material to be resorbed into the circulation.

Bones are not permanent structures—they are dynamic. They are a reservoir of calcium used to maintain blood calcium levels. Parathyroid hormone and calcitonin are involved in the deposition and resorption of calcium salts in bone. Depending on the level and direction of the stress, bone cells lay down or resorb the calcium salts from which they are made (Figure 6.1.8). This is why bone grafts usually work so well. A piece of bone from the tibia in the leg can be grafted into the spinal column. It will soon be reshaped by physical stress to suit its new location and the work it has to do.



FIGURE 6.1.7 X-ray of a broken bone.

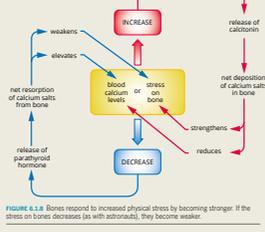


FIGURE 6.1.8 Bones respond to increased physical stress by becoming stronger. If the stress on bones decreases (as with astronauts), they become weaker.



FIGURE 6.1.6 Man suffering from acromegaly.

Histamine is an organic nitrogenous compound that binds to specific receptors on various cell types. Histamine causes:

- blood vessel dilation
- a decrease in blood pressure
- an increase in the permeability of blood vessels to immune cells and fluids for a better immune response at the site of antigen contact
- contraction of smooth muscles lining the airways, which can make it more difficult to breathe
- activation of fluid-secreting cells, which results in a runny nose, teary eyes and sneezing, which expels foreign antigens.

1 An antihistamine is a drug that counteracts the effects of histamine by blocking histamine receptors and therefore suppressing some allergy symptoms.

EXTENSION

Treatment for allergic reactions

Medications

Antihistamines block the effects of histamine by binding to the same receptors as histamine, thereby preventing histamine from binding to them. Other medications used to treat allergies, for example corticosteroids, suppress the immune system more broadly and reduce the immune response in general.

If the allergic reaction is severe enough to cause anaphylaxis, an immediate intramuscular injection of adrenaline (or epinephrine) is needed (Figure 8.2.4). Adrenaline auto-injectors are commonly known and marketed as EpiPens (Figure 8.2.5). Adrenaline counters the actions of histamine by causing:

- blood vessels to constrict (decreasing swelling and increasing blood pressure)
- muscles in the airways to relax (so the airways open up)
- the heart to beat faster, which increases the blood flow to the heart (This prevents cardiovascular collapse, which results from a lack of effective blood flow to the heart due to excessive dilation of the blood vessels that result from too much histamine.)

Allergen immunotherapy

Allergen immunotherapy (or desensitisation) is used to treat hypersensitive reactions to particular allergens, such as bee sting toxin. Beginning with extremely small amounts, an allergen is injected multiple times in increasing amounts over a period of months. This causes the formation of specific immunoglobulin G (IgG) antibodies against the allergen. IgG antibodies are a key component of the humoral immune response and are the main immunoglobulins in blood serum.

If IgG antibodies react with the allergen before it can bind to IgE antibodies to cause an allergic response, the allergic response is prevented. During the course of treatment, the individual slowly becomes less and less sensitive to the particular allergen being treated.

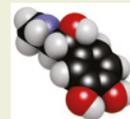


FIGURE 8.2.4 A molecular model of adrenaline (epinephrine), a hormone and neurotransmitter. Atoms: hydrogen (white), carbon (black), oxygen (red), nitrogen (blue).



FIGURE 8.2.5 This girl is using an adrenaline auto-injector to prevent herself going into anaphylactic shock.

Highlight

Focus on important information such as key definitions and summary points.

BioFile

BioFiles include interesting information and real world examples.

Extension

Extension goes beyond the core content of the Study Design. Material is intended for students who wish to expand their depth of understanding.

Chapter review

Each chapter concludes with a set of higher-order questions to test students' ability to apply the knowledge gained from the chapter.

Section summary

Each section includes a summary to assist students consolidate key points and concepts.

Section review

Each section concludes with questions to test students' understanding and ability to recall the section's key concepts.

11.3 Review

SUMMARY

- Evolution does not always occur at a slow, gradual pace.
- Mutations in master regulatory genes give rise to novel phenotypes and may lead to rapid speciation if those phenotypes are advantageous.
- Master regulatory genes control the process of embryonic development.
- Some master regulatory genes can change the rate and timing of gene expression during embryonic development. This causes the expression of a gene to be sped up or slowed down.
- Some master regulatory genes can change the arrangement of body structures during embryonic development.
- Hox genes are a type of master regulatory gene that controls the arrangement of the body plan along the head-to-tail axis during embryonic development.
- Master regulatory genes are at the top of the gene hierarchy, controlling the expression of other genes.
- Master regulatory genes are highly conserved across different species because they are so important for correct development and biological functioning.

- Cichlid fish in East Africa are an example of adaptive radiation.
- The *BMP4* (bone morphogenetic protein number 4) gene regulates the development of cartilage and muscular cell development in the jaws of a cichlid fish.
- Mutation of the *BMP4* gene causes variations in the size and shape of the jaw of a cichlid fish.
- Darwin's finches on the Galapagos Islands are also an example of adaptive radiation.
- The *BMP4* gene and *CaM* gene control the size and shape of a finch's beak.
- BMP4* protein controls the width of the beak. The more *BMP4* present during embryonic development, the wider the beak will be.
- CaM* protein controls the length of the beak. If it is present in large amounts during the bird's embryonic development, it will develop a longer beak.

KEY QUESTIONS

- Complete the following statement by filling in the gaps with the correct answers. Mutations in _____ regulatory genes are thought to cause changes in _____ genes. These changes can result in major _____ and functional changes and may lead to _____.
 2 Why are mutations in master regulatory genes relatively rare?
 3 Select the most likely explanation for the evolutionary development of bat wings.
 A A bat's wing results from the finger bones growing faster than the rest of the bat's body.
 B A bat has a different set of genes associated with limb development that are not found in any other organism.
 C A bat's wing results from the finger bones continually growing throughout its life.
 D A bat's wing is homologous to a bird's wing.
- What is the main function of Hox genes and why are these genes considered to be at the top of the gene regulation hierarchy?
- The following statements about cichlid evolution is not correct!
 A The diversity of cichlid fishes is an example of adaptive radiation.
 B The evolution of different cichlid fishes in East Africa is best explained by gradual accumulation of mutations.
 C Cichlid fishes are found in East Africa.
 D The different-sized jaws of cichlid fishes are a result of different amounts of *BMP4*.
- How do the master regulatory genes *BMP4* and *CaM* influence the development of fish beaks?

Chapter review

KEY TERMS

- BMP4* (bone morphogenetic protein number 4) gene
- branch
- clade
- cladogram
- conservative substitution
- conserved
- gene probe
- heterochrony
- homologous
- Hox gene
- hybridised
- lead
- lineage
- Linnaean system of classification
- master regulatory gene
- maximum parsimony
- molecular clock
- mutation rate
- node
- non-conservative substitution
- outgroup
- phylogenetic tree
- phylogenomics
- phylogram
- polytomy
- root
- semi-conservative substitution
- sister taxa
- taxon (plural taxa)
- taxonomy

KEY QUESTIONS

- The melting temperature of DNA from a single species is 86°C. A DNA hybridisation experiment was performed between three species A, B and C. The results of the experiment are shown in the table below.

DNA mix	Melting temperature (°C)
A-B	78
A-C	72
B-C	81

 The cladogram generated from this information would be:
 A  B 
 C  D 
- The graph that would best illustrate the assumed rate of the molecular clock is:
 A  B 
 C  D 

Area of Study review

Each Area of Study concludes with a comprehensive set of exam-style questions, including multiple choice and extended response, that assist students in drawing together their knowledge and understanding and applying this to these question styles.

UNIT 4 • Area of Study 2

REVIEW QUESTIONS

How do humans impact on biological processes?

Multiple choice questions

- Which of the following statements most correctly describes how antibiotic resistance has developed in bacteria?
 A Colonies of antibiotic-resistant bacteria have developed as a result of the bacteria undergoing mutations in response to the antibiotics.
 B Some bacteria have a pre-existing allele that allows them to break down antibiotics. These bacteria increase in number in an environment containing antibiotics.
 C Bacteria that have undergone mutations in response to antibiotics pass that resistance to other bacteria by horizontal transfer. These bacteria then increase in number.
 D Humans create antibiotic resistance in bacteria by not taking all of the antibiotics in a course that has been prescribed by a doctor.
- Which step in the process of PCR best describes annealing?
 A separating the DNA strands
 B binding the primers
 C adding the polymerase
 D building the complementary DNA strands
- The figure below is a DNA profiling printout obtained from one individual. Ten regions have been analysed, 9 STRs and the sex chromosome markers. In the centre of the figure there is a peak labelled as 32.



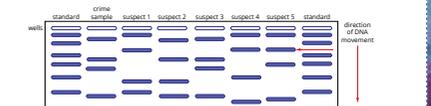

	Uninfected <i>E. coli</i> Nutrient agar only	Infected <i>E. coli</i> Nutrient agar and kanamycin	Transformed <i>E. coli</i> Nutrient agar only	Transformed <i>E. coli</i> Nutrient agar and kanamycin
A	plate A	plate C	plate D	plate A
B	plate A	plate B	plate C	plate D
C	plate D	plate A	plate B	plate C
D	plate C	plate D	plate A	plate B

- Antiviral medications provide treatments to reduce the seriousness of viral infections. Which of the following best describes how do they do this?
 A They block the receptors used by the virus to attach and enter the cells.
 B They block transcription in the infected cells.
 C They prevent the virus particles from leaving the cell.
 D All of the above.

- Different drugs are appropriate for different pathogens. Canadian lights fungus, penicillin fights bacteria, Relenza is effective against influenza virus. The plasmodium which causes malaria is a protozoan. Which would be the most effective treatment for malaria?
 A Canadian
 B penicillin
 C Relenza
 D None of the above.
- Rational design of a drug to combat a virus involves targeting a particular viral protein. Which of the following characteristics would be the most useful in designing a drug to combat the virus?
 A The protein is used by the virus in the early stages of its reproduction.
 B The protein is used by the virus to attach to its host cells.
 C The protein is used by the virus in the later stages of its reproduction.
 D The protein is common to several strains of the virus.

Short answer questions

- The 'Ever Open Convenience Store' had experienced a number of robberies. The police were keen to catch the offender, who had a habit of putting a pair of rubber gloves on before a robbery. The police had five suspects, but were unable to gather sufficient evidence to clearly identify the perpetrator. The robber wore rubber gloves, a mask, concealing clothing and a balaclava. After the fourth robbery the police found the little finger roped from a pair of rubber gloves. The piece of glove was carefully collected and sent to the forensic science laboratory to be tested for DNA. Such material will contain a very small amount, if any, of DNA.
 a What is the source of the DNA found inside the glove?
- Such small amounts of DNA are not suitable for preparing a DNA profile. How will the forensic scientists acquire enough DNA to create a DNA profile? Draw a flow chart describing the process.
- DNA from the crime scene was collected and amplified. A DNA profile was made using the amplified DNA from the crime scene and DNA from each of the five suspects. The profile is shown at the bottom of the page.
 i The standards are 1000bp, 2000bp, 4000bp, 5000bp, 7000bp and 10000bp. What is the size of the band indicated by the red arrow?
 ii Why are standards needed?
 iii Explain which suspect best matches the crime scene sample.
 iv Does a match mean that the suspect performed the crime?
 v Myotonic dystrophy is a serious disease that causes wastage of muscles. It can affect cardiac muscle, resulting in heart problems. The most severe form of the disease is caused by a mutation in the *DMPK* gene, which is found on the long arm of chromosome 19. It is caused by a CTG trinucleotide repeat. In most people there are between 5 and 37 repeats but in individuals with myotonic dystrophy the number of repeats exceeds 50. It is often an adult-onset disease and has an autosomal dominant pattern of inheritance. This means that if the allele is inherited it is certain that the disease will develop, but the person may not know until later in life.
 a Explain how electrophoresis could be used to identify whether an individual has the mutated allele.
 b Before a person can undergo genetic testing they must spend some time discussing associated issues with a counsellor. What are some issues that could be associated with genetic testing for myotonic dystrophy?



Answers

Comprehensive answers for all section review, chapter review and Area of Study review questions are provided via *Heinemann Biology 2 5th edition ProductLink*.

Glossary

Key terms are shown in **bold** throughout, and listed at the end of each chapter. A comprehensive glossary at the end of the book defines all key terms.

Heinemann Biology 2

5th edition



Student Book

Heinemann Biology 2 5th edition has been written to fully align with the VCE Biology Study Design 2017–2021. The series includes the very latest developments and applications of biology and incorporates best practice literacy and instructional design to ensure the content and concepts are fully accessible to all students.

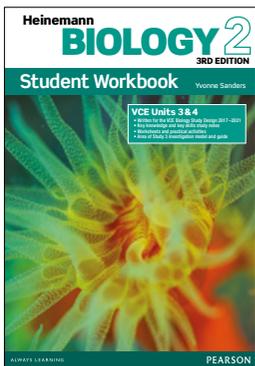
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