



NSW Education Standards Authority

2019 HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total marks: 100

Section I – 20 marks (pages 2–12)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13–32)

- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this section

Section I

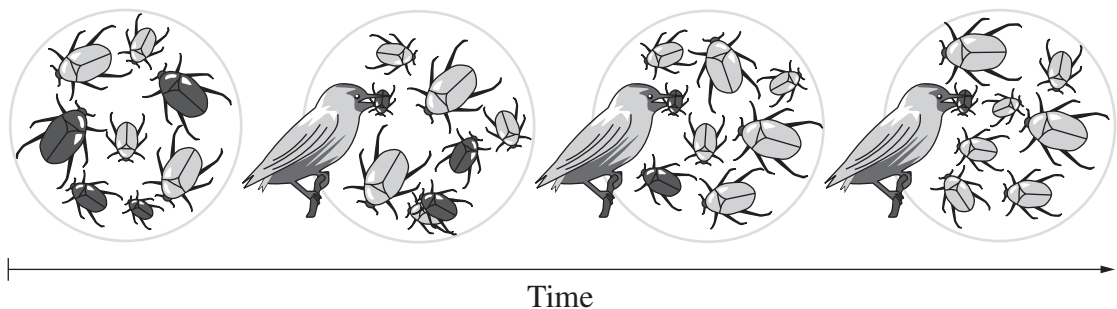
20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

- 1 Which of the following is an example of a non-infectious disease?
- A. Polio caused by a virus
 - B. Cholera caused by a bacterium
 - C. Wheat rust caused by a fungus
 - D. Haemophilia caused by a gene mutation
- 2 What does the body produce in response to a vaccine?
- A. Antigens
 - B. Antibiotics
 - C. Antibodies
 - D. Activated toxins
- 3 The diagram shows the impact of birds feeding on a population of beetles over time.

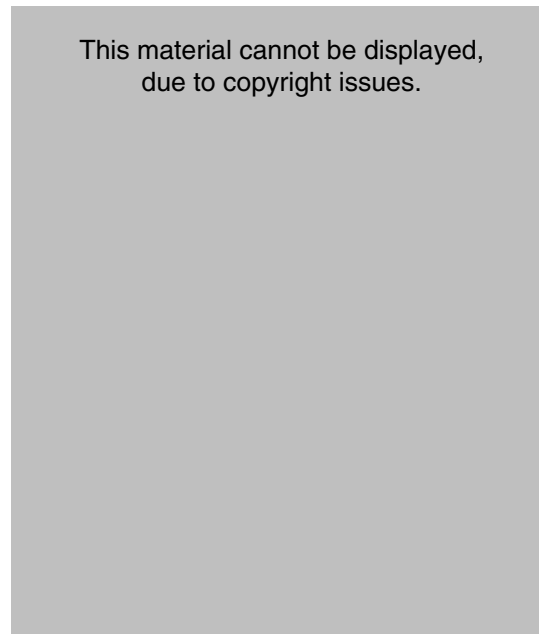


Natural Selection, Understanding Evolution
University of California, Museum of Paleontology. 30 October 2019
https://evolution.berkeley.edu/evolibrary/article/0_0_0/evo_255

Which of the following accounts for the change in the beetle population?

- A. Mutation
- B. Gene flow
- C. Genetic drift
- D. Environmental pressure

- 4 The figure shows a part of a DNA molecule.

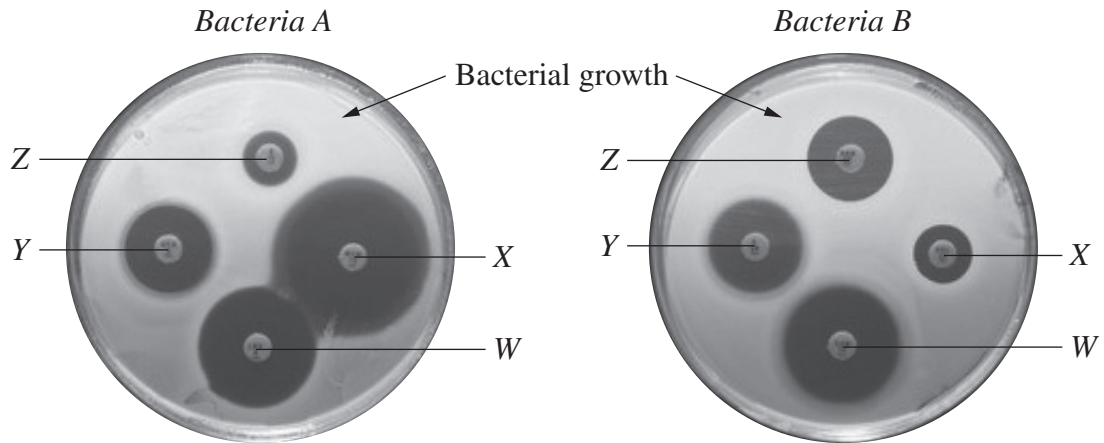


<https://ib.bioninja.com.au/standard-level/topic-2-molecular-biology/26-structure-of-dna-and-rna/dna-structure.html>
(Organisation of DNA – Antiparallel of DNA Strands)

- How many complete nucleotides are shown in the figure?
- A. 1
 - B. 2
 - C. 4
 - D. 8
- 5 Which of the following is part of the innate immune response?
- A. Antibodies
 - B. Phagocytes
 - C. Stomach acid
 - D. B lymphocytes
- 6 How does the cochlear implant assist people with severe hearing loss?
- A. It amplifies sound.
 - B. It stimulates the ear drum.
 - C. It stimulates the auditory nerve.
 - D. It amplifies vibrations in the cochlea.

- 7 Two types of bacteria were isolated from a patient's throat swab and grown in pure culture on separate agar plates. On each plate there were FOUR different antibiotic discs, W, X, Y and Z.

The photograph shows the plates seven days later.



Which antibiotic should be used to treat the patient?

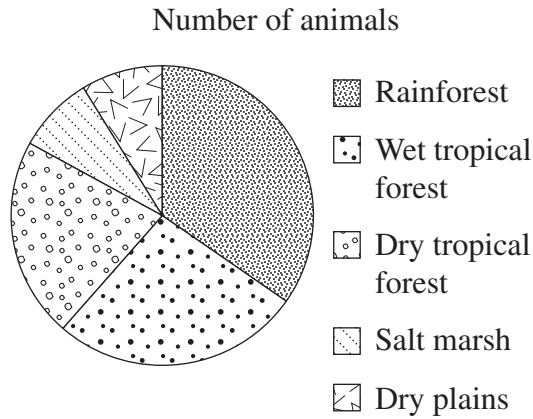
- A. W
- B. X
- C. Y
- D. Z

Replacement image.
Original image awaiting copyright.
<http://www.bacteriainphotos.com/disk%20diffusion%20testing.html>

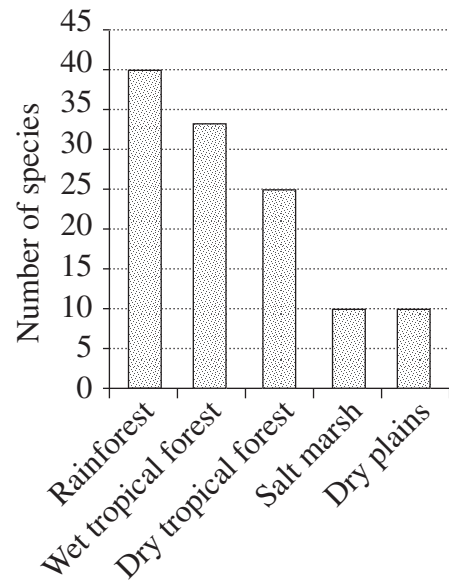
- 8 A group of four students set out to determine the animal species diversity over an area of one hectare in each of five different habitats. Each student graphed their data as shown.

Which of the graphs produced is the most suitable to represent animal species diversity in the different habitats?

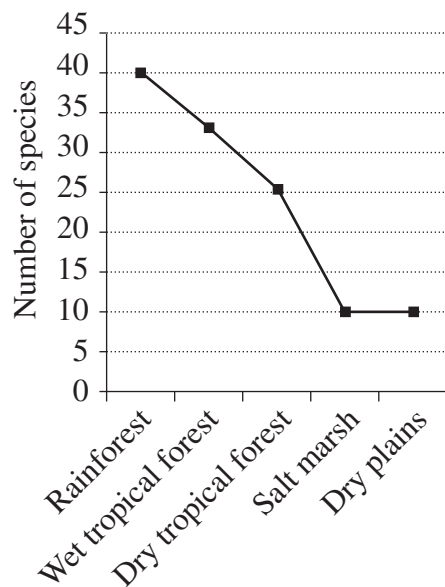
A.



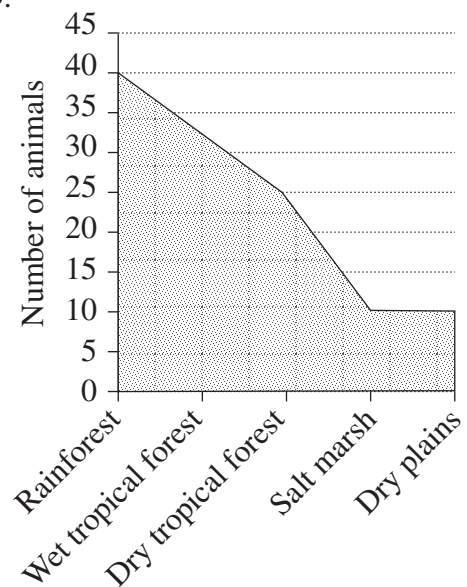
B.



C.



D.



- 9** Which of the following is an advantage for animals using internal fertilisation rather than external fertilisation?
- A. It prevents dehydration of gametes.
 - B. It involves large numbers of gametes.
 - C. It relies on adaptations such as mating rituals.
 - D. It allows gametes to combine to form unique offspring.

- 10** A group of islands are separated from each other by large stretches of water. Each island has its own policy on quarantine.

A nearby country is experiencing an outbreak of an infectious disease in its cattle.

An investigation is to be designed to find which of the quarantine policies operating on the islands is the most effective.

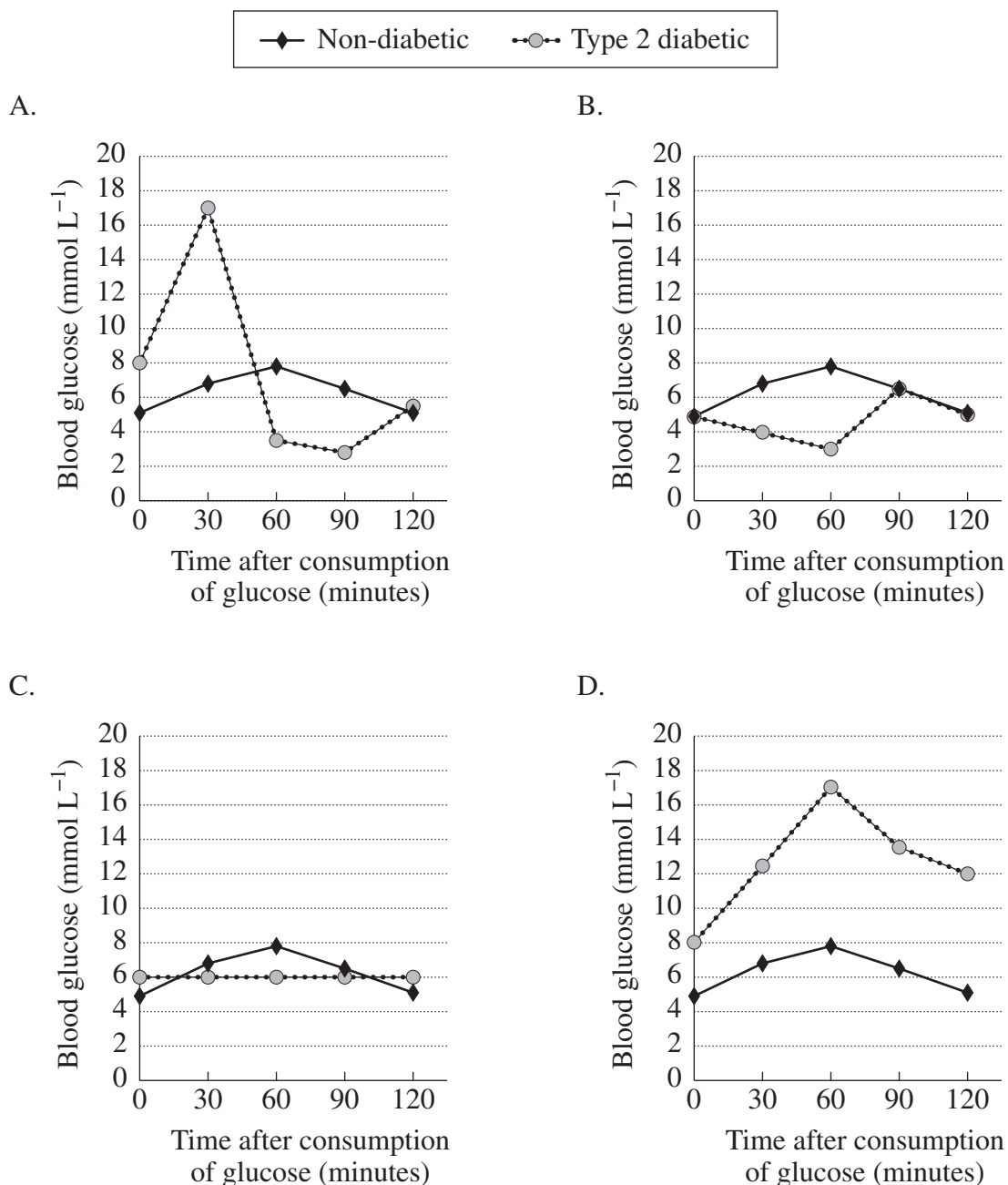
Which of the following would be a suitable design feature of the investigation?

- A. The control is the smallest island.
 - B. The control is the number of infected cattle.
 - C. The independent variable is quarantine policy.
 - D. The independent variable is the number of infected cattle.
- 11** Which of the following is always true of a mutation that produces a dominant allele?
- A. It will be lethal in a population.
 - B. It will be expressed in heterozygous individuals.
 - C. It will only be expressed in homozygous individuals.
 - D. It will spread more quickly through the population than a recessive allele.

- 12 The glucose tolerance test is used to investigate the control of glucose in the human body. Patients consume 75 g of glucose and their blood glucose is monitored.

Type 2 diabetes is a condition where the cells of the body do not respond adequately to insulin.

Which graph could represent the results of glucose tolerance tests in a non-diabetic person and a person with untreated Type 2 diabetes?



13 Genetic drift is a gradual change in

- A. the alleles of an individual due to mutation.
- B. allele frequency in a population due to chance.
- C. the genes of a population due to natural selection.
- D. gene frequency in a population due to natural selection.

14 The following DNA base sequence is used to code for a sequence of four amino acids.

CGC ATC ATG CTA

Which of the following correctly represents the anticodons on the transfer RNA during synthesis of this string of amino acids?

- A. GCG UAG UAC GAU
- B. CGC AUC AUG CUA
- C. CGC ATC ATG CTA
- D. GCG TAG TAC GAT

15 A germ-line mutation is known to have occurred.

How is it possible that there has been no noticeable change in the phenotype of the offspring?

- A. The mutation occurred in a stretch of RNA.
- B. The mutation occurred in a protein-coding region.
- C. The mutation occurred in a stretch of non-coding DNA.
- D. The mutation did not affect the DNA sequence of any gametes.

- 16 The diagram shows the concentration of an antibody to a particular pathogen.



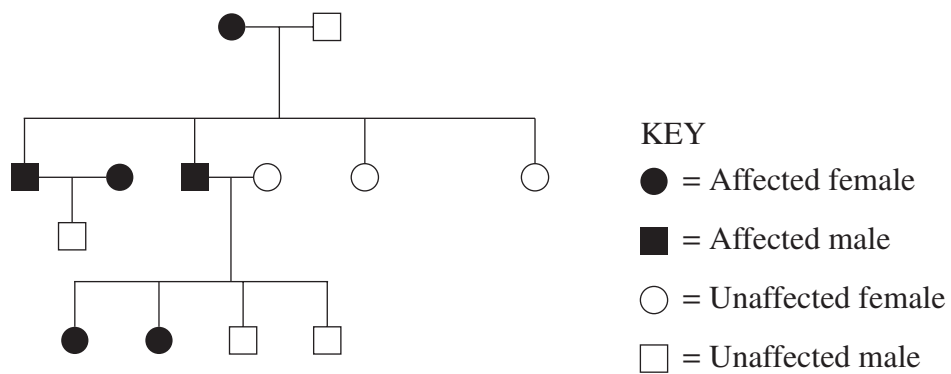
Two students are exposed to the pathogen. Student *X* had previously been vaccinated against this pathogen. Student *Y* had never been exposed to it.

Which row of the table shows the most likely levels of antibody in the blood of each student a week after exposure to the pathogen on this occasion?

Concentration of antibody in the blood (mg L⁻¹)

	<i>Student X</i>	<i>Student Y</i>
A.	250	1500
B.	1500	1000
C.	1000	1500
D.	1500	250

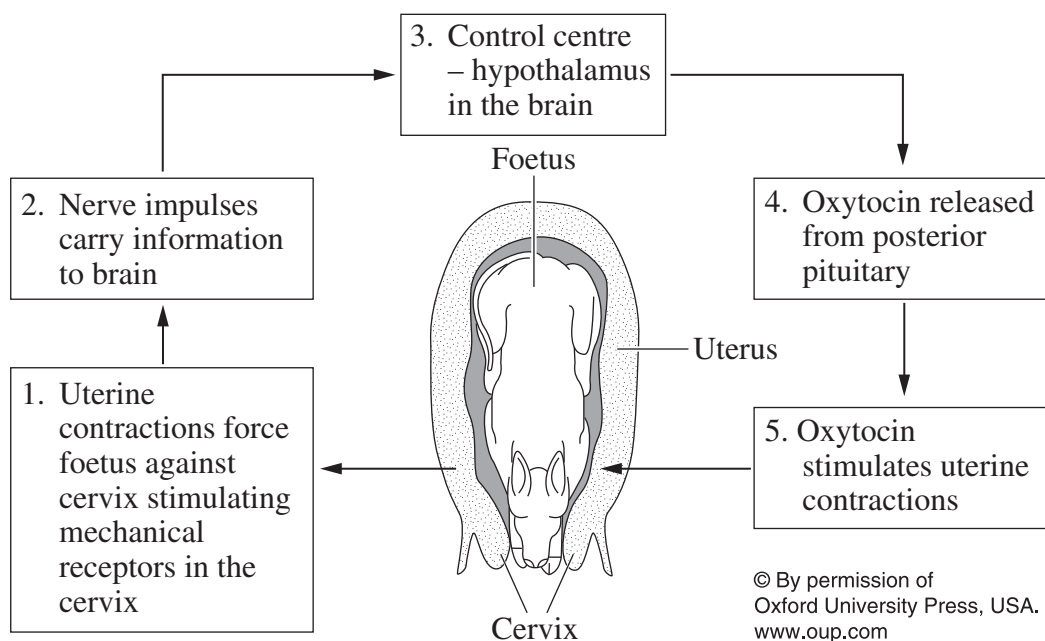
- 17 The pedigree shows the inheritance of a genetic disorder.



Which row of the table correctly identifies the two possible types of inheritance for this disorder?

	<i>Autosomal dominant</i>	<i>Autosomal recessive</i>	<i>Sex-linked dominant</i>	<i>Sex-linked recessive</i>
A.	✓		✓	
B.	✓			✓
C.		✓	✓	
D.		✓		✓

- 18 The diagram shows the effect of the hormone oxytocin on the uterus during the birth of a mammal.

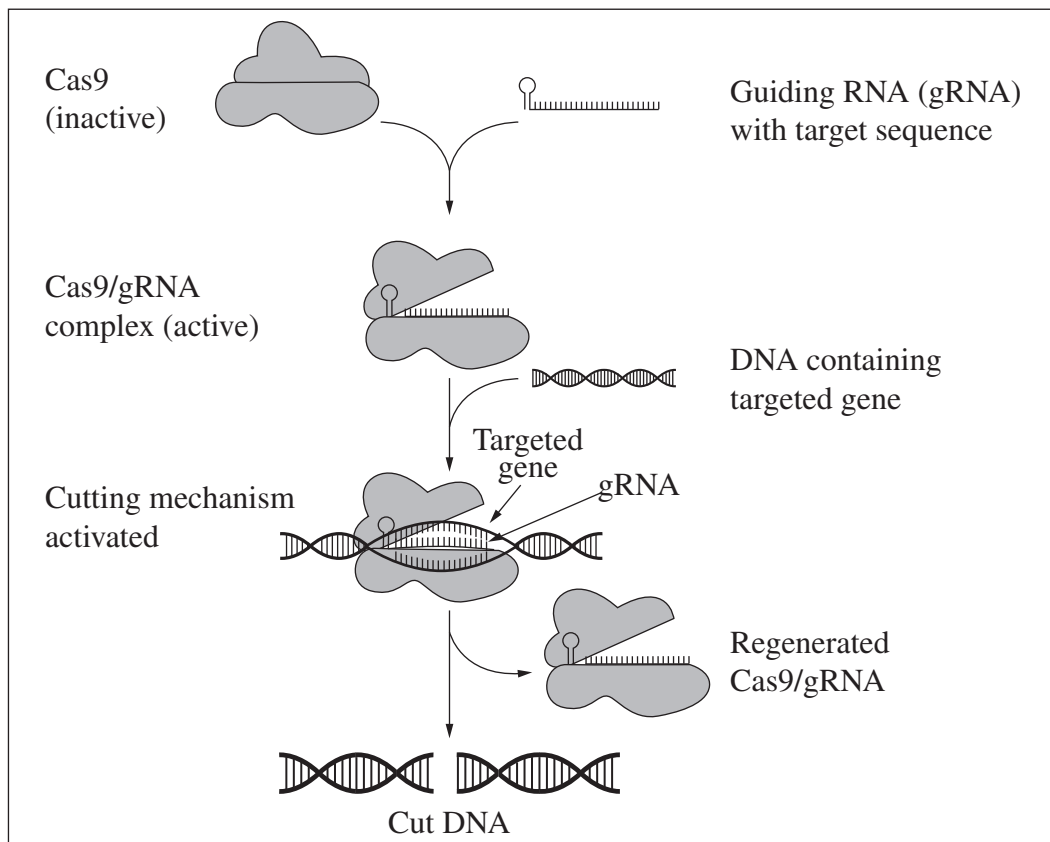


Which of the following best identifies and explains the feedback loop demonstrated in the diagram?

	<i>Feedback loop</i>	<i>Explanation</i>
A.	Negative	The production of oxytocin results in the production of more oxytocin.
B.	Positive	The production of oxytocin results in the production of more oxytocin.
C.	Negative	The production of oxytocin results in the detection of the contraction by receptors in the cervix.
D.	Positive	The production of oxytocin results in the detection of the contraction by receptors in the cervix.

Use the following diagram to answer Questions 19–20.

The diagram shows how CRISPR/Cas9 can be used as a new tool for genetic engineering. This technology has dramatically improved scientists' ability to successfully modify genomes.



Courtesy of Global Biotech Revolution

19 What type of structure must Cas9 be?

- A. Enzyme
- B. mRNA
- C. Ribosome
- D. tRNA

20 Scientists have been able to use biotechnology to ‘cut and paste’ DNA for decades.

Why would the new CRISPR/Cas9 technology have improved the scientists' success in cutting DNA of specific genes?

- A. Cas9 is able to combine with specific DNA.
- B. Cas9 has an active site that cuts target DNA.
- C. gRNA has the same nucleotides as the target DNA.
- D. gRNA has nucleotides complementary to the target DNA.

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Centre Number

Biology

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Student Number

Section II Answer Booklet

80 marks

Attempt Questions 21–33

Allow about 2 hours and 25 minutes for this section

Instructions

- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

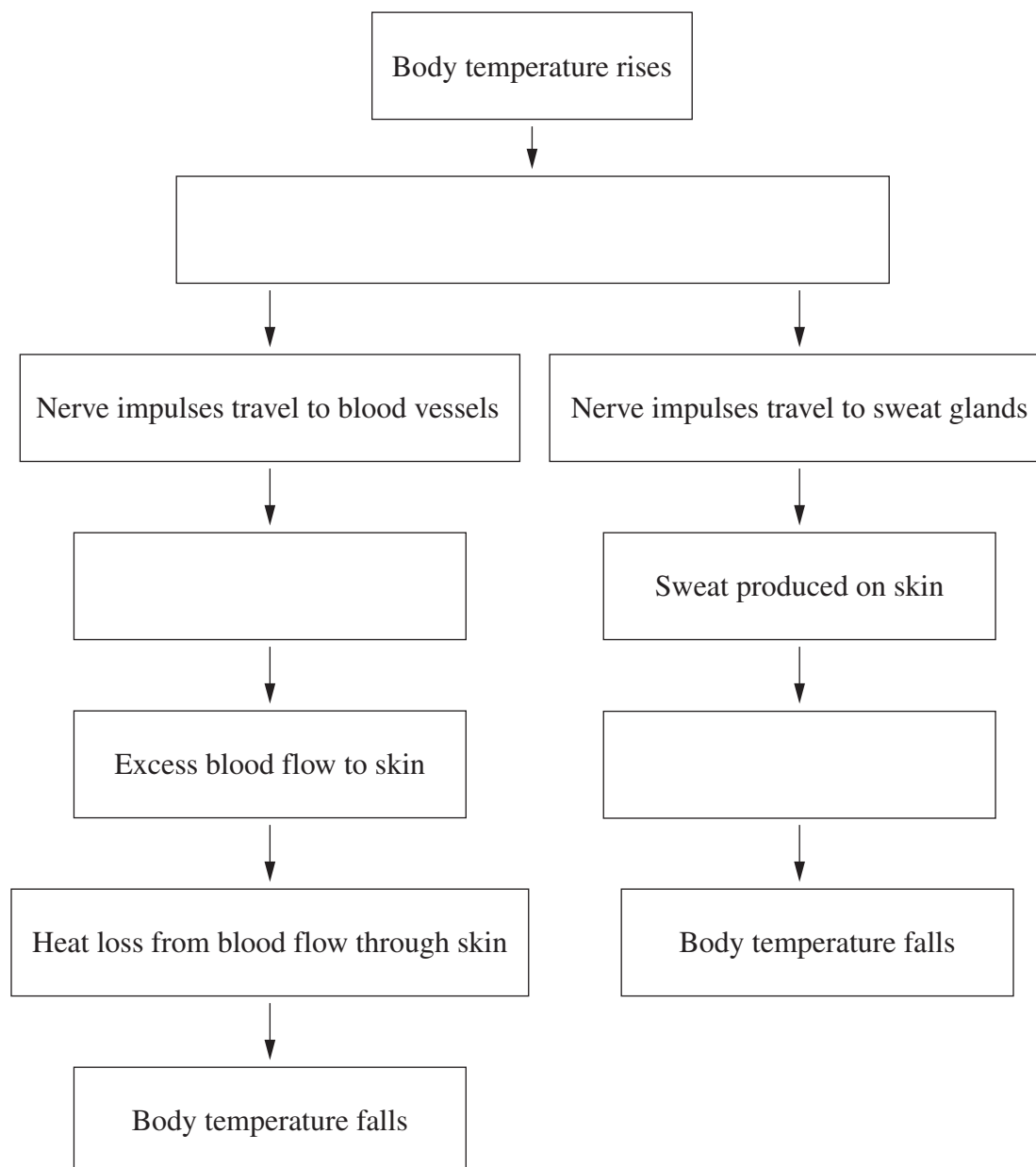
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Question 21 (3 marks)

The diagram shows a flow chart of the reaction of a human body to an increase in temperature.

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Fill in the three blank steps on the flow chart.



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Question 24 (5 marks)

Explain the loss of biodiversity that may result from TWO biotechnologies used in agriculture.

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Question 25 (5 marks)

A human karyotype that shows evidence of chromosomal mutation is shown.



Frequency and pattern of cytogenetic alterations in primary amenorrhea cases of Kashmir, North India
– Scientific Figure On ResearchGate, Tahir Mohi-Ud-Din Malla

- (a) Identify the evidence of chromosomal mutation in the karyotype. 1

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- (b) Explain how cell division and fertilisation could lead to the production of this karyotype. 4

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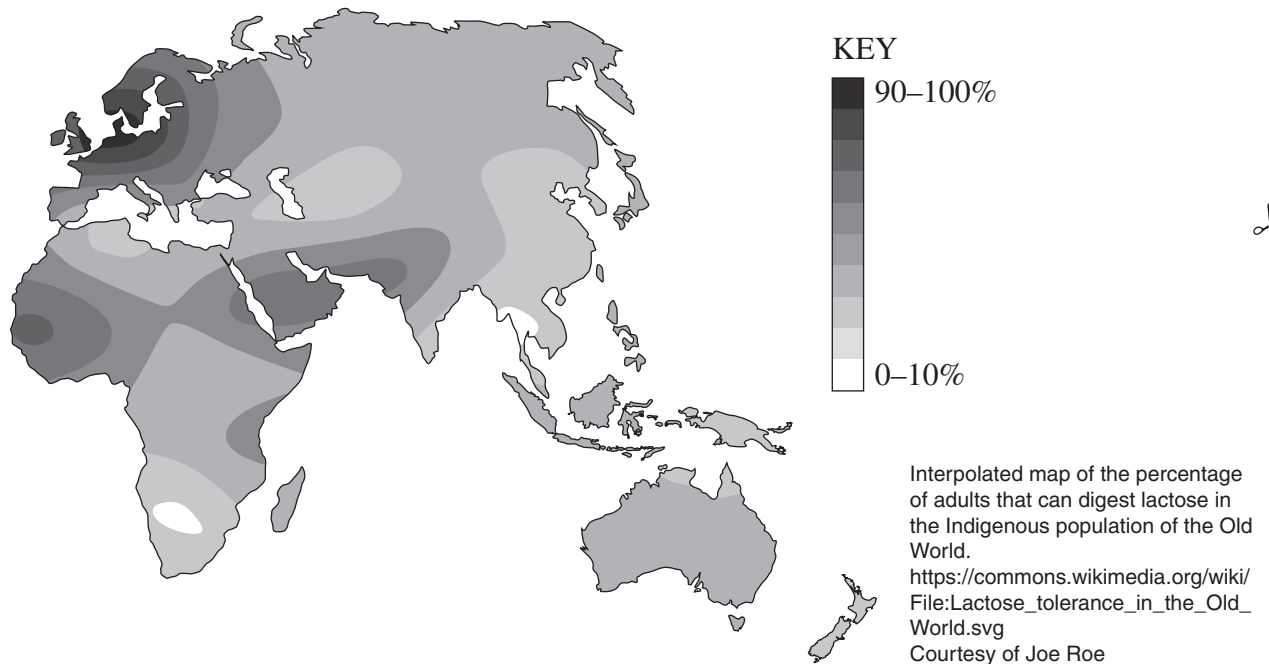
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Question 26 (5 marks)

The map shows the percentage of adult indigenous populations able to digest lactose.

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The ability to digest lactose is due to the presence of an enzyme (lactase) which can metabolise the sugar (lactose) present in milk. The gene responsible for producing lactase is usually permanently switched off at some time between the ages of 2 and 5 years. However, some people remain able to digest lactose throughout their lives.

With reference to evolution and DNA, provide possible reasons for the distribution shown in the map.

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Question 27 (5 marks)

Yeast is a single-celled fungus that can reproduce by *budding*.

- (a) What type of reproduction is *budding*? **1**

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- (b) Outline a procedure that could be used to test the effect of temperature on reproduction in yeast. **4**

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Question 28 (6 marks)

Huntington's disease is an autosomal dominant condition caused by a mutation of a gene on chromosome 4. It causes nerve cells to break down.

Stargardt disease is an autosomal recessive condition caused by a mutation of a different gene on chromosome 4. It causes damage to the retina.

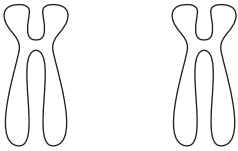
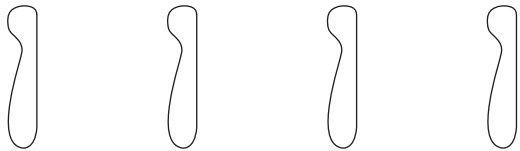
A patient is heterozygous for both Huntington's (Hh) and Stargardt disease (Rr). His father's extended family has numerous cases of both of these diseases. His mother does not have either disease and is homozygous for both genes.

- (a) Complete the tables, showing the TWO alleles the patient inherited from each parent. 2

<i>Alleles from father</i>	<i>Alleles from mother</i>

- (b) The diagram shows the patient's homologous pair of chromosome 4 at various stages of meiosis. 4

Add the relevant alleles to the diagram to model the production of possible gamete combinations. Include a key and an example of crossing over.

Homologous pair of chromosome 4 before crossing over		KEY
Homologous chromosomes after crossing over and separation		
Gametes		

Question 29 (3 marks)

Describe ONE mechanism by which plants maintain internal water homeostasis.

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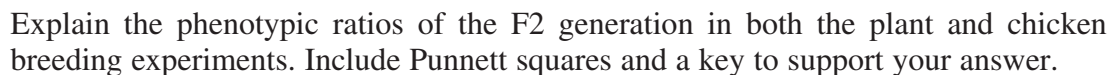
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Question 31 (5 marks)

- (a) Outline ONE adaptation of a specific pathogen that facilitates its entry into a host. **2**

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- (b) Explain how the mode of transmission of pathogens influences the spread of diseases. **3**

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Question 32 (10 marks)

Use the following data to answer parts (a) and (b).

Dengue fever and malaria are examples of infectious diseases transmitted between humans by mosquitoes. Dengue fever is caused by a virus transmitted by mosquitoes of the genus *Aedes*. Malaria is caused by a single-celled organism transmitted by mosquitoes of the genus *Anopheles*.

The following data provide information about the global incidence of these two diseases over time.

Global malaria data for selected years from 1900 to 2010

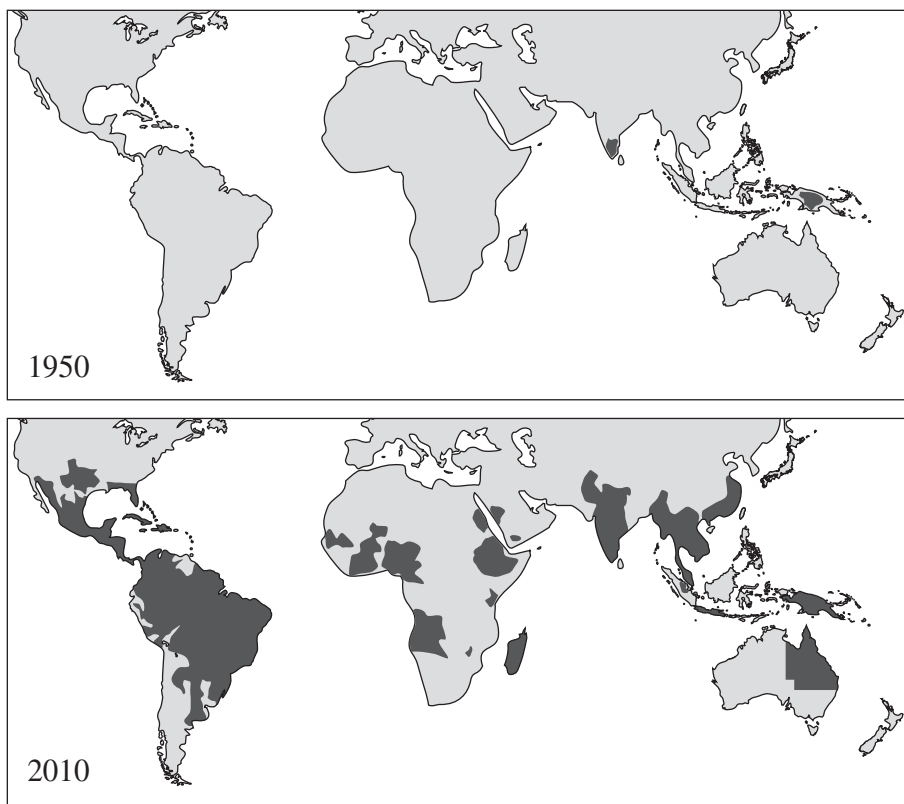
Year	Global population ($\times 10^9$)	Number of countries with reported cases	Population at risk	
			($\times 10^9$)	(%)
1900	1.2	140	0.9	75
1946	2.4	130	1.6	67
1965	3.4	103	1.9	65
1975	4.1	91	2.1	51
1992	5.4	88	2.6	48
1994	5.6	87	2.6	46
2002	6.2	88	3.0	48
2010	6.8	88	3.4	50

S I Hay, C A Guerra, A J Tatem, A M Noor and R W Snow (2004). 'The global distribution and population at risk of malaria: past, present and future', *The Lancet Infectious Diseases*, 4(6): 327–336. Reproduced with permission.

Question 32 continues on page 25

Question 32 (continued)

Distribution of reported cases of dengue fever in 1950 and 2010



KEY ■ Reported cases of the viral disease dengue fever

Max Roser and Hannah Ritchie (2018) – Dengue fever distribution maps in 1950 and 2010.
Published online at [OurWorldInData.org](https://ourworldindata.org).
Retrieved from <https://ourworldindata.org/malaria>

- (a) Based on the data provided, identify trends in the global disease burden for both malaria and dengue fever.

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Question 32 continues on page 26

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Question 32 (continued)

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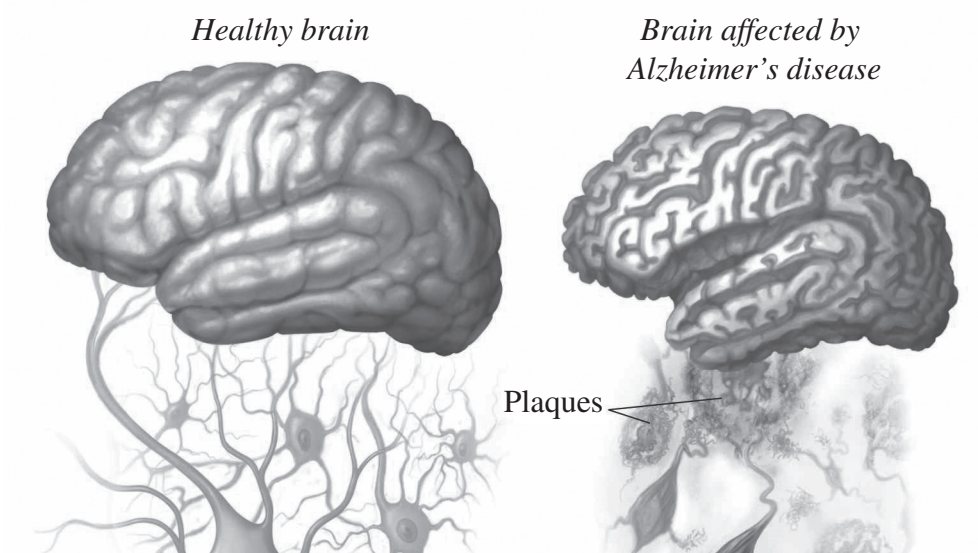
End of Question 32

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Question 33 (20 marks)

Alzheimer's disease causes destruction of brain tissue, dementia and eventually death.

The diagram shows the effect of Alzheimer's disease on the brain.



Used with permission from Mayo Foundation for Medical Education and Research, all rights reserved

- (a) Amyloid beta protein is produced in the human brain throughout life. In people with Alzheimer's disease, it accumulates in excessive amounts.

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Outline the main steps that brain cells use to make proteins such as amyloid beta.

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Question 33 continues on page 29

Question 33 (continued)

- (b) The gene with the greatest known effect on the risk of developing late-onset Alzheimer's disease is called APOE. It is found on chromosome 19.

The APOE gene has multiple alleles, including e2, e3 and e4.

- (i) What are multiple alleles?

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- (ii) The table shows the risk of developing Alzheimer's disease for various APOE genotypes compared to average risk in the population.

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<i>APOE</i> genotype	e2/e2	e2/e3	e2/e4	e3/e3	e3/e4	e4/e4
<i>Risk of developing Alzheimer's disease (compared to average)</i>	40% less likely	40% less likely	2.6 times more likely	Average	3.2 times more likely	14.9 times more likely

Risk of susceptibility, based on alleles. © Alzheimer.org

Analyse the data to assess the risk of developing Alzheimer's disease associated with the e2, e3 and e4 alleles.

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Question 33 continues on page 30

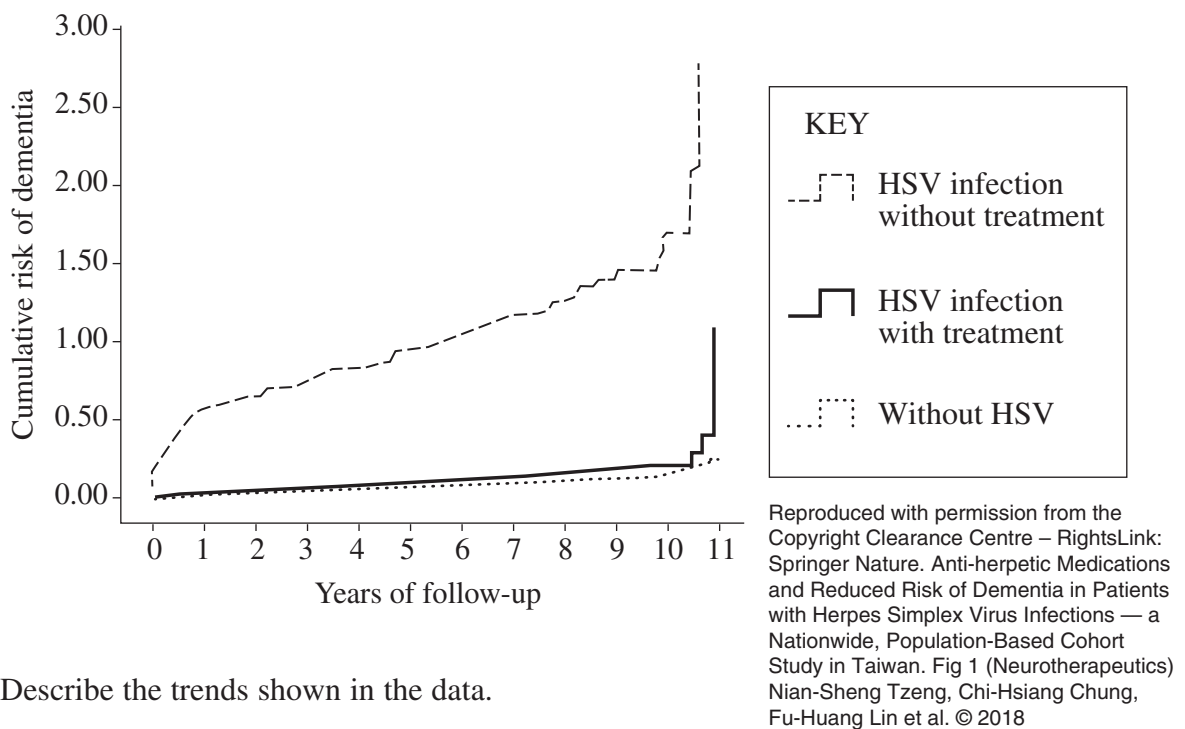
Question 33 (continued)

- (c) A large epidemiological study was conducted. It used historical data to investigate the association between *Herpes simplex* virus (HSV) infection and dementia. Dementia is caused by a variety of brain illnesses. Alzheimer's disease is the most common cause of dementia.

3

The study used the records of 8362 patients with HSV infection and 25086 randomly selected sex- and age-matched control patients without HSV infection. Some of the patients with HSV had been treated with antiviral medication.

The graph below shows some results of the study.



Describe the trends shown in the data.

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Question 33 continues on page 31

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Section II extra writing space

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