Cellular Control

1. What is an operon?

A. The binding site for a repressor protein.
B. Any group of genes responsible for the metabolism of lactose in prokaryotes or eukaryotes.
C. A cluster of genes under the control of a promoter.
D. A regulatory gene.

Your answer ☐

[1]

2. The table shows the genetic code in a short length of DNA, the corresponding codons on mRNA, and the anticodons on the corresponding tRNA.

Row	Original DNA	mRNA	tRNA
A	CCG TTA GCA	GGC AAT CGU	CCG TTA GCA
B	CAT AAT ACG	GUA UUA UGC	CAU AAU ACG
C	ATA CGC ATC	AUA CGC UAG	UAU GCG AUC
D	ACG GTA AAA	ACG GAU UUU	ACG GTA AAA

Which of the rows, **A** to **D** shows the correct codons and anticodons?

Your answer ☐

[1]

3. The bacterium *E. coli* produces lactase only when the sugar lactose is available. The mechanism to control production of lactase is called the *lac* operon.

Statements 1 – 3 describe the role of molecules in the way the *lac* operon controls lactase production.

1 – lactose binds to the repressor protein
2 – the repressor protein binds to lactase
3 – lactase leaves the cell

Which of the options, **A** to **D**, identifies the correct statements?

A. 1, 2 & 3
B. Only 1 & 2
C. Only 2 & 3
D. Only 1

Your answer ☐

[1]

4. Below are three processes that occur within living organisms.

1 apoptosis
2 mitosis
3 meiosis

Which of these processes is important in determining the body plan of an organism?

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐

[1]

5. The table below shows the stages of the cell cycle.

Which row, **A** to **D**, shows the correct order of the different stages?

	Cytokinesis	**G1**	**G2**	**Mitosis**	**S**
A	four	two	three	one	five
B	five	one	three	two	four
C	three	four	one	two	five
D	four	two	five	one	three

Your answer ☐

[1]

6. Hox genes contribute to the overall body plan of an animal.

Which of the following rows correctly describes Hox genes?

	Base sequence	**Product**	**Mutations**
A	varies between taxonomic groups	transcription factor	entirely random
B	varies between taxonomic groups	transcription factor	never occur
C	similar in all animals	polypeptide	have little or no effect
D	similar in all animals	polypeptide	are often lethal

Your answer ☐

[1]

7. Hox genes contain a homeobox sequence of 180 base pairs.

Two species have a homeobox sequence of 180 base pairs where 1.7% of the base pairs are different.

Which of the following shows the number of amino acids coded for that would be different in the two species?

A minimum 0 and maximum 1
B minimum 0 and maximum 3
C minimum 1 and maximum 2
D minimum 1 and maximum 3

Your answer ☐

[1]

8. Genes are not expressed during cell division because chromosomes are more tightly wound around histone proteins than during interphase.

Which of the following shows the level at which gene expression is being controlled when DNA is more tightly wound during cell division?

A post-transcriptional
B post-translational
C transcriptional
D translational

Your answer ☐ **[1]**

9. Which of the following processes is important in determining the overall body plan of an organism?

A endocytosis
B exocytosis
C meiosis
D mitosis

Your answer ☐ **[1]**

10. There will be outbreaks of new infectious diseases in the future. They will arise from mutations in the genomes of existing organisms. The mutating organisms may not at present be pathogenic, or they may be animal pathogens that mutate to become able to infect humans.

What feature of a pathogen such as *Mycobacterium tuberculosis* could be altered by a mutation, making a vaccine ineffective?

_____

_____ **[1]**

11. A gene codes for the production of lactase. This gene is normally switched off after an infant moves to adult food. Almost all adult mammals are unable to digest lactose. They are said to be **lactose intolerant.** Humans are an exception.

Most humans have a genetic mutation that prevents the shutdown of lactase production.

State what structural detail of a polypeptide is altered by gene mutations.

_____ **[1]**

12. A gene mutation is a change in the sequence of nucleotides within a gene.

i. Explain how it is possible for a mutation to have no effect on the protein produced from that gene.

_____

_____

_____

_____ **[2]**

ii. Explain how a mutation could alter the protein so that it no longer performs its correct function in the cell.

_____

_____

_____

_____ **[2]**

13. Tigers, *Panthera tigris*, are predatory mammals. They have evolved striped patterns on their fur (as shown below and in Fig. 3.1a **on the insert**), which provide camouflage in their habitats.

Fig. 3.1a

i. Adaptations can be divided into three types.

State the type of adaptation represented by the tiger's stripes.

_____ **[1]**

ii. Describe and explain how a tiger with striped fur may have evolved from a non-striped ancestor.

In your answer you should discuss the different types of genes that might be involved in the creation of the striped pattern in the tiger's fur.

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_____ **[6]**

14. The sweet pea plant has been used to study inheritance since the nineteenth century. The seeds of the sweet pea can vary in colour and shape.
The gene that controls colour has two alleles:

- **Y** is dominant and produces yellow seeds.
- **y** is recessive and produces green seeds.

The gene that controls shape has two alleles:

- **R** is dominant and produces round seeds.
- **r** is recessive and produces wrinkled seeds.

The yellow colour in peas is the result of an enzyme that breaks down chlorophyll, which is green.

- The **Y** allele codes for the production of an enzyme that breaks down chlorophyll.
- The **y** allele is the result of a mutation in the **Y** allele.
- The **y** allele codes for an inactive form of this enzyme.

i.  Outline how the **Y** allele codes for the production of this enzyme and explain why the **y** allele codes for an enzyme with a different primary structure.

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_____

_____

_____

_____

_____ **[6]**

ii. With reference to the proteins coded for by the seed colour gene, explain why the **y** allele is recessive.

_____

_____ **[1]**

15. Fig. 16, below and **on the Insert** H420/02**,** Biological diversity (AS/A level), June 2018, shows 6 onion cells at various stages of mitosis.

Fig. 16

i. The volume of cell **A** is 5.4×10^4 µm^3.

Assume that cell **B** is spherical.

Calculate the volume of cell **B**.

Use the formula: $\text{volume of sphere} = \frac{4}{3}\pi r^3$

Give your answer in standard form in µm^3.

Answer ..... **[3]**

ii. State the type of microscope that was used to view these images. Justify your answer.

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[2]

iii. Mitosis is involved in growth and repair of tissues.

State **two** other roles of mitosis in multicellular organisms.

1 ---

2 ---

[1]

16(a). Gene transcription is controlled by transcription factors. Fig. 16.1 shows how a transcription factor can control transcription.

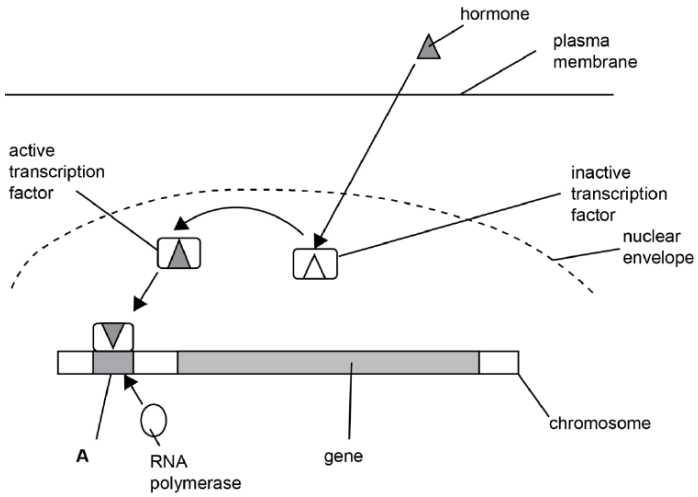

Fig. 16.1

i. Name site **A**.

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[1]

ii. Using the information in Fig. 16.1, describe how transcription can be controlled in eukaryotes.

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[3]

(b). Describe how gene expression can be regulated after transcription.

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[3]

17. Fig. 20 shows the disaccharide lactose, which is found in milk.

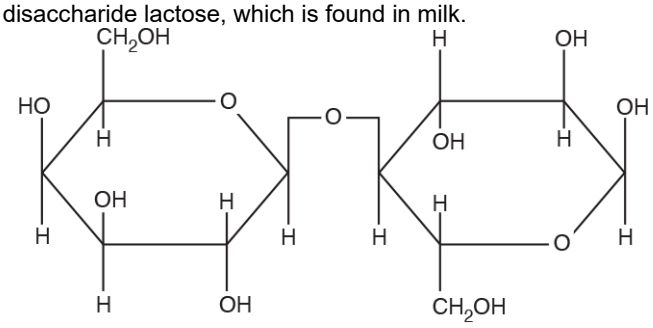

Fig. 20

One of the monomers of lactose is galactose.
The bacterium *E. coli* usually uses glucose as a respiratory substrate.
Under certain circumstances, *E. coli* is able to use galactose as a respiratory substrate by breaking down lactose into glucose and galactose and then using both glucose and galactose as respiratory substrates.

i. Explain how the structure of galactose allows it to be used as a respiratory substrate.

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[3]

ii. *E. coli* usually grows in conditions where the extracellular concentration of lactose is low. In such conditions lactose does not easily cross the bacterial cell surface membrane.

Suggest and explain why lactose is unable to cross membranes.

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[2]

iii. In order for lactose to enter the cytoplasm of *E. coli* a protein is required.
The *E. coli* living in the digestive system of young mammals are more likely to contain this protein than *E. coli* living in the digestive system of old mammals.

Suggest an explanation for this observation.

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[2]

18. The colour of onion bulbs is determined by two genes, **A/a** and **B/b**.

- **A** is a dominant allele and codes for the production of a red pigment.
- Onion bulbs that are homozygous for the recessive allele, **a**, produce no pigment and are white.
- **B** is a dominant allele that inhibits the expression of allele **A**.
- The recessive allele, **b**, allows the production of the red pigment.

A white onion plant was cross-pollinated with a red onion plant. All 15 offspring had the genotype **AaBb**.

i. Identify the following:

The genotype of the white onion plant .....

The genotype of the red onion plant .....

The phenotype of the offspring .....

[3]

ii. State the type of gene interaction shown by the genes **A/a** and **B/b**.

_____ **[1]**

iii. Suggest how allele **B** inhibits the expression of allele **A**.

_____

_____

_____

_____ **[2]**

19(a). The body plan of multicellular organisms is under genetic control.

Complete the passage below using the most appropriate words from the list.

analogous	**archaea**	**development**	**DNA**	**domains**
homeobox	**homologous**	**homozygous**	**kingdoms**	**operon**
phyla	**plant**	**preserved**	**prokaryotes**	**regulator**
ribosomes	**transcription**	**translation**		

The development of body plan in eukaryotic organisms is controlled by

..... genes. These genes code for proteins that are able to bind

to ..... and turn specific genes on and off and are known as

..... factors. These proteins contain a sequence of base pairs

that varies little between species within the animal, ... or

fungus ..... .

[5]

(b). Investigations into the activity of genes that control body plan frequently use fruit flies and mice.

One reason fruit flies are used is that there are fewer public concerns about the ethics of using flies.

i. Suggest **two other** reasons why fruit flies are chosen for research into genes controlling the development of body plan.

1 ---

2 ---

[2]

ii. There are some public concerns about the ethics of using mice in these investigations.

Suggest **two** reasons why mice are chosen as a suitable species for investigation.

1 ---

2 ---

[2]

20. Hox genes code for transcription factors and control the development of the body plan. Fig. 16.2 shows a congenital deformity caused by failure of the control mechanism.

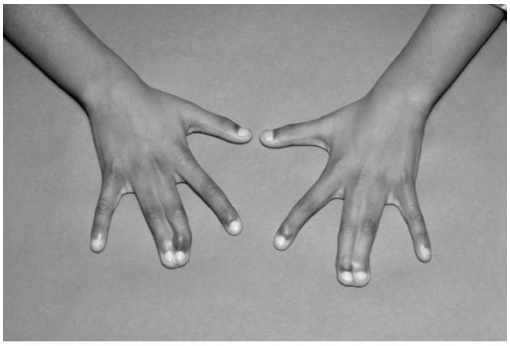

Fig. 16.2

Explain how failure of the control mechanism during development could lead to such a deformity.

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[3]

21. Two species of chimpanzees, the chimpanzee and the bonobo, are the closest living relatives of humans.

Fig. 19.1 is a diagram representing the current classification of chimpanzees and humans within the Family Hominidae.

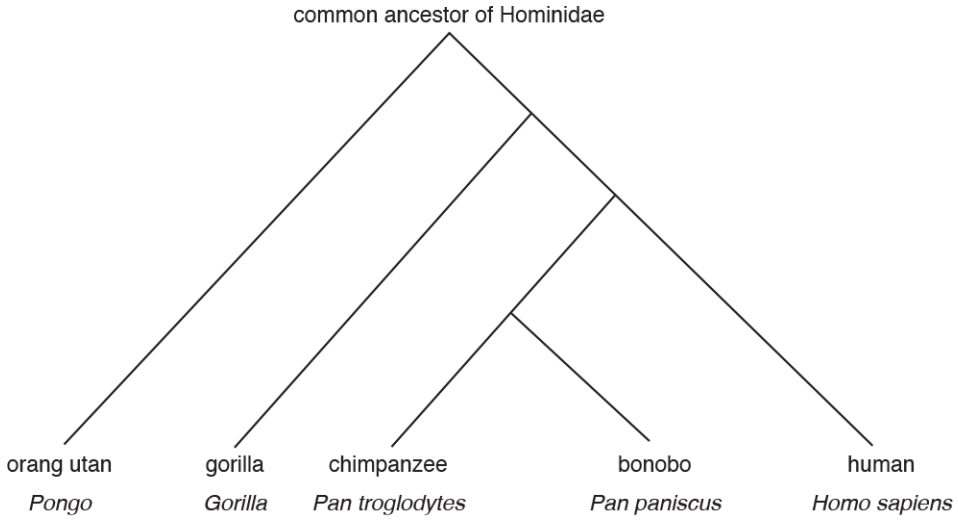

Fig. 19.1

Differences between the nucleotide base sequences can be used to estimate the length of time since two species diverged from one another.
The greater the number of differences, the greater the length of time that has elapsed since the two organisms were part of the same species.

Fig. 19.3 shows the line of best fit for the differences in DNA between pairs of primate species plotted against the number of years since the two species diverged from a common ancestor.

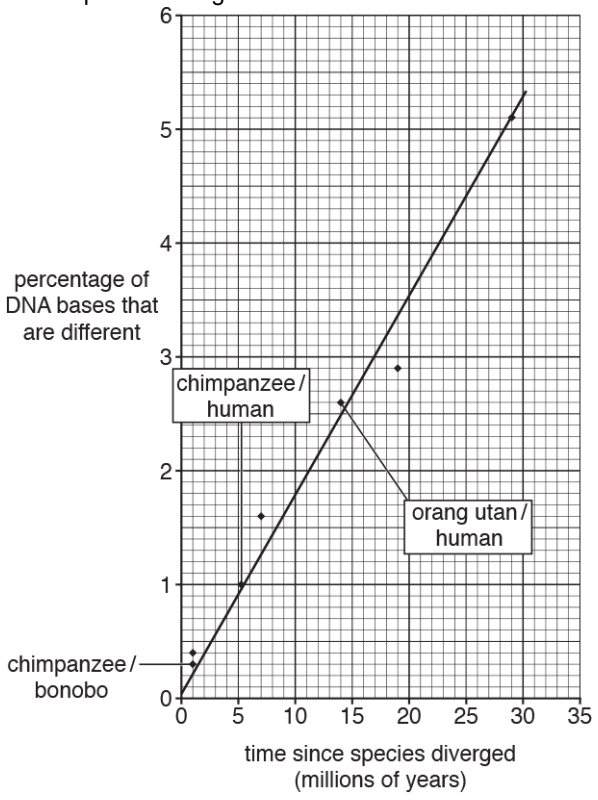

Fig. 19.3

i. Calculate the rate of DNA change using the data in Fig. 19.3.

Give your answer to **three** significant figures.

Answer……% per millions years **[2]**

ii. The mutation rate in mammals can vary by as much as 20% between species.

Use Fig. 19.3 to calculate the time since the phylogeny of humans diverged from chimpanzees, and the range over which this estimate may vary.

time since divergence = ……

range = ……

[2]

iii. Some scientists have suggested that humans and chimpanzees should be reclassified as belonging to the same genus.

Evaluate their suggestion using evidence from **Figs. 19.1 to 19.3 and** your own knowledge of the scientific basis for the classification of organisms.

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[6]

iv. One type of gene is known as a homeobox gene.

The base sequences of homeobox genes in humans and chimpanzees are almost identical.

What conclusions about the evolutionary relationship between humans and chimpanzees can be drawn from this piece of evidence?

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[1]

22. DNA codes for proteins within the cell. Some regions of DNA are described as non-coding.

i. Explain why some regions of DNA can be described as 'non-coding'.

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[2]

ii. Non-coding regions of DNA show more variation than coding regions. This makes non-coding regions useful in DNA profiling.

Suggest why non-coding regions of DNA show more variation.

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[1]