23. The eukaryotic cell cycle is regulated by three checkpoints. Mutations can occur in genes that control the cell cycle checkpoints.

Scientists recorded observations of two different tissues.

i. In one tissue, the scientists found a genetic mutation that stopped the metaphase checkpoint from working.

Suggest an abnormality the scientists might observe in the cells of this tissue.

_____

_____ **[1]**

ii. In the other tissue, the scientists observed cells with chromosomes that had been replicated despite containing damaged DNA.

Suggest which cell cycle checkpoint is no longer working in this tissue **and** justify your answer.

_____

_____

[1]

24. The figure is a diagram that represents the different phases of the cell cycle.

X, **Y** and **Z** represent checkpoints in the control of the cell cycle.

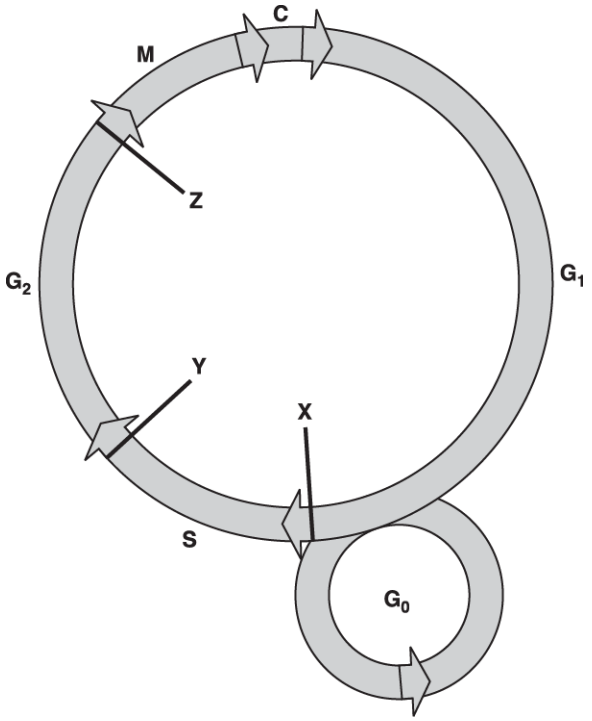


Fig. 2.3

i. State all the letters in the figure that represent the **phases** of interphase.

_____

[1]

ii. Suggest what is being checked at checkpoint **Y** on the figure .

_____

_____

_____

[1]

25. Cells can be counted and analysed using a technique called flow cytometry. DNA in the cells is stained with a fluorescent dye before analysis. The degree of fluorescence is dependent on the amount of DNA present.

i. Use your knowledge of the cell cycle to name the stages of interphase that match the following descriptions.

The stage in which a cell produces the least fluorescence

_____

The stage in which a cell produces the most fluorescence

_____

The stage in which the highest number of cells is recorded

_____

[3]

ii. Scientists analysed a sample of liver cells. Of these cells, 27.2% were found to be undergoing cell division or nuclear division. An adult human's liver contains approximately 180 billion cells.

Estimate the number of cells in interphase in an adult human's liver.

Write your answer in standard form to **two** significant figures.

Answer = ... **[1]**

iii. Suggest why the use of fluorescent dyes in flow cytometry is inappropriate when analysing red blood cells.

_____

_____

[1]

26. A student observed a prepared slide of an onion root tip under a microscope.
The total number of cells in the field of view was 265.

The number of cells at the different stages of the cell cycle are shown in Table 23.

Stage of cell cycle	Number of cells
interphase	207
prophase	42
metaphase	4
anaphase	6
telophase	6

Table 23

The cell cycle takes 20 hours. The number of cells visible at each stage is proportional to how long each stage of the cell cycle lasts.

Calculate the time taken for prophase to occur.

Give your answer in minutes to the nearest whole number.

time taken = ... min **[2]**

27. indicates the relative time spent in different phases of the cell cycle for three different types of cell, **P**, **Q** and **R**.

Cell type	Relative time spent in a phase			
	G_1/G_0	S	G_2	M/C
P	18	50	13	19
Q	18	25	11	16
R	100	0	0	0

i. Which of the cells **P**, **Q** or **R** takes the shortest time to divide?

---

[1]

ii. Suggest why cell **P** spends twice as much time in phase **S** than cell **Q**.

---

[1]

iii. What can be deduced about the behaviour of cell **R**?
Give reasons for your answer.

---

[2]

28. The table describes adaptations of three types of specialised cell.

	Erythrocytes	**Neutrophils**	**Palisade cells**
A	biconcave shape with flattened nucleus to allow them to squeeze through narrow capillaries	a large, spherical nucleus and cytoplasm that contains many lysosomes	thick cell walls to maintain turgor
B	biconcave shape with no nucleus and flexible to allow them to squeeze through narrow capillaries	a multi-lobed nucleus that makes it easier to squeeze through small gaps	thin cell walls allowing rapid diffusion of carbon dioxide
C	biconcave shape with no nucleus and flexible to allow them to squeeze through narrow capillaries	a large, spherical nucleus and cytoplasm that contains many lysosomes	thick cell walls maintain turgor
D	biconcave shape with flattened nucleus to allow them to squeeze through narrow capillaries	a multi-lobed nucleus that makes it easier to squeeze through small gaps	thin cell walls allowing rapid diffusion of carbon dioxide

Which of the rows, **A** to **D**, is a correct description of the three cells?

Your answer ☐ **[1]**

29. Mosses are small plants that live in damp conditions.

The life cycle of many mosses involves two stages: a gametophyte and a sporophyte.

The gametophyte contains haploid cells and produces sperms and eggs.

The sporophyte contains diploid cells and produces spores which can be spread easily through the air.

The spores germinate and grow into a gametophyte.

Fig. 19.2 shows the life cycle of the moss *Funaria*.

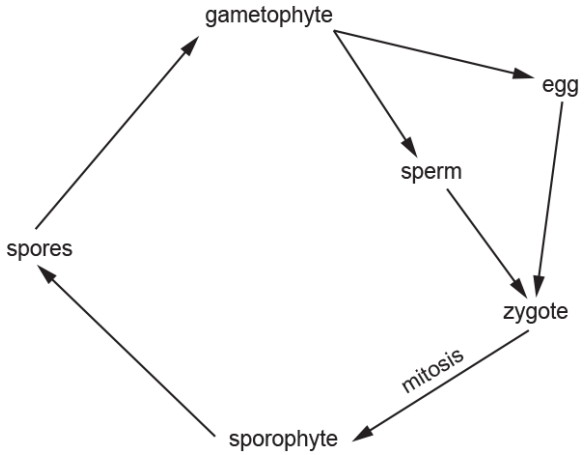


Fig. 19.2

i. The zygote grows into the sporophyte by mitosis.

The haploid gametophyte of one species of *Funaria* contains 28 chromosomes.

A single DNA molecule contains two strands.

Calculate the number of strands of DNA present in the nucleus of the zygote immediately before mitosis.

number of strands = ... **[1]**

ii. Mark an **X** on **Fig. 19.2** at the point at which meiosis occurs.

..... Answer on **Fig. 19.2** .....
[1]

iii. A diagram of a moss sperm is shown in Fig. 19.3.

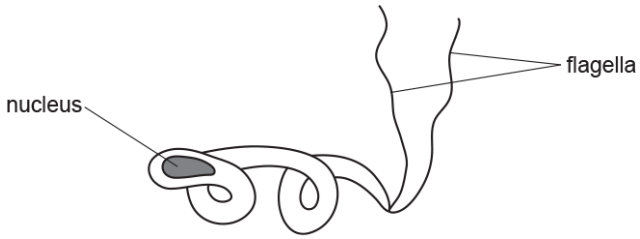


Fig. 19.3

The flagella allow the sperm to move towards an egg.

Suggest and explain another adaptation that is likely to be present in these sperm cells.

---

[2]

30.

During a bacterial infection, activated white blood cells multiply by mitosis.

In order to study the behaviour of chromosomes during mitosis, higher resolution images are needed.

i. Complete the table below about microscopes and their images.

	Laser scanning confocal microscope	**Scanning electron microscope**	**Transmission electron microscope**
Maximum resolution	200 nm	3–10 nm	0.5 nm
Image appearance	2D / 3D	.....	.....
Image colour	.....	.....	black and white

[2]

ii. A transmission electron microscope image of a white blood cell was studied. It was concluded that the cell had stopped dividing at the G2 checkpoint.

Suggest **two** observations that would have led to this conclusion.

1 ----------

2 ----------

[2]

31. During which stage of the cell cycle does semi-conservative DNA replication take place?

A first growth phase

B prophase

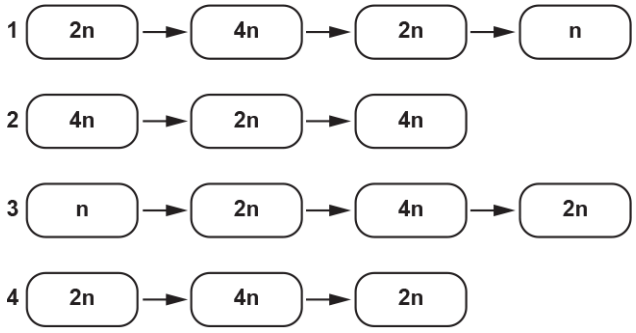
C second growth phase

D synthesis phase

Your answer ☐ **[1]**

32. During cell division, the chromosome number in the cells changes.

The following sequences describe the chromosome number in cells before, during and after different types of cell division.



Which of the options, **A** to **D**, correctly describes the stages of mitosis and meiosis in human cells?

A 1 is mitosis, 2 is meiosis

B 2 is mitosis, 3 is meiosis

C 3 is mitosis, 4 is meiosis

D 4 is mitosis, 1 is meiosis

Your answer ☐ **[1]**

33. 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.

_____

_____

_____

_____

_____ **[2]**

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

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

1 _____

2 _____

[1]

34. Mitosis and meiosis are important in the life cycles of organisms.

Hydra is a small animal that lives in fresh water.

When environmental conditions are favourable, *Hydra reproduces* asexually. Large numbers of offspring can be produced in this way.

Asexual reproduction in *Hydra* is shown in Fig. 19.1.

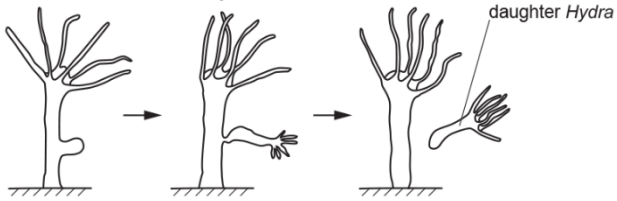


Fig. 19.1

i. Asexual reproduction involves mitosis.

Name the stages of mitosis in the correct order.

_____

_____ **[2]**

ii. Suggest why *Hydra* reproduces asexually when conditions are favourable.

_____

_____

_____

_____

_____

_____ **[2]**

35. 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. Name the stage of mitosis shown in cell **A**.

_____ **[1]**

ii. In the space provided below draw cell **A**. Label your drawing to show visible features.

[4]

36(a). An experiment was carried out where a student observed cells in different tissues under the microscope.

- The cells were undergoing mitosis.
- 200 cells were observed for each tissue.
- The number of cells in each stage of mitosis was recorded.

The results are shown in Table 2.2.

Tissue type	Number of cells in stage of mitosis				Total
	Prophase	Metaphase	Anaphase	Telophase	
V	65	55	7	73	200
W	85	59	6	50	200

The student had expected that the results observed for tissue type **W** would not be significantly different from those for tissue type **V**.

i. Identify the pieces of evidence in Table 2.2 that caused the student to suspect that the results for tissue type **W** might be **significantly** different from those for tissue type **V**.

[1]

ii. The student decided to analyse the data using a statistical test.

A friend suggested using Student's -test.

Why is Student's -test **not** suitable for dealing with this data?

[1]

(b). The chi-squared (x^2) test can be used to analyse the data.

i. Complete the rows for metaphase and telophase in the table below and calculate the $\mathbf{x}^2$ value for the data.

The $\mathbf{x}^2$ value is calculated using the following formula:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Cells	Observed (O)	Expected (E)	(O–E)	$(O–E)^2$	$\frac{(O - E)^2}{E}$
In prophase	85	65	20	400	6.154
In metaphase					
In anaphase	6	7	-1	1	0.143
In telophase					
Total	200	200			

x^2 = ... **[3]**

ii. The value of chi-squared (x^2) can be used to conclude whether the results for cells in tissue type **W** differ significantly from those for tissue type **V**.

The number of **degrees of freedom** determines which row of the $\mathbf{x}^2$ probability table is used.

The number of degrees of freedom is defined as:

the number of categories - 1

What will be the number of degrees of freedom used in this analysis?

[1]

iii. The student had expected that the results observed for tissue type **W** would not be significantly different from those for tissue type **V**.
Use your calculated value for $\mathbf{x}^2$ and the information from the $\mathbf{x}^2$ probability table below to conclude whether or not the results observed for tissue type **W** are significantly different from those for tissue type **V**.

Degrees of freedom	**Probability (p)**				
	0.99	**0.95**	**0.05**	**0.01**	**0.001**
1	0.00	0.00	3.84	6.64	10.83
2	0.02	0.10	5.99	9.21	13.82
3	0.11	0.35	7.82	11.35	16.27
4	0.30	0.71	9.49	13.28	18.47
5	0.55	1.15	11.07	15.09	20.52
6	0.84	1.64	12.59	16.81	22.46
7	1.24	2.17	14.07	18.48	24.32

Conclusion

[2]

37(a). The photomicrographs shown in Fig. 23 below are taken from an animal cell undergoing mitosis.

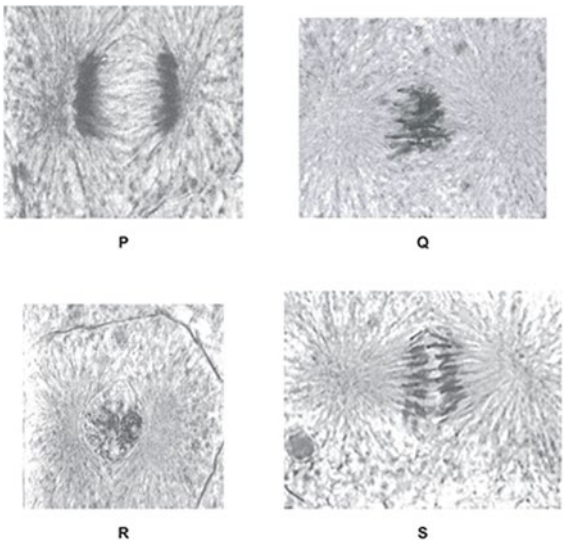


Fig. 23.

i. Write the letters of the images, **P** to **S**, in the correct mitotic sequence.

.... **[1]**

ii. Describe in detail what is happening in image **Q**.

[2]

(b). In the space below produce a **labelled** diagram of the cell in image **S** from Fig. 23.

[3]

38. Fig. 2.1 shows three images, **C** to **E**, of animal cells undergoing mitosis.

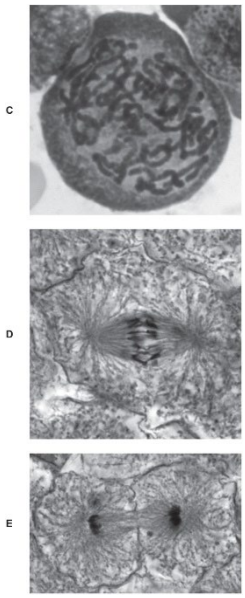


Fig. 2.1

Describe the events taking place in cells **C**, **D** and **E**.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ **[6]**

39. A zygote undergoes rapid cell division.

Explain why the type of nuclear division in a zygote is mitosis and not meiosis.

_____

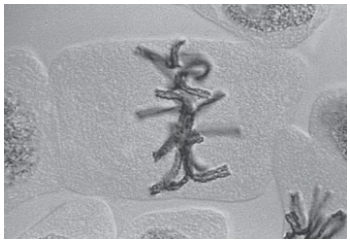
_____

_____

_____

_____ **[2]**

40. The image shows a stage in mitosis.



Which of the following options, **A** to **D**, is the stage of mitosis shown above?

A. anaphase

B. metaphase

C. prophase

D. telophase

Your answer ☐

[1]

41. Meiosis is a type of nuclear division.

Fig. 1.2 shows a photomicrograph of plant cells undergoing meiosis.

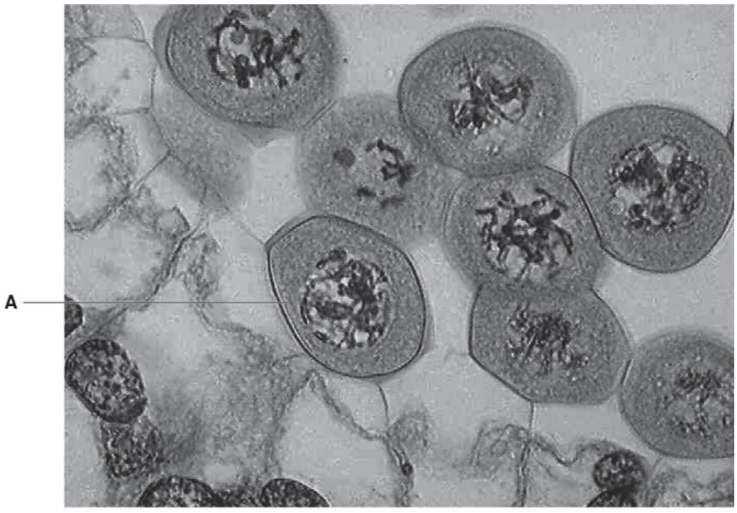


Fig. 1.2

i. Identify the stage of meiosis 1 shown in the cell labelled **A.**

_____ **[1]**

ii. Based only on your observations of Fig. 1.2, state **two** reasons for your answer in **(b)(i)** .

_____

_____

_____

_____ **[2]**

iii. Another stage of meiosis is metaphase 1.

Explain how the organisation of homologous chromosomes during metaphase 1 increases genetic variation.

_____

_____

_____

_____

_____

_____

_____ **[3**

42. Sperm cells in animals are formed by a process known as spermatogenesis.

Fig. 19.1 is a summary of the process of spermatogenesis.

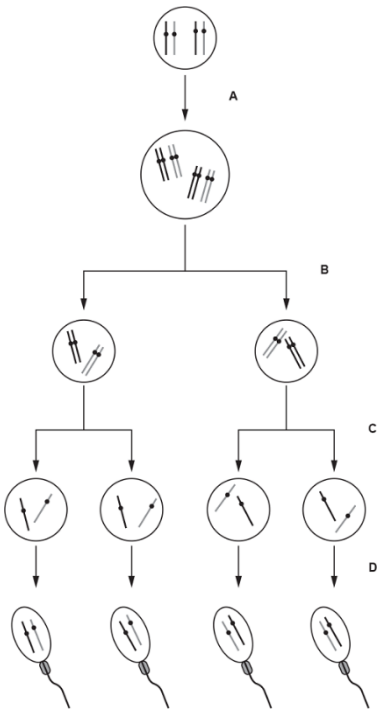


Fig. 19.1

Three phases of meiosis are listed below.

Match each phase of meiosis to a letter on Fig. 19.1.

Metaphase 1 occurs during the stage labelled ……

Telophase 2 occurs during the stage labelled ……

Anaphase 1 occurs during the stage labelled ……

[3]

43. Mitosis and meiosis are important in the life cycles of organisms.

Hydra is a small animal that lives in fresh water.

When conditions are not favourable, *Hydra* reproduces sexually. This often happens in the winter.

Cells in the body wall produce sperms and eggs by meiosis.

Large numbers of sperms are released into the water. These sperms can fertilise eggs from different individuals. Each egg forms a tough outer coat, and can lie dormant at the bottom of the water until conditions improve.

i. *Explain how sexual reproduction in *Hydra* leads to genetic variation in the offspring.

[6]

ii. Suggest why sexual reproduction in *Hydra* usually occurs in the winter.

[1]

44. Mitosis and meiosis play an important role in the life cycles of organisms.

The figures represent an outline of the life cycles of two different organisms.

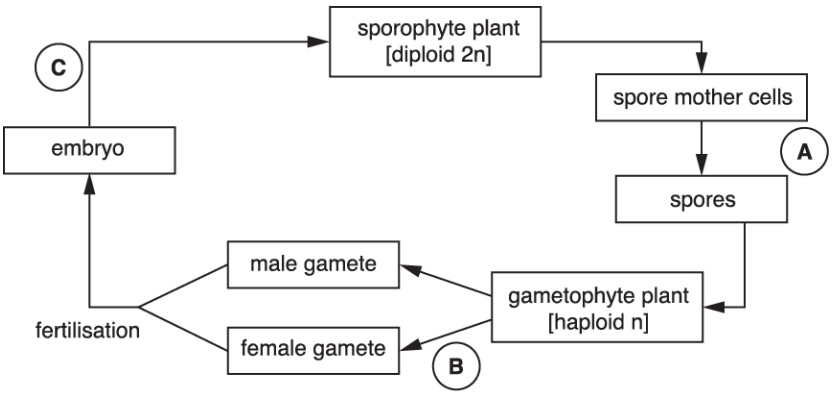
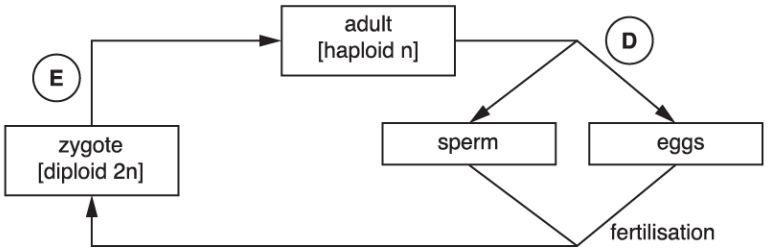


Fig. 2.1



Place a tick (✓) in each row of the table to indicate the type of nuclear division that occurs at each of the letters **A** to **E**.

	Mitosis	Meiosis
A		
B		
C		

	Mitosis	Meiosis
D		
E		

[3]

45. Plant growth requires the production of new xylem cells.

Describe how new xylem cells are produced.

---

[2]

46. Fig. 19.1 shows a neutrophil responding to a pathogenic bacterium.

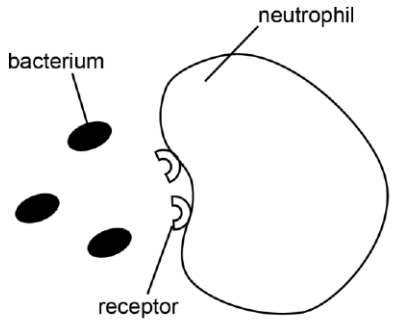


Fig. 19.1a

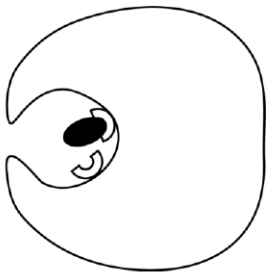


Fig. 19.1b

i. What is the role of an opsonin during this process?

---

[1]

ii. Other than having specific receptors, describe **one** way in which the structure of the neutrophil is specialised.

---

[1]

47(a). Bone marrow contains stem cells that can develop into erythrocytes, neutrophils and lymphocytes.

Describe the changes that must occur inside these stem cells as they differentiate to form erythrocytes.

_____

_____

_____

_____

_____ **[2]**

(b). Cells from an embryo can be used for medical research and for research on the development of an organism.

Suggest **three** ways in which the use of embryonic stem cells in research has practical benefits to biological knowledge.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

(c). During development, cells become organised into tissues and organs.

Explain the difference between *muscle tissue* and *a muscle.*

_____

_____

_____

_____

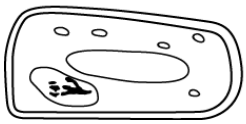
_____ **[2]**

48. Which of the diagrams, **A** to **D**, is a stem cell?

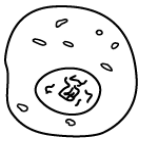
A

B

C



D



Your answer ☐

[1]

49. Multicellular organisms, such as plants, have evolved internal transport systems.

i. Explain the benefit to plants of internal transport systems.

_____

_____

_____

_____ **[2]**

ii. The transport systems of plants contain cells that are specialised to perform a particular function.

The table below shows information about three types of specialised plant cell. Three boxes have been completed already.

Complete the rest of the table by placing the correct responses in the empty boxes.

Cell	Location	Example of a substance transported	Contains chloroplasts? (✓ or ✗)
Guard cell		carbon dioxide	
Companion cell			✗
Root hair cell	roots		

[3]

50. Explain why a plant leaf is described as an organ.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ **[4]**

51. Fig. 22.2 shows a podocyte from the kidney. The many gaps between the microscopic processes form fenestrations in the Bowman's capsule.

Fig. 22.2

i. Explain why podocytes are usually unable to undergo mitosis.

_____

_____

_____

_____

_____

_____

_____ **[3]**

ii. Studies show that after damage by infection or injury, it is possible for nephron tissues to be regenerated. Adult stem cells are involved in this process.

What features of adult stem cells make them suitable for regeneration of tissues in the kidney?

_____

_____

_____

_____

_____ **[2]**

52. Fig. 19.2 is a transverse section of a sperm cell. The mitochondria of sperm cells form a spiral around the central flagellum.

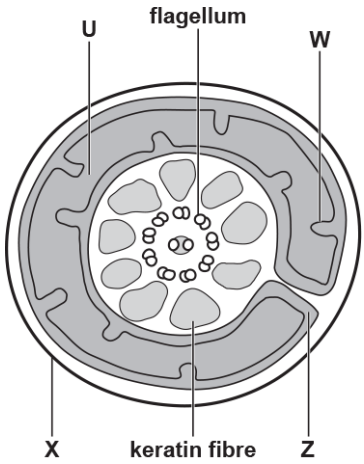


Fig. 19.2

i. Identify the structures labelled with the following letters:

U

W

Z

[3]

ATP, $FADH_2$ and hexose 1,6-bisphosphate are three organic products of respiration in sperm cells.

Table 19 shows how the production of ATP, $FADH_2$ and hexose 1,6-bisphosphate in sperm cells is affected by three different substances.

Substance	Organic products of respiration per sperm cell		
	ATP (10^{-10} mol s^{-1})	$FADH_2$ (10^{-11} mol s^{-1})	Hexose 1,6-bisphosphate (10^{-11} mol s^{-1})
Cyanide	2.54	0.00	5.78
Fluoride	0.00	0.00	0.00
Sucrose	6.89	2.53	5.42

Table 19

ii. What can be concluded about the difference between the effects of **cyanide** and **fluoride** on respiration in sperm?

_____

_____

_____

_____ **[1]**

53. Which of the following statements, **A** to **D**, correctly explains why meristems can differentiate into xylem vessels in plant stems?

A Meristems are living and unspecialised.

B Meristems are living and specialised.

C Xylem vessels are dead and specialised.

D Xylem vessels are dead and unspecialised.

Your answer ☐

[1]

54. Which of the rows, **A** to **D**, in the table below shows the correct order of increasing complexity of organisation within an organism?

A	epithelium	goblet cell	lung	respiratory system
B	epithelium	respiratory system	goblet cell	lung
C	goblet cell	epithelium	lung	respiratory system
D	goblet cell	lung	respiratory system	epithelium

Your answer ☐ **[1]**

55. A zygote undergoes rapid cell division.

After many rounds of cell division, the zygote forms a blastula. A blastula is an animal embryo at an early stage of development. As the blastula develops, it becomes a hollow ball of cells with an inner cell mass. The inner cell mass is a source of embryonic stem cells.

i. Explain the role of embryonic stem cells in the development of the embryo.

_____

_____

_____

_____

_____ **[2]**

ii. Explain why the cells of the inner cell mass are **not** totipotent stem cells.

_____

_____

_____

_____

_____ **[2]**

56. The human body is able to protect itself from disease in a variety of ways.

The table shows a list of cells and structures.

Letter	Cell or structure
A	antigen-presenting cells
B	erythrocytes
C	goblet cells
D	lymphocytes
E	lysosomes
F	mucous membranes
G	neutrophils
H	phagosomes
I	platelets
J	skin

i. Which letter or letters indicate cells or structures involved in preventing the entry of pathogens into the body?

_____ **[1]**

ii. Which letter or letters indicate cells or structures that act as a **physical barrier** to the entry of pathogens?

_____ **[1]**

iii. Which letter or letters indicate cells or structures that are involved in phagocytosis?

_____ **[1]**

iv. Which letter or letters indicate a tissue?

Explain your answer.

_____

_____

_____ **[1]**

57. Which of the following statements, **A** to **D**, does **not** correctly describe the structure or formation of plant vascular tissues?

A	Companion cells are linked to xylem vessels by plasmodesmata.
B	Mature sieve tube elements do not contain nuclei.
C	Phloem and xylem are formed by differentiation of vascular meristems.
D	Xylem vessels have non-lignified pits to allow movement in and out.

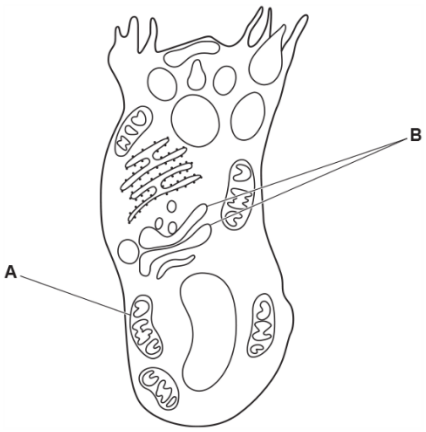
Your answer ☐

[1]

58. Mucus is composed of water, carbohydrates, proteins and triglycerides.

Mucus is secreted by goblet cells.

Below is a diagram of a goblet cell as seen under an electron microscope.



i. Suggest why goblet cells have large numbers of the cellular component labelled **A**.

_____

_____ **[1]**

ii. Suggest how the role of the cellular component labelled **B** is relevant to the function of the goblet cell.

_____

_____

_____

_____ **[2]**

59.

i. A student wrote the following passage about cells:

'Erythrocytes and neutrophils are formed in the spleen. One of the places ciliated epithelial cells are found is in blood vessels. Sperm cells are the male gametes and contain the haploid number of chromosomes. The cell wall of the guard cell is thicker on the side furthest away from the stoma, so the cell does not change shape symmetrically as its volume changes. Root hair cells increase the surface area for absorption of water and mineral ions from the soil.'

Identify **and** correct the errors in the passage.

Error 1_ _

Correction_ _

Error 2_ _

Correction_ _

Error 3_ _

Correction_ _

[3]

ii. A man with a body mass of 73 kg was admitted to hospital with an infection. His neutrophil production was measured at approximately 3804 billion cells in a 24h period.

When healthy, the man was producing approximately 1.6 billion neutrophils kg^{-1} h^{-1}.

Calculate the percentage increase in neutrophil production due to the infection.

percentage increase = ...% **[2]**

iii. Erythrocytes and neutrophils are both examples of specialised blood cells.

Squamous and ciliated epithelial cells are also examples of specialised cells.

Describe how each of these **four** cells is specialised for its function.

[6]

60(a). Fig. 23 shows a microscope image of a cross section taken from the stem of a sunflower, *Helianthus annuus*.

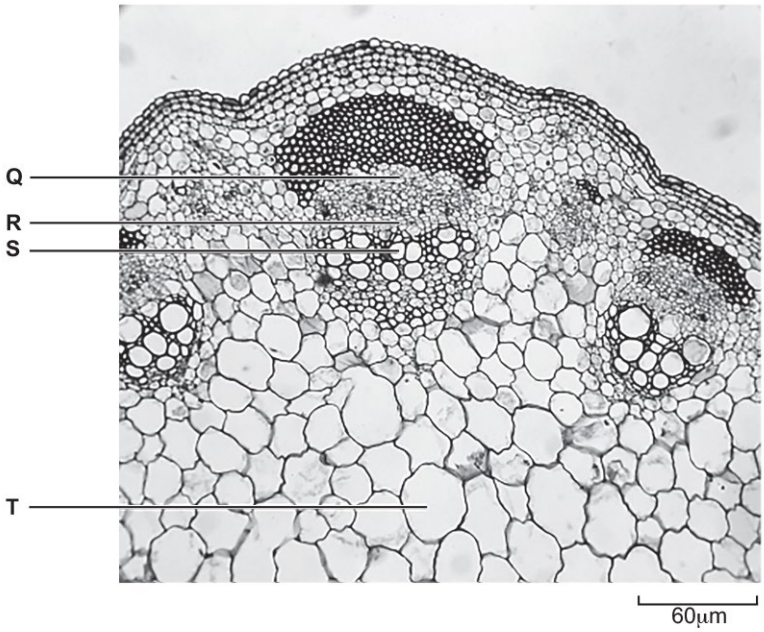


Fig. 23

i. The cell labelled **T** on Fig. 23 is a parenchyma cell which carries out photosynthesis and stores starch. Suggest why cell **T** and the cells surrounding it, can be classified as parenchyma **tissue.**

_____

_____ **[1]**

ii. **Name** the two tissues labelled **Q** and **S** on Fig. 23.

Q _____

S _____ **[2]**

(b). The tissues labelled **Q** and **S** in Fig. 23 are produced by mitosis from the tissue labelled **R** on Fig. 23. Identify the tissue labelled **R**.

R _____ **[1]**

61. The use of stem cells is being evaluated for the treatment of certain human diseases.

Name **two** potential sources of human stem cells and for **one** source, describe an ethical issue associated with the use of stem cells.

[4]

62. Haemoglobin is found in erythrocytes. Unlike other vertebrates, the mature erythrocytes of mammals lack nuclei and other membrane-bound organelles.

i. Explain **one** advantage and **one** disadvantage of the lack of nuclei and other membrane bound organelles to mammalian erythrocytes.

Advantage

Disadvantage

[2]

ii. Viruses do not use erythrocytes as host cells, whereas the malarial pathogen *Plasmodium* spends part of its life cycle inside erythrocytes.

Suggest why.

[2]

iii. Explain why erythrocytes do **not** make use of any of the oxygen that they are transporting.

---**[2]**

63(a). Fig. 1.1 shows a microscopic image of part of a fish gill.

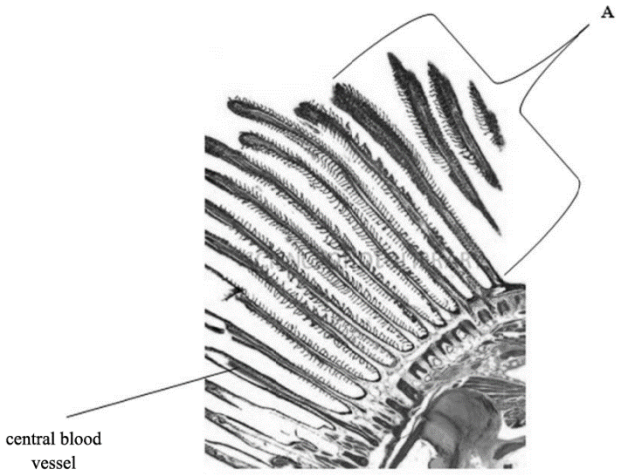


Fig. 1.1

Name structure **A**.

---**[1]**

(b). Explain how **Fig. 1.1** shows that gills are adapted for efficient gas exchange.

---**[4]**

(c). Each gill is supported by a gill arch made of bone. Bone tissue is made of living cells, collagen and an inorganic component.

Explain why bone is described as a tissue and gills are described as organs.

_____

_____

_____

_____

_____ **[3]**

64. Name the type of cell present in meristematic tissue and describe how xylem vessel elements are produced from this type of cell.

Type of cell

_____

Description

_____

_____

_____

_____

_____

_____

[4]