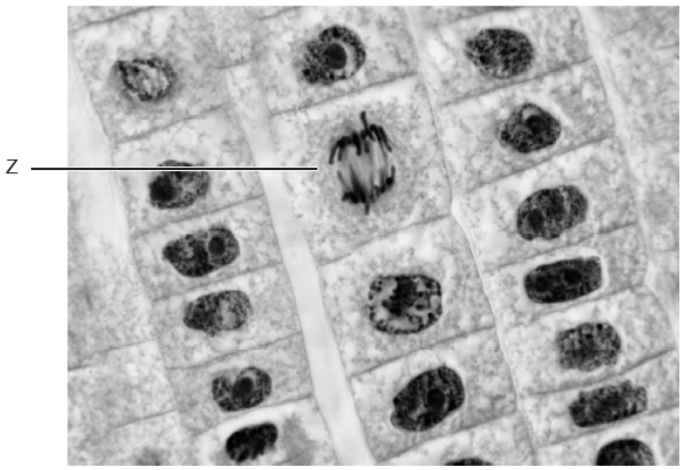
D2.1. Cell and nuclear division [233 marks]

1. [Maximum mark: 1]

The micrograph shows onion (*Allium cepa*) root tip cells dividing by mitosis.



[Source: Natalierussell77, 2023. Mitosis in Onion Root - various stages. [image online] Available at: https://commons.wikimedia.org/wiki/File:Mitosis_in_Onion_Root_-_various_stages_(Anaphase_and_Interphase).jpg. Licensed under the Creative Commons Attribution-Share Alike 4.0 International license: https://creativecommons.org/licenses/by-sa/4.0/deed.en. Source adapted.]

In which phase is cell Z?

A. Interphase

B. Prophase

C. Metaphase

D. Anaphase [1]

2. [Maximum mark: 1]

What occurs in cell division during both mitosis and meiosis?

A. Condensation of DNA by supercoiling in telophase

B. Movement of microtubules to move chromatids in anaphase

C. Pairing of homologous chromosomes in prophase

D. Crossing over between chromosomes in metaphase [1]

3. [Maximum mark: 1]

Which characteristic is shared by all tumours?

A. Cells metastasize from the primary tumour

B. They result from mutations

C. Spherical in shape

D. Malignancy

[1]

4. [Maximum mark: 5]

The table shows the nuclear DNA content of some plant and animal species.

Species scientific name	Common name	Chromosome number	Genome size / DNA million base pairs
Apis mellifera	honey bee	16	215
Homo sapiens	human	46	3080
Ailurus fulgens	red panda	36	2340
Pinus sylvestris	Scots pine	22	20 000
Paris japonica	canopy plant	40	150 000

(a) Suggest, giving a reason, whether gametes or somatic cells have been used to provide the information in the table. [1]

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(b) State **one** way in which chromosomes are classified to construct the karyotype of an individual. [1]

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(c) Outline the role of histones in plant and animal chromosomes. [1]

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(d) Using the data provided in the table, discuss whether genome size positively correlates to organism complexity. [2]

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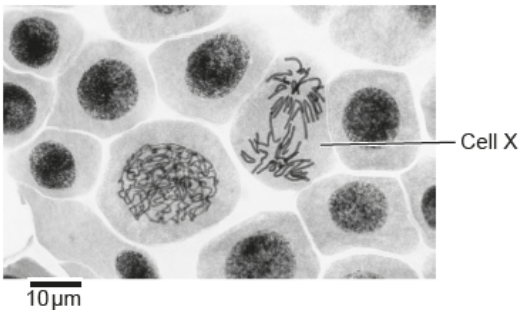
5. [Maximum mark: 7]

The micrograph shows onion (*Allium cepa*) meristematic tissue.



[Source: Reischig, J., 2014. [*Root meristem of onion*] Available at: https://commons.wikimedia.org/wiki/File:Mitosis_(261_14)_Pressed;_root_meristem_of_onion_(cells_in_prophase,_anaphase).jpg. Source adapted. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license: https://creativecommons.org/licenses/by-sa/3.0/deed.en.]

(a) Identify the phase of mitosis occurring in cell X. [1]

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(b) Calculate the magnification of the image. [1]

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(c) Meiosis is another type of cell division. List **two** structures in which meiosis takes place in a flowering plant such as an onion.

1. . . . . .

2. . . . . .

[2]

(d.i) Define pollination. [1]

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(d.ii) Outline how cross-pollination can be promoted by flowering plants. [2]

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6. [Maximum mark: 15]
The genome is the total of all the DNA in an organism, containing all the genetic information required for development and growth.

(a) Describe the possible causes and consequences of a substitution mutation in DNA. [4]

(b) Distinguish between cell division by mitosis and by meiosis in eukaryote cells. [4]

(c) Explain how gene expression can be regulated during transcription to determine an organism's phenotype. [7]

7. [Maximum mark: 15]
Eukaryotes are a diverse group of organisms, including animals and plants.

(a) Distinguish between structures in animal and plant cells. [3]

(b) Outline adaptations of animals to herbivory and ways in which plants are adapted to resist herbivores. [4]

(c) Compare and contrast the processes of mitosis and cytokinesis in animal and plant cells. [8]

8. [Maximum mark: 15]
Members of a species typically all have the same number of chromosomes.

(a) Explain the need for both fusion of gametes and meiosis in a **sexual** life cycle. [4]

(b) Describe the events in interphase and mitosis that ensure that the chromosome number does not change during an **asexual** life cycle. [7]

(c) Discuss the barriers to hybridization between species and how polyploidy can overcome these barriers. [4]

9. [Maximum mark: 15]
Hereditary information is stored in nucleic acids and passed on to offspring.

(a) Outline how mitosis allows for the same hereditary information to be passed on to new cells. [3]

(b) Describe the importance of DNA in speciation. [4]

(c) Explain the genetic basis of inheritance patterns in organisms that reproduce sexually. [8]

10. [Maximum mark: 1]
Which processes occur during the development of secondary tumours?

I. Cytokinesis

II. Metastasis

III. Mitosis

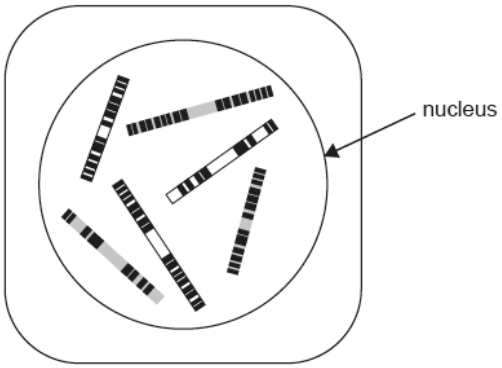
A. I and II only

B. II and III only

C. I and III only

D. I, II and III [1]

11. [Maximum mark: 1]
What type of cell is represented in the diagram?



A. Haploid gamete

B. Haploid somatic cell

C. Diploid gamete [1]

D. Diploid somatic cell

12. [Maximum mark: 1]
When do sister chromatids separate during meiosis?

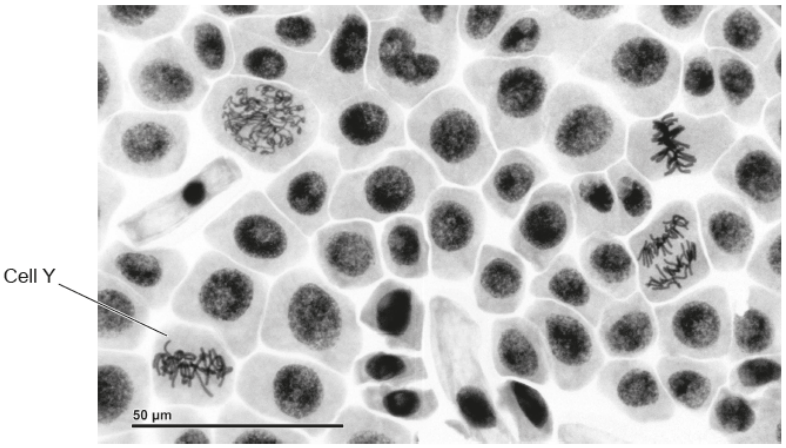
A. Anaphase I

B. Metaphase I

C. Anaphase II

D. Metaphase II [1]

13. [Maximum mark: 1]
The micrograph shows cells dividing by mitosis in the root tip of an onion (*Allium cepa*).



[Source: Reischig, J., 2014. [*Mitosis.*] [image online] Available at: https://commons.wikimedia.org/ [Accessed 15 January 2024]. Reference redacted. Source adapted.]

Which change would take place in cell Y if mitosis was allowed to continue?

A. Splitting of centromeres

B. Formation of spindle fibres

C. Supercoiling of chromosomes

D. Separation of homologous pairs

[1]

14. [Maximum mark: 1]

There is no evidence that rates of non-disjunction in meiosis increase as the age of the father increases from 30 to 45, yet the frequency of Down syndrome in offspring increases. What could explain this?

[Source: Thompson, J.A., 2019. *BMC Med Res Methodol* 19(1). [online] Available at: https://pubmed.ncbi.nlm.nih.gov/31014243/ [Accessed 2 January 2024]. Reference redacted. Source adapted.]

A. Down syndrome is not caused by non-disjunction.

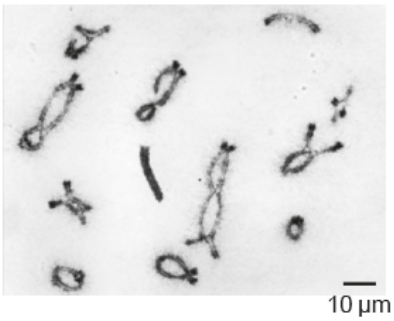
B. Meiosis rates decrease in males between the ages of 30 and 45.

C. Down syndrome is sex-linked, so non-disjunction can only take place in the mother.

D. Rates of non-disjunction increase as the age of the mother increases, and parents of a child tend to be similar in age. [1]

15. [Maximum mark: 1]

The image shows details of a cell from a male locust *Schistocerca gregaria*.



[Source: Jones, G.H. and Franklin, F.C.H., 2006. *Cell* 126(2), pp. 246–248. [e-journal] Available at: https://pubmed.ncbi.nlm.nih.gov/16873056/ [Accessed 11 April 2023]. Source adapted.]

What can be deduced from this image?

A. It is in prophase of mitosis.

B. It is in prophase II of meiosis.

C. It contains circular chromosomes.

D. It contains chiasmata as crossing over is taking place. [1]

16. [Maximum mark: 7]

The image shows a cell in the anther of a lily (*Lilium sp.*) plant during the first division of meiosis.

[Source: Reschke, E., n.d. [*Lilium - Lily 400X*.] [image online] Available at: https://www.gettyimages.com.mx [Accessed 13 April 2023]. Source adapted.]

(a.i) Identify the stage of meiosis shown in the image. [1]

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(a.ii) State where in the lily flower pollen would be formed. [1]

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(b) Distinguish between plant pollination and fertilization. [2]

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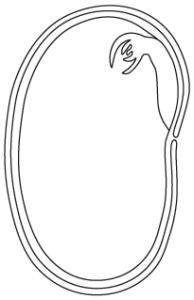
(c) The diagram shows a cross section through a broad bean (*Vicia faba*) seed.



(c.i) On the diagram, label the cotyledon. [1]

(c.ii) Outline the function of the cotyledon. [2]

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17. [Maximum mark: 15]
Reproduction depends on numerous factors both genetic and hormonal.

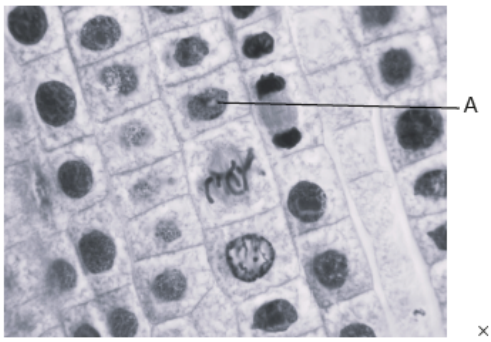
(a) Outline the process of transcription. [4]

(b) Describe how non-disjunction can cause Down syndrome. [4]

(c) Explain the roles of **named** hormones in the development and function of the sexual reproductive systems in males and females. [7]

18. [Maximum mark: 5]

(a) The photomicrograph shows a section of onion (*Allium cepa*) root tip cells.



[Source: Natalierussell77. https://commons.wikimedia.org/wiki/File:Mitosis_in_Onion_Root_-_various_stages_(Metaphase_and_Telophase).jpg. CC BY-SA 4.0 Deed. https://creativecommons.org/licenses/by-sa/4.0/deed.en.]

(a.i) Describe how a mitotic index could be obtained from this image. [2]

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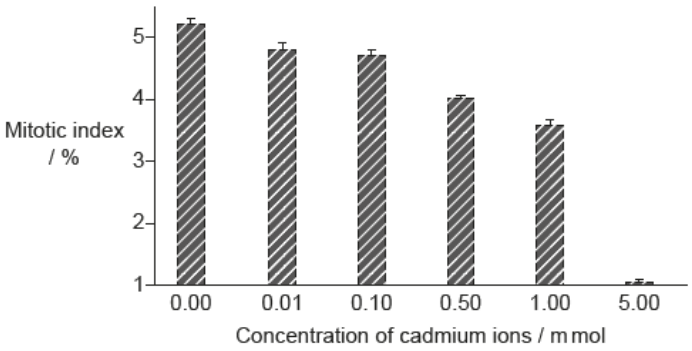
(a.ii) Calculate the actual length of the cell labelled A, giving the units. [1]

Cadmium is a heavy metal that can cause environmental problems. Cadmium ions are released from various human activities such as the release of sewage sludge, mining and industrial processes. Plants take up cadmium ions and they enter food chains.

A study was carried out to look at the effect of various concentrations of cadmium ions on the mitotic index of the apical meristem of root cells from 4-day-old wheat (*Triticum aestivum*) seedlings.



[Source: Bezrukova, M. V., Fatkhutdinova, R. A., & Shakirova, F. M. (2016). Protective effect of wheat germ agglutinin on the course of mitosis in the roots of *Triticum aestivum* seedlings exposed to cadmium. *Russian Journal of Plant Physiology*, 63(3), 358–364. Springer Nature. https://doi.org/10.1134/s102144371603002x.]

(b.i) State the effect of cadmium ion concentration on the mitotic index of root cells from wheat seedlings. [1]

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(b.ii) Suggest the effect the change in mitotic index would have on the wheat plant. [1]

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19. [Maximum mark: 1]

What occurs during the first division of meiosis?

A. Replication of DNA

B. Separation of chromatids

C. Halving of the chromosome number

D. Production of two identical cells [1]

20. [Maximum mark: 1]

A microscope slide of an onion (*Allium cepa*) root tip shows the number of cells in different stages of mitosis.

Stage of mitosis	Number of cells
Interphase	30
Prophase	10
Metaphase	3
Anaphase	5
Telophase	2

What is the mitotic index?

A. 0.2 [1]

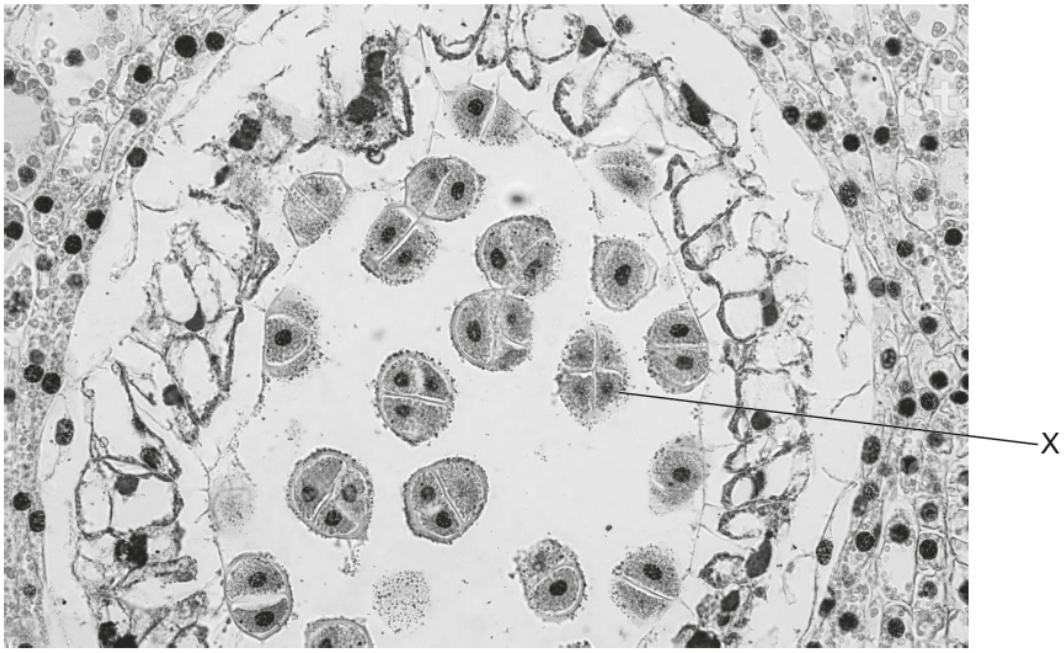
B. 0.3

C. 0.4

D. 0.6

21. [Maximum mark: 1]

The micrograph shows a cross section of a lily (*Lilium longiflorum*) anther.



[Source: Sinhyu / iStock.]

What can be found in X?

A. Haploid nuclei produced by meiosis

B. Diploid nuclei produced by fertilization

C. Haploid nuclei produced by mitosis

D. Diploid nuclei produced by pollination [1]

22. [Maximum mark: 1]
What happens in the first division of meiosis?

A. Formation of chiasmata where two sister chromatids join

B. Exchange of chromatids between homologous chromosomes

C. Exchange of DNA between non-sister chromatids of homologous chromosomes

D. Formation of chiasmata between non-homologous chromosomes [1]

23. [Maximum mark: 1]
Non-disjunction of chromosome 21 causes trisomy. What can be said about the incidence of non-disjunction in chromosome 21?

A. It increases greatly with maternal age after 30 years.

B. Chromosome 21 always suffers non-disjunction.

C. Very young mothers have no chance of non-disjunction.

D. There is no relation between age and the probability of non-disjunction. [1]

24. [Maximum mark: 1]
At what stage of meiosis do chromosome pairing and crossing over occur?

A. Interphase

B. Prophase 1

C. Metaphase 1

D. Prophase 2 [1]

25. [Maximum mark: 1]
For what reason do gametes contain only one allele of each gene?

A. To prevent inbreeding in a population

B. Haploid cells contain only one set of chromosomes

C. The two alleles of a gene are separated during mitosis

D. Crossing over will always produce one allele of a gene [1]

26. [Maximum mark: 1]
What is a result of crossing over in meiosis?

A. Gene linkage

B. Non-disjunction

C. Haploid cells

D. Variation in gametes [1]

27. [Maximum mark: 1]
The image shows a cell from the root tip of an onion (Allium cepa) (2n = 16) during late prophase of mitosis.

[Source: Davidson, M.W. and Molecular Expressions at Florida State University, n.d. *Late prophase*. [image online]
Available at: https://micro.magnet.fsu.edu/micro/gallery/mitosis/mitosis.html [Accessed 5 October 2021].]

How many chromatids are present in the cell?

A. 8

B. 16

C. 32

D. 64 [1]

28. [Maximum mark: 15]
All living organisms contain chromosomes. In addition to acting as stores of genetic information, these chromosomes are involved in a range of active processes during the life of a cell and of an organism.

(a) Outline the changes to chromosomes that occur during prophase in the first division of meiosis. [4]

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(b) Describe the processes that are carried out by enzymes that bind to DNA. [7]

(c) Explain the effects that the environment can have on DNA in living organisms. [4]

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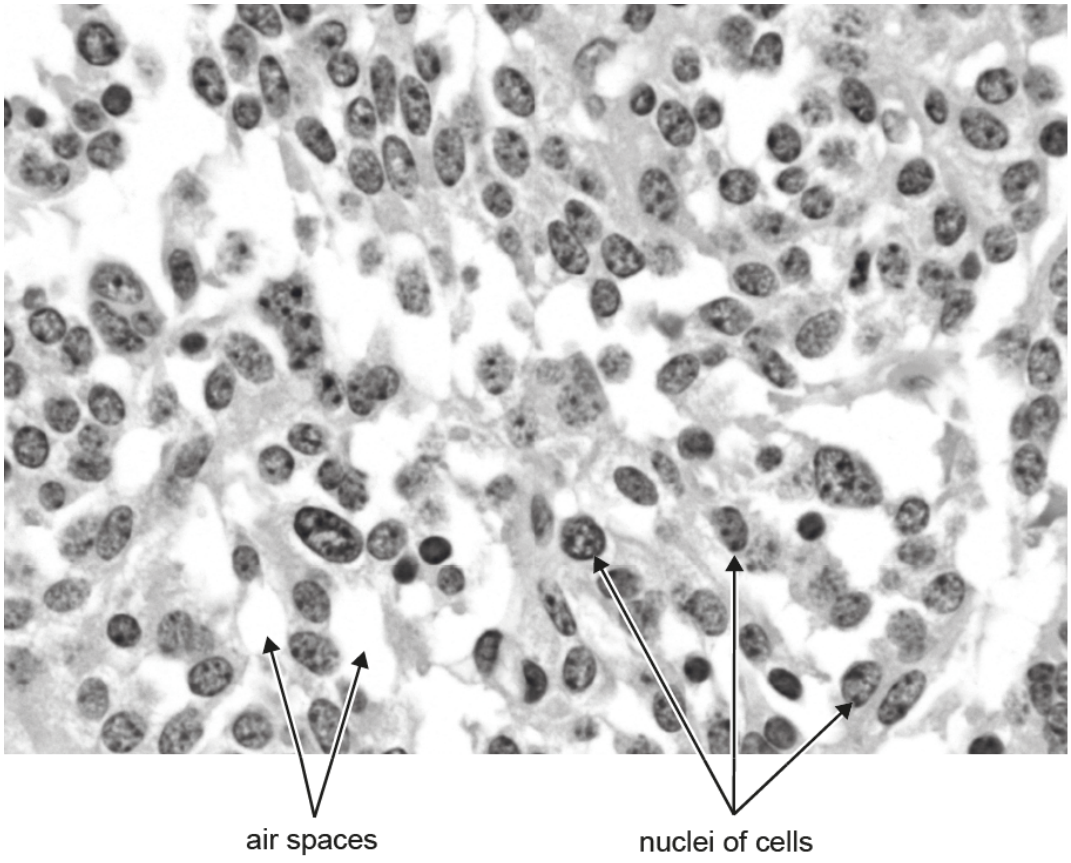
29. [Maximum mark: 4]

The light micrograph shows tumour tissue from a patient's lung.



[Source: Nephron, 2012. Lung carcinoid – very high mag. [image online] Available at: https://commons.wikimedia.org/wiki/File:Lung_carcinoid_-_very_high_mag.jpg [Accessed 18 October 2021]. Public domain.]

(a) State one cause of lung cancer. [1]

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(b) Suggest one difference between tissue taken from a lung cancer tumour and normal lung tissue that might be seen in micrographs. [1]

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(c) The lung tumour in the light micrograph was slow-growing. Predict with a reason what would have been visible in the micrograph if the tumour was growing rapidly. [2]

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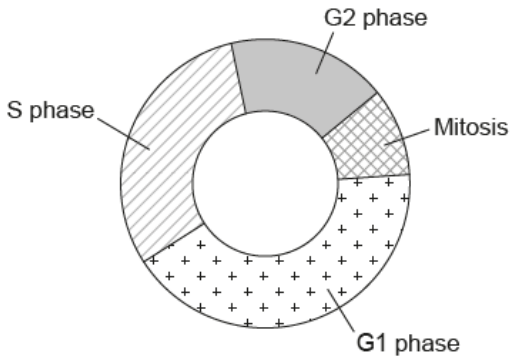
30. [Maximum mark: 1]

In which stage of the cell cycle are chromosomes duplicated?



[Source: M1llx, 2019. Cell cycle simple pl. [online] Available at: https://commons.wikimedia.org/wiki/File:Cell_cycle_simple_pl.png This file is licensed under the Creative Commons Attribution-Share Alike 4.0 International license. https://creativecommons.org/licenses/by-sa/4.0/deed.en [Accessed 1 August 2019].]

A. G1 phase

B. G2 phase

C. S phase

D. Mitosis [1]

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31. [Maximum mark: 1]

Cisplatin is an anti-cancer drug that prevents tumour cells from dividing by mitosis as it inhibits cell processes at stage S of interphase. How does cisplatin prevent cancer cells from dividing?

A. It inhibits the replication of DNA.

B. It inhibits the growth of the spindle fibres.

C. It prevents the breakdown of the nuclear membrane.

D. It prevents the condensation of chromosomes. [1]

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32. [Maximum mark: 1]

Which process occurs in meiosis but not in mitosis?

A. Attachment of spindle fibres to the centromeres of each chromosome

B. Movement of homologous chromosomes to opposite ends

C. Replication of DNA prior to the start of cell division

D. Separation of sister chromatids during anaphase [1]

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33. [Maximum mark: 1]

What is produced by meiosis in a cell of a male animal?

A. Four gametes, each with the same number of chromosomes

B. Two gametes, each with the same number of chromosomes

C. Four gametes, each with different numbers of chromosomes

D. Two gametes, each with different numbers of chromosomes [1]

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34. [Maximum mark: 1]

In the chimpanzee (*Pan troglodytes*), the haploid number of chromosomes is 24. How many sister chromatids are present in the G2 phase of a somatic cell, such as a cell in the bone marrow of the chimpanzee?

A. 12

B. 24

C. 48

D. 96 [1]

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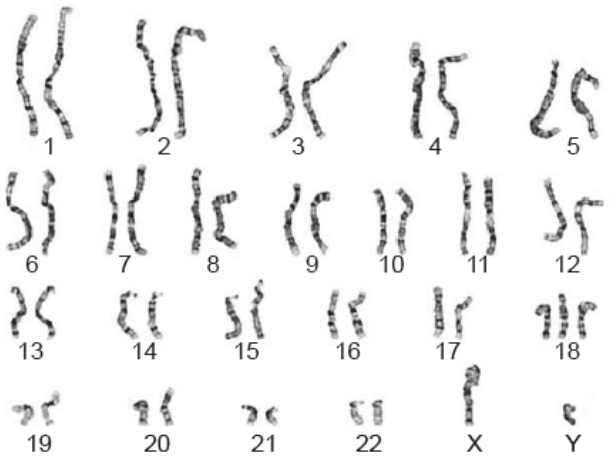
35. [Maximum mark: 1]

The karyogram shown belongs to a human being.



[Source: Reproduced from Tennakoon J, Kandasamy Y, Alcock G, Koh TH. Edwards syndrome with double trisomy. *Singapore Med J*. 2008 Jul;49(7):e190-1. PMID: 18695855.]

What can be deduced from this karyogram?

A. The person is a male with Down syndrome.

B. The person is a female with Down syndrome.

C. The person is a male with a genetic disorder.

D. The person is a female with a missing chromosome. [1]

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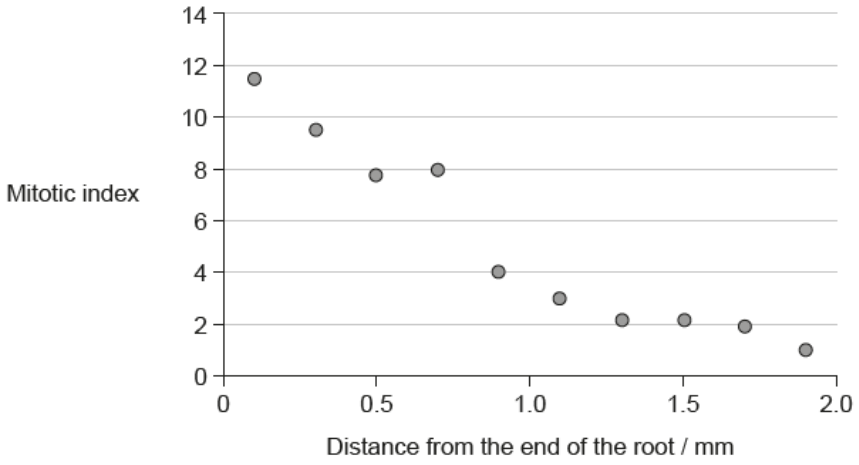
36. [Maximum mark: 1]

The graph shows the mitotic index in the roots of lentil plants at different distances from the end of the root.



[Source: *Physiologia Plantarum*, Volume 105, Issue 1, January 1999, Pages 171–178, Effect of microgravity on the cell cycle in the lentil root F. Yu, D. Driss-Ecole, J. Rembur, V. Legué, G. Perbal Wiley Online Library: https://onlinelibrary.wiley.com/doi/abs/10.1034/j.1399-3054.1999.105125.x]

What can be deduced from the graph?

A. As the distance from the end of the root increases, more cells are undergoing mitosis.

B. At 0.5 mm from the end of the root, most of the cells are in prophase.

C. There were fewer cells observed at 1.5 mm than at 0.5 mm.

D. As the distance from the end of the root increases, the percentage of cells in interphase increases. [1]

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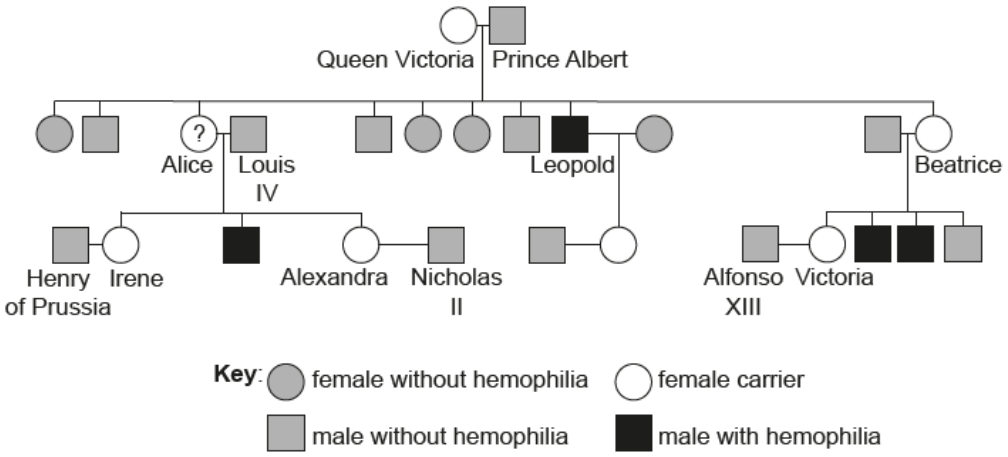
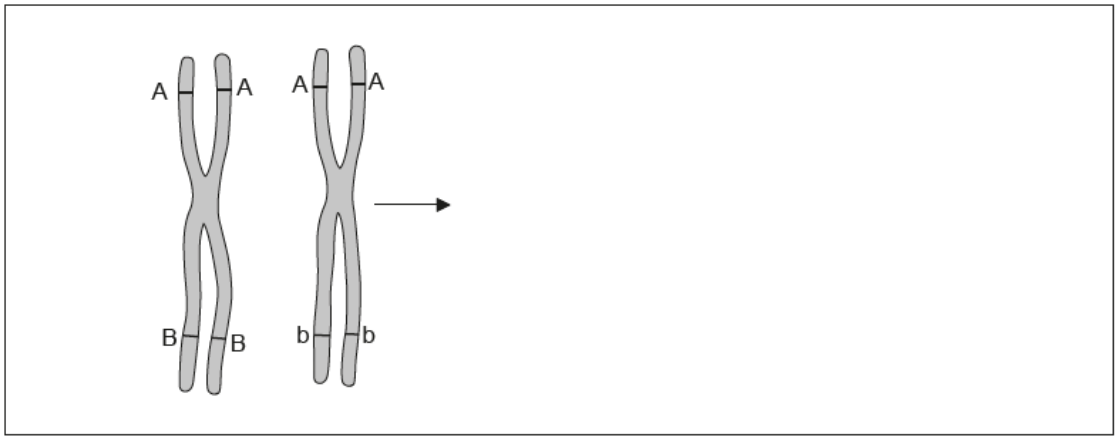
37. [Maximum mark: 9]

Hemophilia is a sex-linked disease that affected some members of royal families in Europe during the 19th and 20th centuries.



The diagram shows the structure of two chromosomes after the first division of meiosis, assuming that there was no crossing over or chiasmata formation.



(a.i) Draw a Punnett square to show all the possible genotypes of Queen Victoria's children. [2]

(a.ii) Deduce the genotype of Queen Victoria's daughter Alice. [1]

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(b.i) Draw the same chromosomes to show their structure at the same stage of meiosis if there had been one chiasma between two gene loci. [1]

(b.ii) State the stage of meiosis where chiasmata formation may occur. [1]

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(c) Explain gene linkage and its effects on inheritance. [2]

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(d) Explain the mechanism that prevents polyspermy during fertilization. [2]

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38. [Maximum mark: 15]

(a) Draw a labelled diagram to show the structure of a single nucleotide of RNA. [3]

(b) Distinguish between the processes of meiosis and mitosis. [5]

(c) Explain the development of antibiotic resistance in terms of natural selection. [7]

39. [Maximum mark: 15]

Organisms have evolved a great diversity of cell types.

(a) Describe the endosymbiotic theory. [4]

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(b) Explain the need for halving the chromosome number during a sexual life cycle and how this is done. [7]

(c) Outline the binomial system of classification. [4]

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40. [Maximum mark: 1]

Which statement is valid regarding chromatids?

A. Sister chromatids separate during meiosis I.

B. Chiasmata form between non-sister chromatids.

C. Crossing over is the exchange of DNA between sister chromatids only.

D. Non-sister chromatids have the same combination of alleles. [1]

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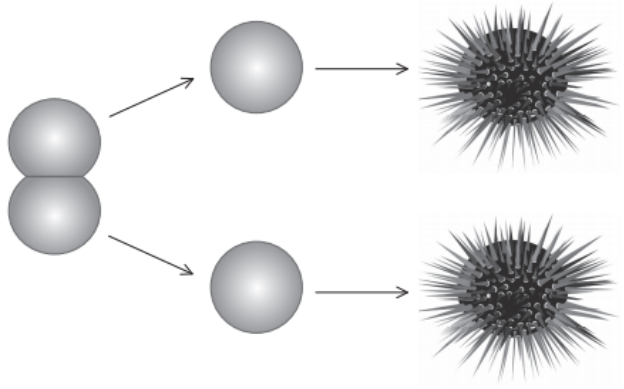
41. [Maximum mark: 1]

A two-cell sea urchin (*Echinoidea*) embryo was physically separated by scientists into two cells. Each cell, through further embryonic development, became an adult sea urchin.



[Source: Clker-Free-Vector-Images/Pixabay.]

What is the relationship between the two adult sea urchins?

A. They are equivalent to non-identical twins.

B. Half of the genes would be the same.

C. Both adults would have haploid cells.

D. They are clones. [1]

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42. [Maximum mark: 1]

Which statement applies to meiosis and mitosis?

A. Meiosis occurs in a greater number of locations in the body compared to mitosis.

B. Separation of chromatids occurs in both meiosis and mitosis.

C. Recombination occurs in both meiosis and mitosis.

D. Reduction in chromosome number occurs in both meiosis and mitosis. [1]

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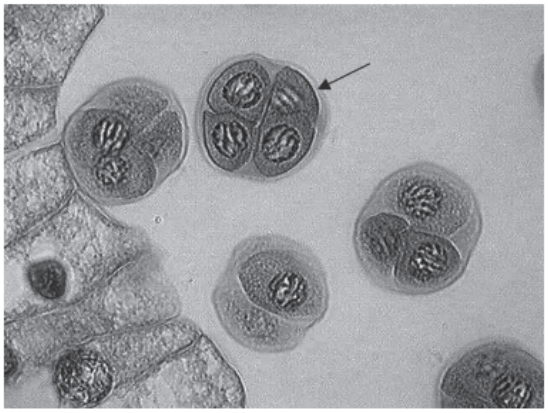
43. [Maximum mark: 1]

The image shows tetrads in the anther of a lily. A tetrad is a group of four cells, produced when one mother cell divides by meiosis. The tetrad indicated by the arrow contains a total of 48 chromosomes.



[Source: [Tetrad], 2012. [image online] Available at: https://www.iasprr.org/old/iasprr-pix/lily/tetrad.jpg [accessed: 4 April 2019]. Photo courtesy of Professor Scott D. Russell.]

What is the diploid number of the plant?

A. 12

B. 24

C. 48

D. 96 [1]

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44. [Maximum mark: 1]

When does DNA replication occur?

A. S phase of interphase

B. Early prophase

C. G phase of interphase

D. Late prophase [1]

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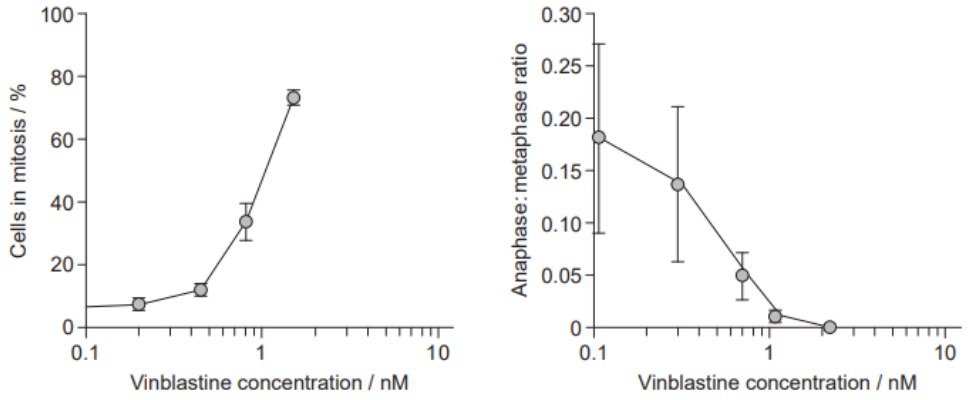
45. [Maximum mark: 6]

The mechanism of action of vinblastine, an anticancer drug, was investigated over a range of concentrations. Vinblastine is an alkaloid isolated from the periwinkle plant (*Catharansus roseus*). The percentage of cells in mitosis and ratio of anaphase to metaphase in cells exposed to this drug *in vitro* for a fixed time were recorded. The data are displayed in two graphs.



[Source: Republished with permission of American Society for Pharmacology and Experimental Therapeutics, from Mechanism of Mitotic Block and Inhibition of Cell Proliferation by the Semisynthetic Vinca Alkaloids Vinorelbine and Its Newer Derivative Vinflunine, *Molecular Pharmacology*, Vivian K. Ngan, Krista Bellman, Bridget T. Hill, Leslie Wilson and Mary Ann Jordan, Volume 60 , Issue 1, 2001; permission conveyed through Copyright Clearance Center, Inc.]

(e) By referring to both graphs, evaluate the hypothesis that vinblastine targets cells in mitosis and prevents them from completing the process. [3]

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(f) Some anticancer drugs inhibit mitosis by blocking the formation of the spindle. Suggest **one** other way in which vinblastine could block mitosis. [1]

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(g) Discuss **one** advantage and **one** disadvantage of using plant tissue to investigate drugs intended to treat cancer in humans.

Advantage:

Disadvantage: [2]

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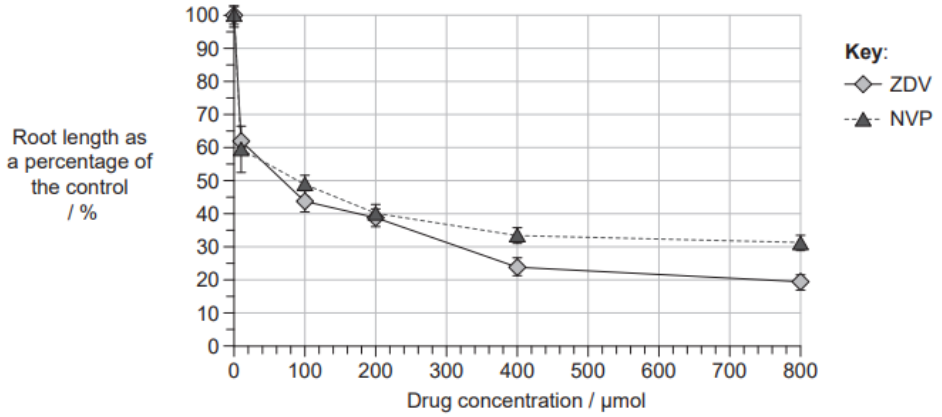
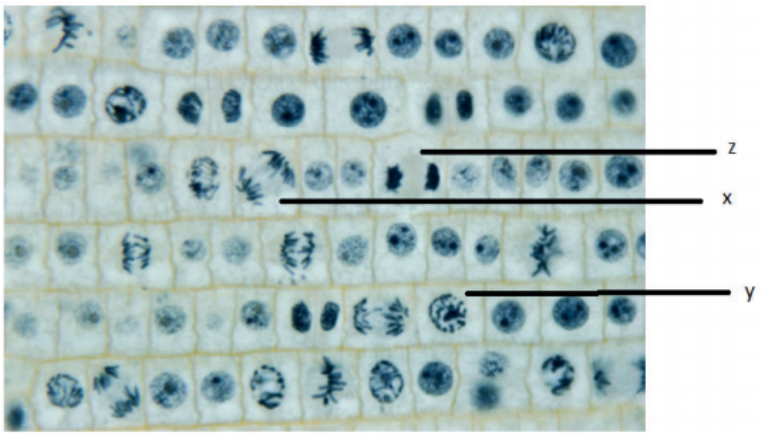
46. [Maximum mark: 12]

Antiretroviral drugs are used to treat Human Immunodeficiency Virus (HIV) infections. Zidovudine (ZDV) and nevirapine (NVP) are examples of antiretroviral drugs. There are concerns that these drugs may be toxic to body cells in mitosis. In a study using *Allium cepa*, root tips were exposed to the drugs for 96 hours at a range of concentrations. The control treatment was a drug concentration of 0µmol. In the graph, root lengths after the 96-hour treatment period are expressed as a percentage of the length of the control.



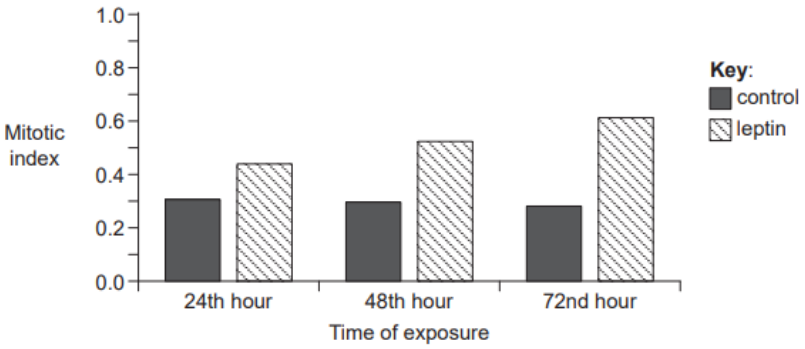
[Source: Onwuamah CK, Ekama SO, Audu RA, Ezechi OC, Poirier MC, Odeigah PGC (2014) Exposure of Allium cepa Root Cells to Zidovudine or Nevirapine Induces Cytogenotoxic Changes. *PLOS ONE* 9(3): e90296. https://doi.org/10.1371/journal.pone.0090296 (CC0 1.0 - https://creativecommons.org/publicdomain/zero/1.0/).]

Both ZDV and NVP are believed to have a damaging effect on the process of mitosis but ZDV in particular is believed to block the formation of the spindle.



[Source: Medical Images / Carolina Biological.]

Mitosis plays an important role in tissue regeneration and can be an important factor in recovery from surgery. The hormone leptin has been shown to promote mitosis in certain circumstances. The bar chart shows the mitotic indices of liver tissue exposed to leptin and control tissue during 72 hours after surgery.



[Source: Adapted from Cilekar M, Uysal O, Bal C, Turel S, Yılmaz S. Leptin increases mitotic index and regeneration ratio in hepatectomized rats. Med Sci Monit Basic Res. 2013 Nov 13;19:279-84. doi: 10.12659/MSMBR.889591]

(a.i) Deduce the concentration of ZDV that would cause a 50 % reduction in root growth compared to the control. [1]

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(a.ii) Identify the root length, as a percentage of the control, resulting from a ZDV concentration of $400\,\mu\text{mol}$. [1]

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(b) Compare and contrast the effect of ZDV and NVP on the growth of *Allium* roots. [2]

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(c) Based on the information, suggest with a reason which of the labelled cell types will become more common in *Allium* root tips treated with ZDV. [2]

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(d) *Allium* root tips continue to show some growth even at high concentrations of NVP. Suggest a possible reason for the growth seen in root tips with 800µmol NVP. [1]

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(e) Deduce the change in mitotic index after 72 hours compared to the control. [1]

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(f) Based on the data, evaluate the evidence for leptin promoting regeneration of liver tissue. [3]

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(g) Outline the role of leptin in appetite control. [1]

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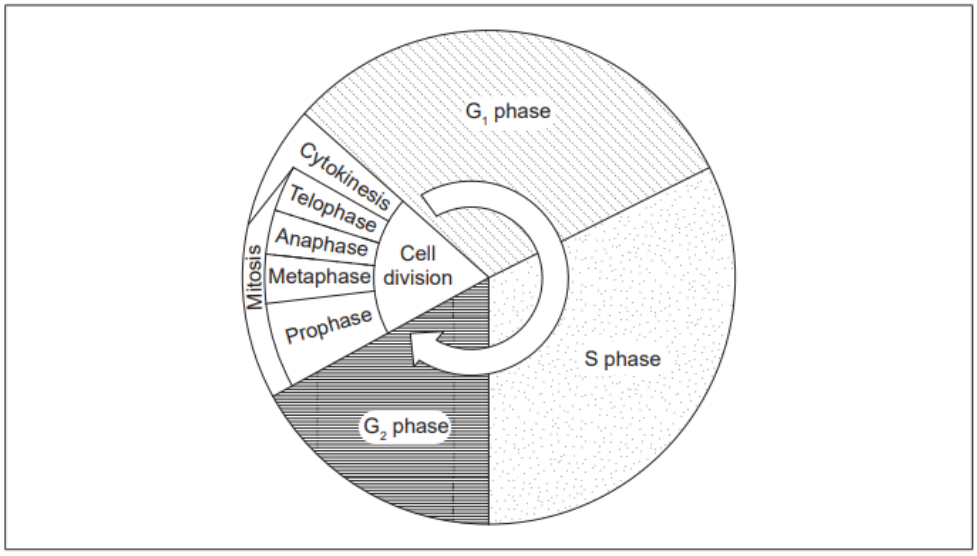
47. [Maximum mark: 7]

The diagram shows the stages in the cell cycle.



(a) State processes occurring during interphase. [2]

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(b.i) Using the letter C, label the stage on the diagram where chromosome supercoiling occurs. [1]

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(b.ii) Using the letter M, label the stage on the diagram where sister chromatids migrate to opposite poles. [1]

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(c) Distinguish between the outcomes of a cell dividing either by mitosis or meiosis. [2]

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(d) The mitotic index is an important prognostic tool for predicting the response of cancer cells to chemotherapy. Outline how the mitotic index is calculated. [1]

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48. [Maximum mark: 1]
What would show that a person has developed metastatic cancer?

A. Alveolus cells forming a tumour in the lungs

B. Cancer cells producing the skin pigment melanin in the liver

C. A tumour in the prostate gland increasing levels of prostate-specific antigen

D. Cancerous lymphocytes in blood plasma [1]

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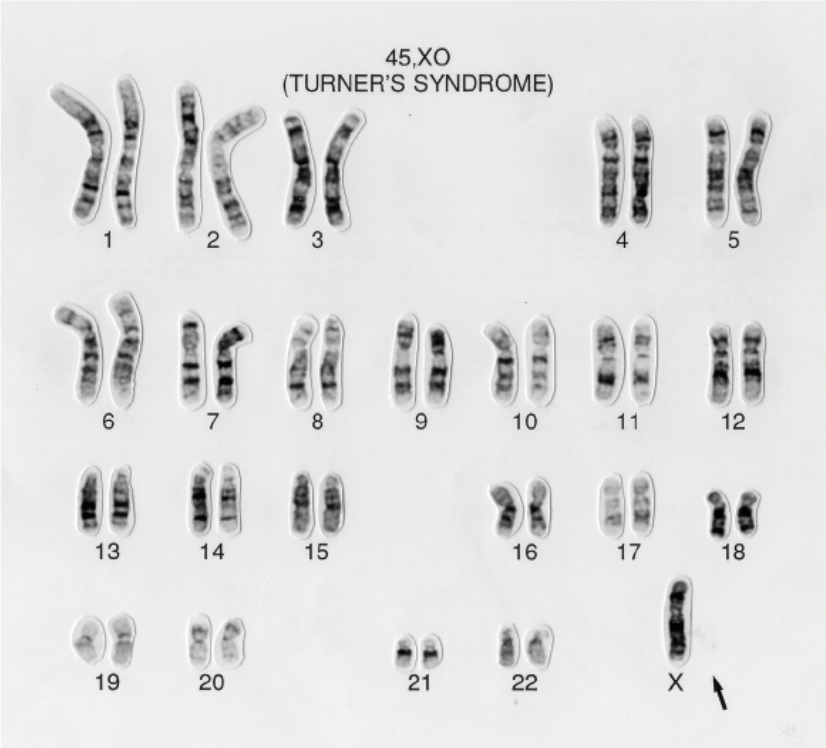
49. [Maximum mark: 1]

Testing the chromosomes of a girl with Turner syndrome produced the following karyogram.



[Source: Turner's syndrome karyotype 45,XO. This female lacks the second X chromosome present in the normal karyotype. Symptoms include short stature, neck webbing, elbow deformity, widely spaced nipples with shield chest, primary amenorrhea, sexual infantilism and sterility. The ovaries are reduced to fibrous streaks. Also known as XO syndrome or ovarian short-stature syndrome. Credit: Wessex Reg. Genetics Centre. Attribution 4.0 International (CC BY 4.0).]

The condition can result from non-disjunction occurring in anaphase I of meiosis in an egg cell. Two cells result from the first division, one of which would lead to Turner syndrome. Which chromosomes will be in the other cell (polar body) at the end of meiosis I?

A. 44 autosomes and X

B. 44 autosomes and XX

C. 22 autosomes and X

D. 22 autosomes and XX [1]

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50. [Maximum mark: 1]

How many chromosomes are there in a cell during anaphase of mitosis, if the diploid number of the cell is 20?

A. 10

B. 20

C. 40

D. 80 [1]

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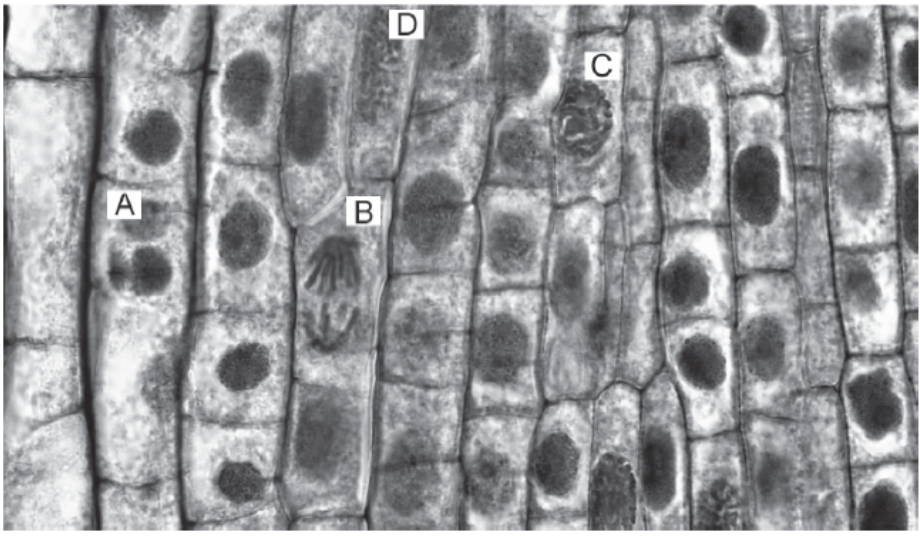
51. [Maximum mark: 1]

In the micrograph, which letter points to a cell in anaphase?



[Source: Berkshire Community College Bioscience Image Library, https://commons.wikimedia.org/wiki/File:Mitotic_Stages_in_Apical_Meristem_of_Allium_Root_Tip_(36762516673).jpg, licensed under Creative Commons CC0 1.0 Universal Public Domain Dedication]

[1]

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52. [Maximum mark: 1]

The table shows the number of cells in various stages of the cell cycle in four samples of ovarian tissue from different patients. Which tissue sample A, B, C or D has the highest mitotic index?

	Number of cells					
	Interphase	**Prophase**	**Metaphase**	**Anaphase**	**Telophase**	**Total**
A.	46	1	1	1	1	50
B.	96	0	1	2	1	100
C.	21	2	0	1	1	25
D.	72	0	1	1	1	75

[1]

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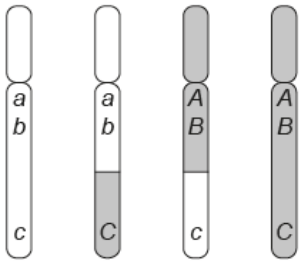
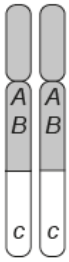
53. [Maximum mark: 1]

The diagram shows the chromosomes derived from a single homologous pair following meiosis in a diploid cell.

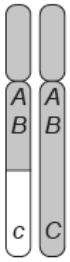


Which diagram represents the homologous pair from which these chromosomes were derived?

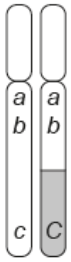
A.



B.



C.



D.

[Source: © International Baccalaureate Organization 2019]

[1]

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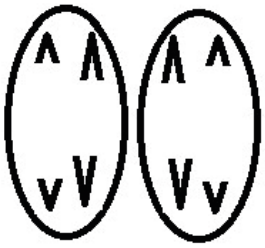
54. [Maximum mark: 1]

The diagram shows a stage in cell division.



[Source: © International Baccalaureate Organization 2019]

What is the stage shown?

A. Anaphase I of mitosis

B. Anaphase II of mitosis

C. Anaphase I of meiosis

D. Anaphase II of meiosis

[1]

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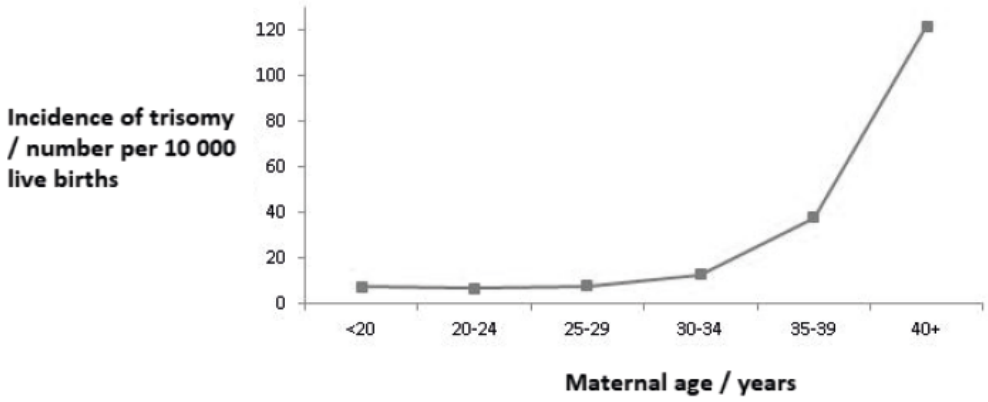
55. [Maximum mark: 1]

The graph shows the incidence of trisomy resulting from non-disjunction in pregnancies at different maternal ages.



[Source: Center for Disease Control]

What can be inferred from the graph?

A. The incidence of three copies of a chromosome increases directly in proportion with the age of the mother.

B. The incidence of three sets of chromosomes increases from age 20.

C. The incidence of three copies of a chromosome increases the most from age 35.

D. The incidence of three sets of chromosomes increases the most from age 30. [1]

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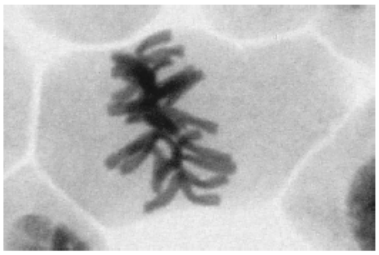
56. [Maximum mark: 1]

The image shows a micrograph of a cell.



[Source: © 2014,
https://commons.wikimedia.org/wiki/File:Mitosis_(261_13)_Pressed;_root_meristem_of_onion_(cells_in_prophase,_metaphase,_anaphase,_telophase).jpg by Doc. RNDr. Josef Reischig, CSc.]

What explains the appearance of the cell in the micrograph?

A. The cell is dying.

B. The DNA is replicating.

C. The cell is in metaphase.

D. The cell is in telophase. [1]

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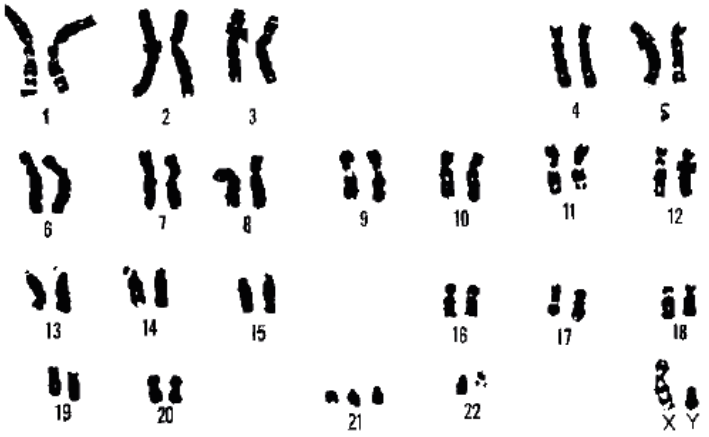
57. [Maximum mark: 2]
The image shows the chromosomes from a body cell of an adult human.



[Source: http://www.ornl.gov/sci/techresources/Human_Genome/graphics/slides/elsikaryotype.shtml,
U.S. Department of Energy Human Genome Program.]

(a) Identify, with a reason, the sex of this individual.

[1]

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(b) Identify the chromosome that is affected by a trisomy in this individual, naming the condition that this trisomy gives rise to.

Chromosome number:

Name of condition: [1]

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58. [Maximum mark: 10]

The karyogram shown is for the African marsh rat (*Dasymys incomtus*). In this species, sex is determined by X and Y chromosomes. Females are XX and males are XY.

[Source: adapted from https://embryology.med.unsw.edu.au]

Thomas Hunt Morgan established that genes for body colour and wing size in *Drosophila* are autosomally linked. The allele for grey body (b^+) is dominant over that for black body (b) and the allele for normal wing size (vg^+) is dominant over that for vestigial wing (vg).

(a) Distinguish between the structure of the chromosomes of prokaryotes and eukaryotes. [2]

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(b) Outline the causes of sickle cell anemia. [2]

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(c.i) Identify, with a reason, the sex of this individual. [1]

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(c.ii) State the haploid number for this nucleus. [1]

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(d.i) A fly that is homozygous dominant for both body colour and wing size mates with a fly that is recessive for both characteristics. In the table, draw the arrangement of alleles for the offspring of this mating and for the homozygous recessive parent.

Heterozygous offspring (grey body, normal wings)	Homozygous recessive parent (black body, vestigial wings)

[2]

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(d.ii) The offspring, which were all heterozygous for grey body and normal wings, were crossed with flies that were homozygous recessive for both genes. The table shows the percentages of offspring produced.

grey body, normal wings	48%
grey body, vestigial wings	3%
black body, normal wings	2%
black body, vestigial wings	47%

Explain these results, based on the knowledge that the genes for body colour and wing size are autosomally linked.

[2]