# 5. The Mitotic Cell Cycle

## 5.1 Replication and division of nuclei and cells

## Paper 1

Question Paper

**1** Which row is correct for stem cells?

| | can repair cells | can be involved in the formation of phagocytes |
|---|---|---|
| **A** | yes | no |
| **B** | yes | yes |
| **C** | no | no |
| **D** | no | yes |

**2** Which metabolic processes will be very active in a cell that has just completed cytokinesis?

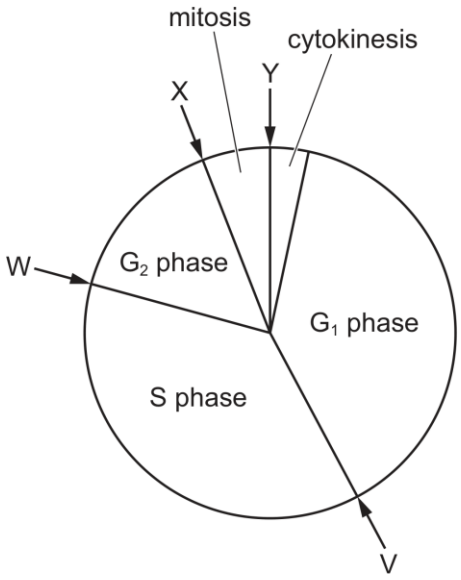
1 ATP formation

2 DNA replication

3 protein synthesis

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 only **D** 3 only

**3** The diagram shows a typical mitotic cell cycle and the point in the cell cycle that has been reached by each of four cells, V, W, X and Y.




Which row correctly identifies the cells that match the two descriptions?

| | DNA replication is complete but the cell has **not** yet reached its maximum size | preparation for microtubule formation is nearly complete but chromosomes have **not** yet condensed |
|---|---|---|
| **A** | V | X |
| **B** | W | Y |
| **C** | V | Y |
| **D** | W | X |

**4** What are the correct roles of mitosis?

| | stem cell growth | replacing lost skin cells |
|---|---|---|
| **A** | ✓ | ✗ |
| **B** | ✓ | ✓ |
| **C** | ✗ | ✗ |
| **D** | ✗ | ✓ |

key
✓ = correct
✗ = **not** correct

**5** Which row about the stages of the mitotic cell cycle is correct?

| | DNA ligase used in the nucleus | RNA polymerase used in the nucleus |
|---|---|---|
| **A** | $G_1$ phase | S phase |
| **B** | $G_2$ phase | mitosis |
| **C** | mitosis | $G_2$ phase |
| **D** | S phase | $G_1$ phase |

**6** There are 64 chromosomes in the muscle cells of a particular mammal.

How many DNA molecules are present in a cell during early prophase and telophase of mitosis?

| | early prophase | telophase |
|---|---|---|
| **A** | 64 | 32 |
| **B** | 64 | 64 |
| **C** | 128 | 128 |
| **D** | 128 | 64 |

**7** Chickens have 78 chromosomes in the nucleus of a body cell.

How many DNA molecules are there in a chicken body cell at the start of prophase of mitosis?

**A** 46 **B** 78 **C** 92 **D** 156

**8** Which processes occur in bone marrow cells that are in a mitotic cell cycle?

1 Phosphate groups bind to ADP molecules to form ATP.

2 Bonds form between nucleotides in a DNA strand.

3 Hydrogen bonds form between tRNA anticodons and mRNA codons.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

**9** The enzyme telomerase prevents loss of telomeres after many mitotic cell cycles.

Which cells need to transcribe telomerase enzyme?

1 stem cells

2 activated memory B-lymphocytes

3 helper T-lymphocytes secreting cytokines

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**10** The cell cycle includes mitosis.

What are features of this type of nuclear division?

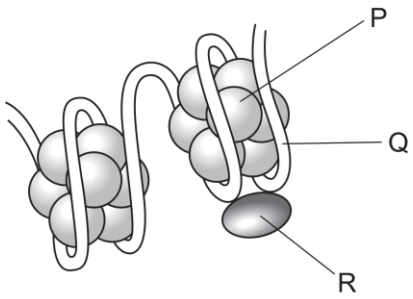
1 forms cells of equal size to the parent cell

2 forms genetically identical nuclei

3 semi-conservative replication of DNA

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

**11** The diagram shows part of the organisation of a section of a DNA molecule and the associated histones, P and R, in prophase of mitosis.




Which statement about the features labelled P, Q and R during prophase of mitosis is correct?

**A** The coiled DNA molecule forms Q and wraps around histone R to form small clusters held in place by histone P.

**B** The groups of histones, P, and its associated DNA, Q, move closer together as the chromosome condenses around R.

**C** The histones P and R are made of protein around which the DNA molecule, Q, is wrapped so that the DNA molecule can fit inside the nucleus.

**D** The linked groups of histones P and R and the associated DNA, Q, form strands that fold and twist together to form a chromatid.

**12** How many copies of each DNA molecule will be found in a cell at the **start** of the stages of the mitotic cell cycle shown?

| | $G_1$ of interphase | cytokinesis |
|---|---|---|
| **A** | 1 | 1 |
| **B** | 1 | 2 |
| **C** | 2 | 1 |
| **D** | 2 | 2 |

**13** Which events are part of mitosis?

1 interphase

2 telophase

3 cytokinesis

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

**14** The statements are about genes and proteins involved in breast cancer.

- The protein coded by the *BRAC1* gene inhibits the growth of breast cancer cells.
- The protein coded by the *p53* gene suppresses tumours.

Which combination of genes is **most likely** to result in breast cancer?

| | *BRAC1* | *p53* |
|---|---|---|
| **A** | ✗ | ✗ |
| **B** | ✗ | ✓ |
| **C** | ✓ | ✗ |
| **D** | ✓ | ✓ |

key

✓ = normal active gene

✗ = mutated gene

**15** A human embryo consists of 12 cells at the start of day 1. The cells divide by mitosis for 4 complete days at a rate of 1 division every 32 hours.

What is the maximum number of cells in the embryo at the end of day 4?

**A** 48 cells

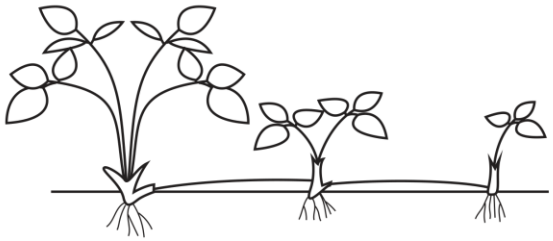
**B** 96 cells

**C** 192 cells

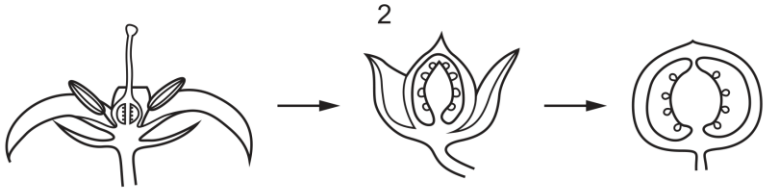
**D** 384 cells

**16** Which diagrams show roles of mitosis?

1



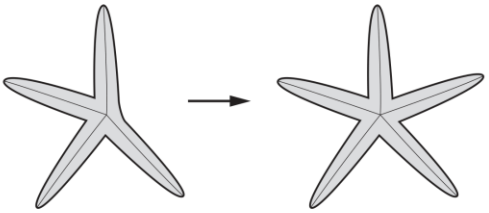
2



3



4



**A** 1, 2, 3 and 4

**B** 1, 2 and 3 only

**C** 1 and 2 only

**D** 3 and 4 only

**17** Which events are part of the mitotic cell cycle?

1 interphase

2 anaphase

3 cytokinesis

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

**18** Which processes require mitosis?

1 the cloning of T-lymphocytes

2 the repair of cell structures by protein synthesis

3 the growth of multicellular organisms from a single cell

4 the reproduction of a unicellular eukaryote

**A** 1, 2 and 3 **B** 1, 3 and 4 **C** 1 and 2 only **D** 3 and 4 only

**19** Which events listed are part of the cell cycle?

1 interphase

2 prophase

3 cytokinesis

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**20** Telomerase is an enzyme that adds nucleotides to telomeres.

Which statement about telomerase is correct?

**A** A high concentration of telomerase in a cell damages genes during DNA replication.

**B** A high concentration of telomerase in cancerous cells limits the rate of tumour growth.

**C** The low concentration of telomerase in stem cells means that these cells can divide an unlimited number of times.

**D** The low concentration of telomerase in body cells means that these cells can divide a limited number of times.

**21** What is a role of mitosis?

**A** growth of organisms

**B** production of genetically different cells

**C** repair of cells

**D** replacement of cancerous tissue

**22** Telomeres prevent the loss of genes from the ends of chromosomes during DNA replication, but they become shorter each time they are copied.

In cancer cells and stem cells, the telomeres remain the same length.

Which statement is correct for **all** human cells?

**A** If telomeres become too short, a cell may stop dividing.

**B** Adding telomeres could increase the rate of ageing of cells.

**C** Telomeres are repaired by the enzyme RNA polymerase.

**D** Telomeres prevent all damage occurring to DNA molecules.

**23** The nucleus of a mouse body cell in $G_1$ phase of the cell cycle has $1.2 \times 10^{-12}$ g of DNA.

What will be the mass of DNA in the nucleus of the cell at the end of S phase and at the end of $G_2$ phase of the cell cycle?

| | end of S phase | end of $G_2$ phase |
|---|---|---|
| **A** | $1.2 \times 10^{-12}$ g | $1.2 \times 10^{-12}$ g |
| **B** | $1.2 \times 10^{-12}$ g | $2.4 \times 10^{-12}$ g |
| **C** | $2.4 \times 10^{-12}$ g | $1.2 \times 10^{-12}$ g |
| **D** | $2.4 \times 10^{-12}$ g | $2.4 \times 10^{-12}$ g |

**24** How many of these processes produce genetically identical cells?

- growth of plant roots
- replacement of dead human skin cells
- repair of damaged muscle tissue
- asexual reproduction of coral

**A** 1 **B** 2 **C** 3 **D** 4

**25** Which row shows the correct number of each component of a single chromosome at the end of prophase of mitosis?

| | centromeres | chromatids | polynucleotide strands | telomeres |
|---|---|---|---|---|
| **A** | 1 | 0 | 2 | 2 |
| **B** | 1 | 2 | 4 | 4 |
| **C** | 2 | 0 | 4 | 2 |
| **D** | 2 | 2 | 2 | 4 |

**26** Which processes occur during interphase?

1 DNA replication

2 microtubule organisation

3 synthesis of ribosomes

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**27** Embryonic stem cells are able to replicate continuously.

What happens to the telomeres during repeated mitotic cell cycles of embryonic stem cells?

**A** Their lengths increase.

**B** Their lengths decrease.

**C** They are completely lost.

**D** They stay the same length.

**28** The enzyme telomerase prevents loss of telomeres after many mitotic cell cycles.

Which cells need to transcribe telomerase enzyme?

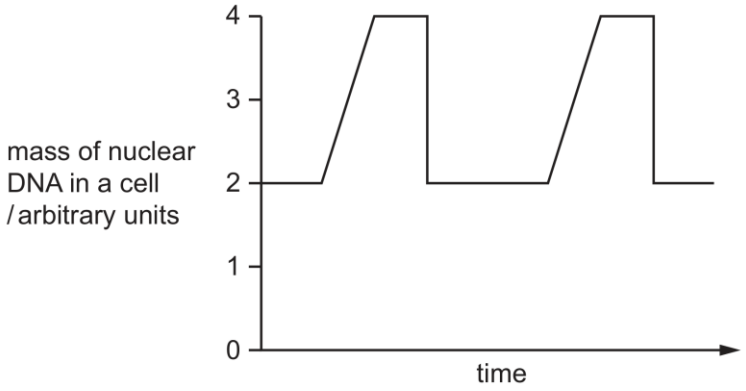
1 cancer cells

2 stem cells

3 activated memory B-lymphocytes

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**29** Which processes that occur in the cell cycle are represented in the diagram?




**A** DNA replication and nuclear division only

**B** DNA replication, nuclear division and cytokinesis

**C** mitosis and cytokinesis

**D** mitosis only

**30** A gene codes for the production of a protein, p53, that binds to damaged DNA during interphase and prevents its replication. A carcinogen in cigarette smoke mutates the gene coding for the p53 protein, preventing production of the protein.

Which statement explains why this mutation may cause cancer?

**A** Cells with no p53 are able to undergo mitosis.

**B** Cells with no p53 replicate their damaged DNA.

**C** The carcinogen in cigarette smoke increases the rate of cell division.

**D** The mutated p53 causes uncontrolled cell division.

**31** The jellyfish, *Turritopsis dohrnii*, is described as being immortal. If *T. dohrnii* is not eaten by predators or diseased, it seems to be able to live forever. There is no way to determine the biological age of a *T. dohrnii* individual.

Which feature of the cells in *T. dohrnii* could explain these observations?

**A** very long G phases in the cell cycle

**B** a very short S phase in the cell cycle

**C** an ability to restore telomeres to their original length

**D** fewer chromosomes than other eukaryotic organisms

**32** Some chemicals, used to stop tumour growth, work by preventing the DNA double helix from uncoiling and separating.

During which stage of the cell cycle would they act?

**A** anaphase

**B** interphase

**C** metaphase

**D** prophase

**33** Human chromosomes have different parts. Some parts are more numerous than others.

Which parts are listed in order from **most** numerous to **least** numerous in a human white blood cell?

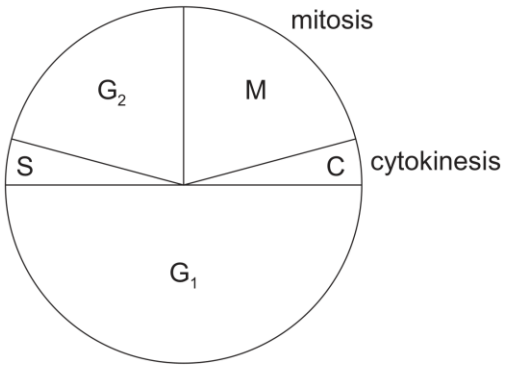
**A** centromere → nucleotide → histone protein

**B** DNA molecule → telomere → centromere

**C** histone protein → telomere → DNA molecule

**D** telomere → centromere → nucleotide

**34** The diagram represents the cell cycle of a human cell. During the cell cycle the number of chromatids changes.




Which row is correct for the number of chromatids in M, $G_1$, and $G_2$?

| | M | $G_1$ | $G_2$ |
|---|---|---|---|
| **A** | 46 | 46 | 92 |
| **B** | 46 | 92 | 92 |
| **C** | 92 | 46 | 92 |
| **D** | 92 | 92 | 92 |

**35** A single skin cell was isolated and transferred to growth medium in a sterile Petri dish. The Petri dish was incubated for 16 days. During this time, the number of skin cells multiplied as a result of repeated mitotic divisions.

One of the chromosomes in the nucleus of each skin cell has a telomere that contains many repeats of the base sequence TTAGGG. On each of days 4, 8, 12 and 16 of the incubation period, a single cell was removed from the Petri dish. The total number of bases in the telomere of this chromosome was determined for each cell. Each of the four cells had a different total number of telomere bases for this chromosome: 5548, 5580, 5645 and 5700.

What was the total number of telomere bases in the chromosome from the cell that had undergone the most mitotic divisions?

**A** 5548 **B** 5580 **C** 5645 **D** 5700

**36** What will be present in each chromosome at the end of the $G_2$ phase of the cell cycle?

**A** two centrioles

**B** two centromeres

**C** two molecules of DNA

**D** two telomeres

**37** Which events listed are part of the cell cycle?

1 interphase

2 metaphase

3 cytokinesis

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**38** Which features of an organism are affected by a drug that kills cells that are dividing mitotically?

1 cell repair

2 cell replacement

3 number of stem cells

4 tissue repair

5 tumour formation

**A** 1, 2, 3, 4 and 5

**B** 1, 2 and 3 only

**C** 1, 4 and 5 only

**D** 2, 3, 4 and 5 only

**39** Which description is correct?

**A** A centromere holds two chromatids together until the end of prophase and attaches to the microtubules of the spindle.

**B** A chromatid is one of two identical parts of a chromosome and is made of proteins and two molecules of DNA.

**C** A chromosome is a structure with two identical parts, made of DNA and proteins, found in the nucleus of a prokaryotic cell.

**D** A telomere is a sequence of DNA nucleotides, such as GGGTAA, repeated many times and found at the ends of each chromatid.

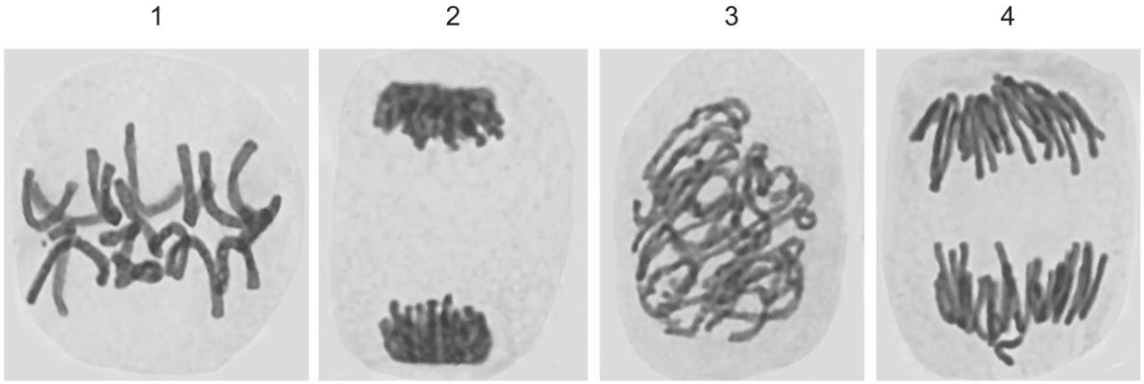
**40** During metaphase, a scientist stains the chromosomes of a diploid animal cell with fluorescent dye to allow the telomeres to be observed.

This cell has 26 chromosomes.

How many telomeres will the scientist observe?

**A** 26 **B** 52 **C** 78 **D** 104

**41** The photomicrographs show cells in various stages of the cell cycle.




Which cells contain twice as many DNA molecules as a cell from the same organism that has just finished a complete mitotic cell cycle ending with cytokinesis?

**A** 1, 2, 3 and 4

**B** 1, 2 and 4 only

**C** 1 and 3 only

**D** 2 and 4 only

**42** Uncontrolled cell division can result in the formation of a tumour.

Which part of the cell cycle would take less time during the formation of a tumour?

**A** cytokinesis

**B** interphase

**C** mitosis

**D** telophase

**43** Which feature of stem cells enables them to replace cells in tissues such as the skin?

**A** They are undifferentiated cells that are present at birth.

**B** They differentiate to form skin cells.

**C** They divide by mitosis to supply some cells that can differentiate.

**D** They have the full number of chromosomes.

**44** During prophase, a scientist stains the chromosomes of a diploid animal cell with a fluorescent dye to stain telomeres. This cell has 32 chromosomes.

How many telomeres will the scientist observe?

**A** 32 **B** 64 **C** 96 **D** 128

**45** Which description of chromosome structure is correct?

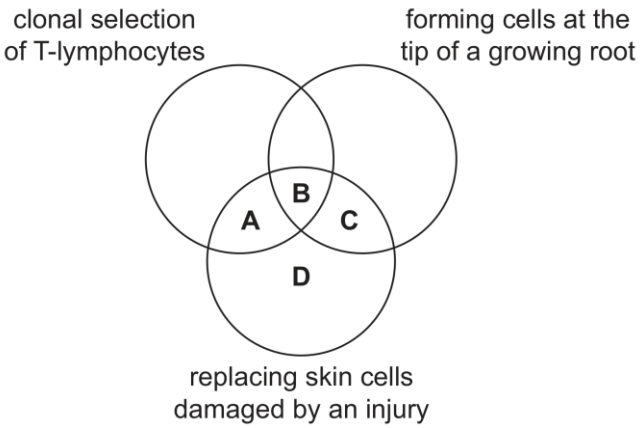
**A** A chromosome at the beginning of interphase consists of two identical chromatids, each containing one linear molecule of DNA.

**B** Telomeres are lengths of non-coding DNA found at one end of each chromatid to prevent loss of genes during cell division.

**C** The two identical chromatids of a chromosome are held together by a centromere in which there is no DNA.

**D** The very long DNA molecule of each chromatid is coiled and held together by proteins called histones.

**46** Which processes involve mitosis?



**47** During telophase of mitosis, a scientist stains the chromosomes of a diploid animal cell with a fluorescent dye to observe the telomeres.

This cell has 22 chromosomes.

How many telomeres will the scientist observe in one of the nuclei?

**A** 22 **B** 44 **C** 66 **D** 88

**48** Methotrexate is a drug used to treat cancer. It can act as an enzyme inhibitor preventing the synthesis of nucleotides containing thymine.

Cells treated with methotrexate are not able to complete the cell cycle.

A cell entering telophase is treated with methotrexate.

Which stage of the cell cycle will be affected by the action of methotrexate?

**A** anaphase

**B** interphase

**C** metaphase

**D** prophase

**49** During the cell cycle, the mass of DNA in a cell is doubled.

At which stage in the cell cycle is the mass of DNA in a cell reduced?

**A** anaphase

**B** cytokinesis

**C** interphase

**D** prophase

**50** How many of the listed structures typically contain genetic material that has telomeres?

- bacterial cell
- chloroplast
- mitochondrion
- nucleus

**A** 1 **B** 2 **C** 3 **D** 4

**51** In eukaryotes, the chromosomes become shorter and thicker during mitosis. The thickening may be increased by molecules called protamines. The protamines replace part of the structure of the chromosome.

Which part of the chromosome is replaced by protamines?

**A** centromeres

**B** chromatids

**C** histones

**D** telomeres

**52** A scientist stains the chromosomes of a diploid plant cell with a fluorescent dye to observe the telomeres.

This cell has 38 chromosomes.

How many telomeres will the scientist observe in one of the nuclei during telophase of mitosis?

**A** 38 **B** 76 **C** 114 **D** 152

**53** Which events listed are part of mitosis?

1 interphase

2 prophase

3 cytokinesis

**A** 1, 2 and 3

**B** 1 and 2 only

**C** 1 only

**D** 2 only

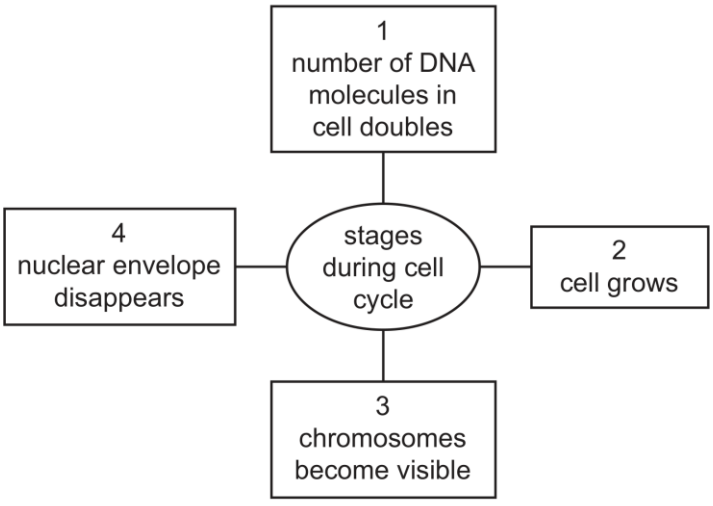
**54** Three parts of a chromosome and their functions are listed.

| part | function |
|---|---|
| P1 centromere | F1 holds the coils of DNA together |
| P2 histone proteins | F2 holds two chromatids together |
| P3 telomere | F3 prevents loss of genes |

Which part is matched with its correct function?

**A** P1 and F1 **B** P2 and F1 **C** P2 and F3 **D** P3 and F2

**55** The diagram shows some of the stages which take place during the cell cycle.




Which two stages take place during interphase?

**A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

**56** The enzyme telomerase prevents loss of telomeres after many mitotic cell cycles.

Which cells transcribe a high concentration of telomerase?

1 neutrophils

2 mature red blood cells

3 activated memory T-lymphocytes

**A** 1 and 2 **B** 1 and 3 only **C** 1 only **D** 3 only

**57** Which row shows the correct number of each component of a single chromosome during prophase of mitosis?

| | centromeres | chromatids | polynucleotide strands | telomeres |
|---|---|---|---|---|
| **A** | 1 | 0 | 2 | 2 |
| **B** | 1 | 2 | 4 | 4 |
| **C** | 2 | 0 | 4 | 2 |
| **D** | 2 | 2 | 2 | 4 |

**58** The cell cycle includes mitosis.

Which are features of nuclear division?

1 forms cells of equal size to the parent cell

2 forms genetically identical nuclei

3 semi-conservative replication of DNA

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

**59** The enzyme telomerase prevents loss of telomeres after many mitotic cell cycles.

Which types of white blood cell involved in an autoimmune condition will contain active telomerase?

| | mature B-lymphocyte plasma cells | neutrophils | helper T-lymphocyte memory cells |
|---|---|---|---|
| **A** | ✓ | ✓ | ✓ |
| **B** | ✓ | ✓ | ✗ |
| **C** | ✗ | ✗ | ✓ |
| **D** | ✗ | ✓ | ✓ |

key

✓ = contain active telomerase

✗ = do not contain active telomerase

**60** Which of these events are part of mitosis?

1 interphase

2 telophase

3 cytokinesis

**A** 1, 2 and 3 **B** 1 and 3 only **C** 1 only **D** 2 only

**61** During which phase of the cell cycle does DNA replication take place?

**A** $G_1$ **B** $G_2$ **C** M **D** S

**62** One of the chromosomes in a nucleus has a telomere which contains many repeats of the base sequence TTAGGG.

This chromosome was extracted from four different cells and the total number of bases in the telomere was determined.

Which total number of bases was found in the cell that had undergone the most mitotic divisions?

**A** 5548 **B** 5580 **C** 5645 **D** 5700

**63** Which of these statements about cytokinesis is always true?

1 Cell structures replicate.

2 Cell structures are shared between two cells.

3 Nuclear envelope reforms.

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 only **D** 3 only

**64** Which statement is correct about the number of telomeres present in prophase of a human body cell?

**A** 46 as there is one telomere at the end of 46 chromosomes

**B** 92 as there is one telomere at each end of 46 chromosomes

**C** 92 as there is one telomere at the end of 92 chromatids

**D** 184 as there is one telomere at each end of 92 chromatids

**65** How many copies of each DNA molecule will be found in a cell at each stage of the mitotic cell cycle?

| | $G_1$ of interphase | cytokinesis |
|---|---|---|
| **A** | 1 | 1 |
| **B** | 1 | 2 |
| **C** | 2 | 1 |
| **D** | 2 | 2 |

**66** Which metabolic processes will be very active in a cell that has just completed cytokinesis?

1 ATP formation

2 DNA replication

3 protein synthesis

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2 only **D** 3 only

**67** A mutation occurs in a gene which prevents the production of telomerase.

What is the effect of this mutation if it occurs in bone marrow stem cells?

**A** a rapid increase in the production of lymphocytes

**B** a tumour grows in the bone marrow

**C** bone marrow stem cells eventually no longer divide

**D** the total blood cell count will be unchanged

**68** Which changes in a group of mammalian cells, dividing by mitosis, would be necessary for the formation of a tumour?

1 Mitosis is no longer inhibited by cell to cell contact.

2 Cells acquire the ability to migrate and set up new colonies.

3 Cells become able to divide indefinitely.

**A** 1 and 2 **B** 1 and 3 **C** 1 only **D** 2 and 3