Year 12 Science: DNA replication, mitosis and the cell cycle

Name: _____ Date: _____

Try these without your notes first, then check the answer key.

Practice

1. At what point in the cell cycle is DNA copied?

2. A cell has 8 chromosomes. How many DNA molecules does it contain at metaphase, and how many chromosomes does each daughter cell get?

3. One DNA strand reads 5' ATGCCTA 3'. Write the new strand built on it during replication, with its ends labelled.

4. In a root tip squash, 45 of the 300 cells counted are in mitosis. Calculate the mitotic index.

5. Explain why a growing root makes more cells rather than making its cells bigger.

Exam-style question: a copper skink

Copper skinks are small lizards common in Auckland gardens. Like most New Zealand skinks, they give birth to live young, and a newborn is only a fraction of its adult size. When a bird grabs its tail, the skink can drop the tail and escape, then slowly grow a new one.

6. Describe when DNA replication happens in the cell cycle, and how the DNA is copied.

7. Explain why DNA replication must happen before mitosis.

8. Explain why the young skink grows by making more cells rather than by its cells getting larger.

9. Discuss why mitosis is needed throughout the skink's life, linking the survival of its cells to the survival of the whole skink.

Fix the mistake

10. Correct this statement: "DNA replication happens during prophase, when the chromosomes appear."

11. Correct this statement: "Interphase is when the cell rests between divisions."

12. Correct this statement: "Mitosis makes four cells that are all genetically different."

13. Correct this statement: "Each daughter cell gets half of the parent cell's DNA."

Answer key (for parents and tutors)

1. At what point in the cell cycle is DNA copied?
   In the S phase of interphase, before mitosis begins.
2. A cell has 8 chromosomes. How many DNA molecules does it contain at metaphase, and how many chromosomes does each daughter cell get?
   16 DNA molecules at metaphase (8 chromosomes, each two chromatids); each daughter cell gets 8 chromosomes.
3. One DNA strand reads 5' ATGCCTA 3'. Write the new strand built on it during replication, with its ends labelled.
   3' TACGGAT 5': A pairs with T and C with G, and the new strand runs antiparallel to the template.
4. In a root tip squash, 45 of the 300 cells counted are in mitosis. Calculate the mitotic index.
   45 ÷ 300 × 100 = 15%.
5. Explain why a growing root makes more cells rather than making its cells bigger.
   A bigger cell has a lower surface area to volume ratio, so substances could not diffuse in and out fast enough; dividing keeps each cell small with a high ratio.
6. Describe when DNA replication happens in the cell cycle, and how the DNA is copied.
   DNA is copied in the S phase of interphase, before mitosis (Achieved). Helicase unzips the double helix by breaking the hydrogen bonds between bases; each strand is a template, and DNA polymerase joins free nucleotides to it by complementary pairing, A with T and C with G, building each new strand antiparallel to its template. Each new molecule has one old and one new strand, so replication is semi-conservative (Merit for template, base pairing and enzymes together).
7. Explain why DNA replication must happen before mitosis.
   Mitosis shares one chromatid of every chromosome between the two daughter cells, so the DNA must be doubled first; otherwise each new cell would get only half the genes and could not make all the proteins and enzymes it needs to work (Merit).
8. Explain why the young skink grows by making more cells rather than by its cells getting larger.
   As a cell grows, its volume increases faster than its surface area, so its surface area to volume ratio falls. Oxygen and glucose could not diffuse in, or carbon dioxide out, fast enough for a large cell, so the skink makes more small cells, each with a high ratio (Merit).
9. Discuss why mitosis is needed throughout the skink's life, linking the survival of its cells to the survival of the whole skink.
   Mitosis is needed at every stage, at different rates (Excellence for linking the ideas). While the young skink grows, mitosis is fast, making many new small cells whose high surface area to volume ratio keeps diffusion fast enough to supply them. When the tail is lost, mitosis at the wound makes new cells to close it and rebuild the tail, and in the adult it keeps replacing worn-out skin and gut cells after growth slows. Because the DNA was copied exactly, every new cell has the full instructions to make the proteins its job needs. Cells that were too large or missing DNA would die, and if enough cells failed, tissues and organs would fail and the skink could not survive.
10. Correct this statement: "DNA replication happens during prophase, when the chromosomes appear."
    DNA is copied in the S phase of interphase, before mitosis starts; in prophase the already-copied chromosomes only coil up and become visible.
11. Correct this statement: "Interphase is when the cell rests between divisions."
    Interphase is the busiest part of the cycle: the cell grows, makes organelles and proteins, and copies all its DNA.
12. Correct this statement: "Mitosis makes four cells that are all genetically different."
    That is meiosis, which makes gametes; mitosis makes two cells identical to the parent, for growth and repair.
13. Correct this statement: "Each daughter cell gets half of the parent cell's DNA."
    The DNA was doubled first, so each daughter cell gets a complete copy, with the same number of chromosomes as the parent.