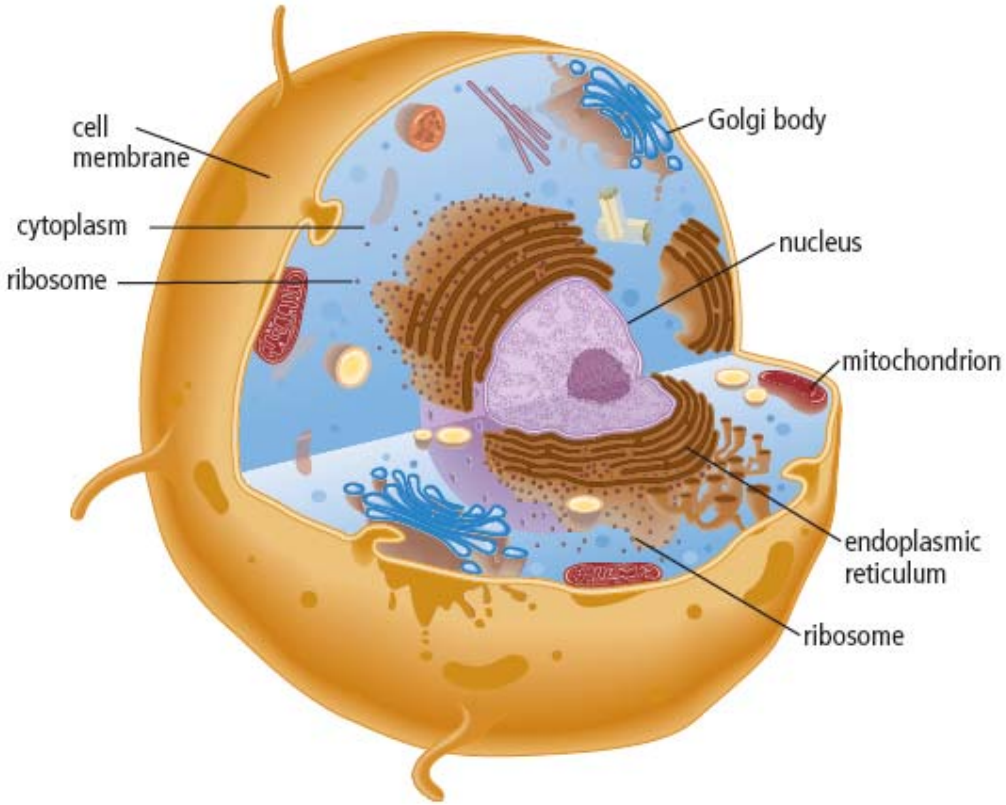

# 4.1 The Function of the Nucleus within the Cell

## Animal Cells

Animal cells are equipped with many structures that allow the cell to perform a variety of functions.

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# Cell Parts and Organelles

## **Animal Cell Parts** (also found in plant cells)

cell membrane - thin covering that controls the flow of materials in and out of the cell.

cytoplasm - jelly-like substance contains the organelles (specialized cell parts)

mitochondria - provide energy for cells

ribosomes - manufacturing plants for proteins

endoplasmic reticulum - membrane-covered channels that act as a transport system for materials made in the cell

vesicles - membrane-covered sacs formed by the endoplasmic reticulum. Vesicles transport new proteins to the Golgi body.

Golgi body - sorts and packages proteins for transport

nucleus - controls all cell activities

nucleolus - membrane-free organelle that makes ribosomes

nuclear membrane - protects the contents of the nucleus

Nuclear pores - openings in the nuclear membrane that allow only certain materials to pass

vacuoles - membrane-bound storage containers

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# The Nucleus and DNA

- The nucleus contains DNA (deoxyribonucleic acid); DNA is the molecule has the master set of instructions for how cells function, what they will produce, and when they will die

**Structure of DNA**

- DNA looks like a twisted ladder - two strands wrap around each other in a spiral shape.
- The sides of the DNA ladder are made of sugar and phosphate.
- The steps of the ladder are made of four nitrogen bases: adenine (A), guanine (G), cytosine (C), and thymine (T).
- The bases join in a specific way
  - A always joins with T
  - G always joins with C

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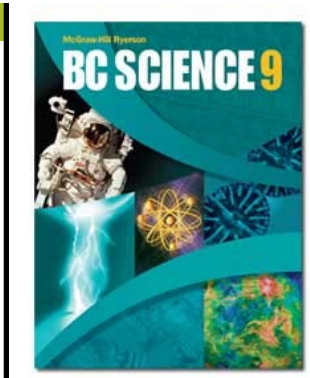
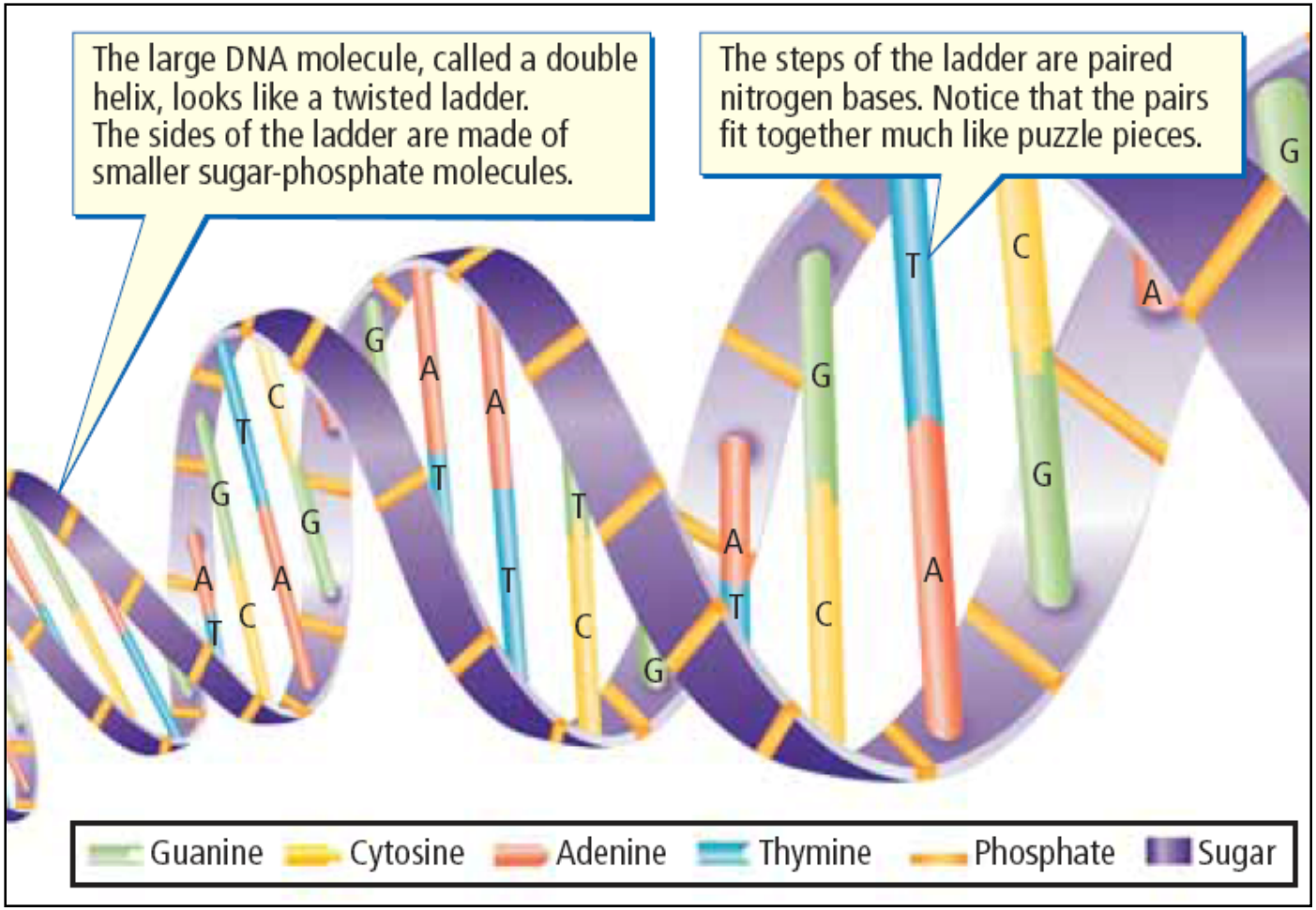



# DNA Structure



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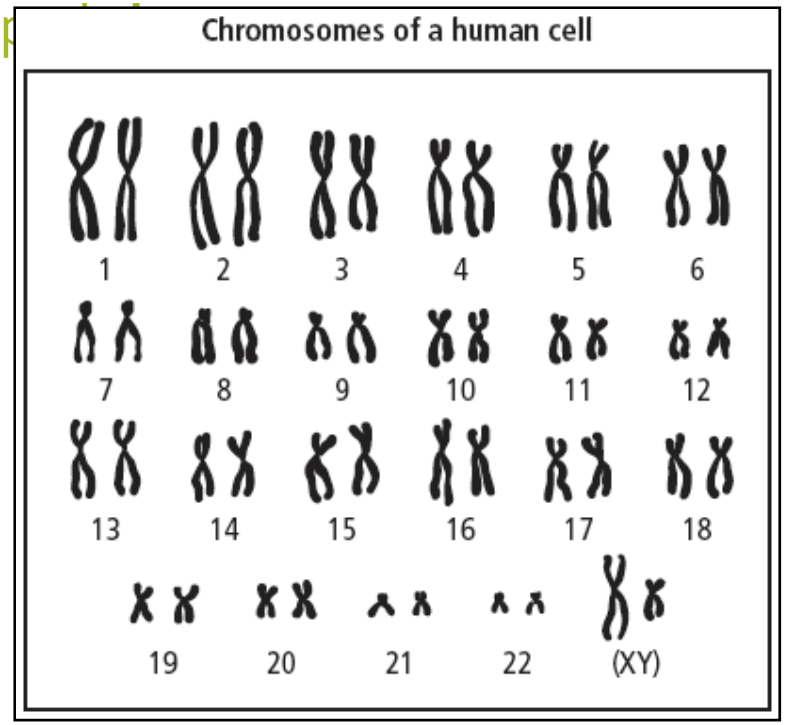
# DNA in the Nucleus

- Most of the time DNA is in the form of **chromatin**
- Chromatin coils tightly into X-shap
- Every organism has a specific number of chromosomes
- Human cells have 46 chromosomes arranged in 23 pairs
- The 23rd pair determines sex; XX for females and XY for males

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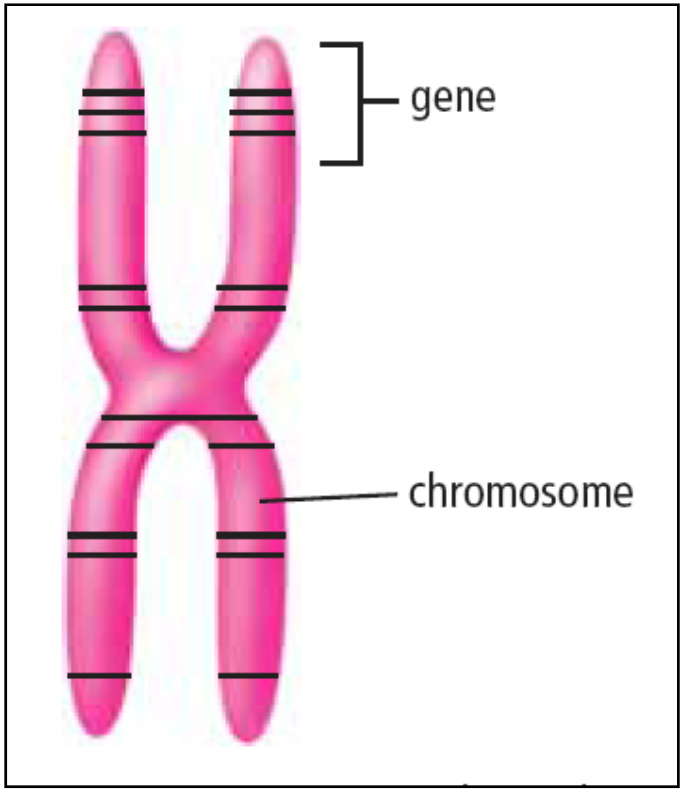
# Genes

- Genes are small segments of DNA located on a chromosome
- Genes store the information needed to produce proteins
- Each chromosome can carry thousands of genes
- All your body cells have the same genes, but only specific genes are "read" in each cell to produce specific proteins
- Specialized proteins called enzymes and hormones carry out important specific functions in the body

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# Production of Proteins

- Protein production in the cell involves several important steps:
  1. The nucleus receives a chemical signal to make a specific protein.
  2. The DNA message for the protein is copied into a small molecule called RNA.
  3. RNA leaves the nucleus through a nuclear pore.
  4. The RNA message is delivered to a ribosome, the ribosome makes the protein.
  5. The manufactured protein enters the endoplasmic reticulum (ER).
  6. A vesicle forms at the end of the ER, and carries the protein to the Golgi body.
  7. The Golgi body repackages the protein for transport out of the cell.
  8. A vesicle forms off the end of the Golgi body to carry the protein to the cell membrane.
  9. The vesicle attaches to the cell membrane, and its protein contents are released out of the cell.

**Take the Section 4.1 Quiz**



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# 4.2 Mutation

- A gene mutation involves a change in the order of bases (A,C,T,G) that make up the gene. There are several types of gene mutation:
  - Deletion (base missing)
  - Addition (extra base added)
  - Substitution (one base substituted for another)
- Gene mutations may produce proteins that are beneficial or harmful to the organism, or may have no effect at all.
- Example: a particular mutated gene produces white coat Kermode bears - they occur as only a small percentage of the population (they are normally black in colour).

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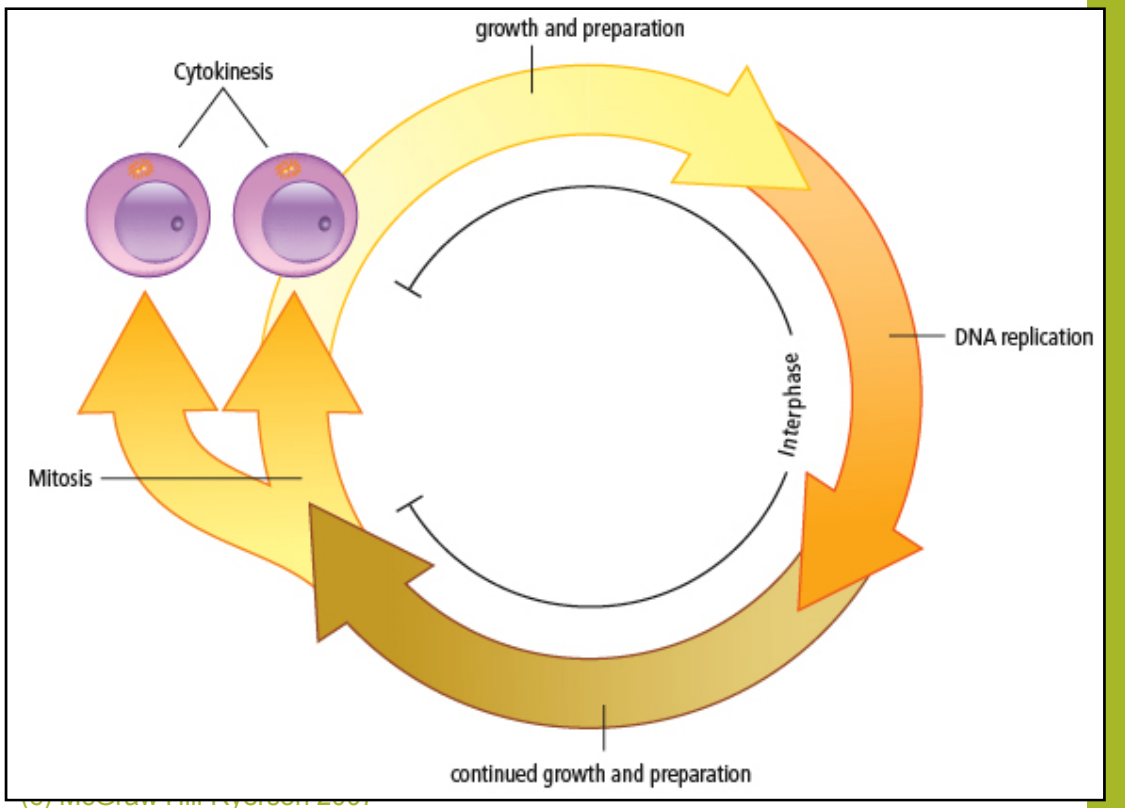
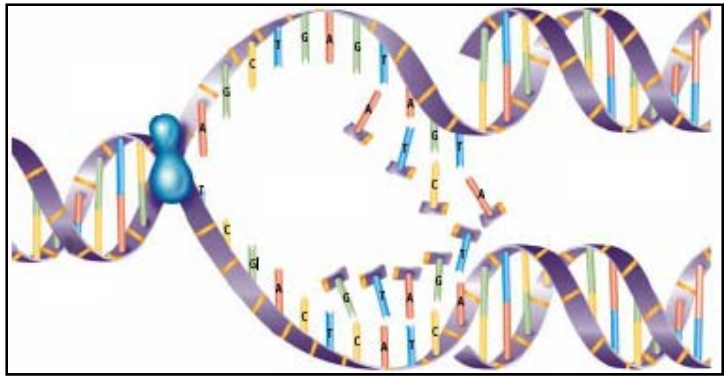
# 5.1 The Cell Cycle and Mitosis

- Due to the loss and death of cells, the body must replace them. A good example of this is human skin cells - each day millions are shed.
- The life of a cell is divided into three stages known as the cell cycle:
- Interphase: cell carries out normal functions.
- Mitosis: nucleus contents duplicated and divide into two equal parts.
- Cytokinesis: separation of two nuclei and cell contents into two daughter cells.




# Parts of the Cell Cycle

- Interphase, the longest cell cycle stage, is when a cell performs normal functions and grows. For example, an intestinal lining cell absorbing nutrients.
- In late interphase, DNA copies itself in the process of replication. Replication involves several steps:
    1. The DNA molecule unwinds with the help of an enzyme.
    2. New bases pair with the bases on the original DNA.
    3. Two new identical DNA molecules are produced.



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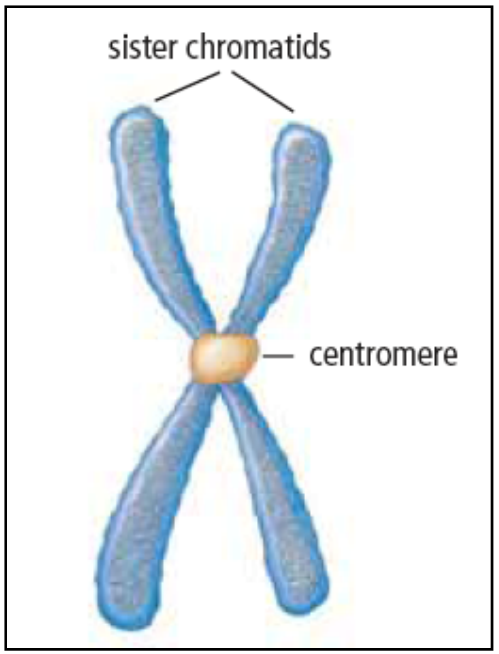
# Mitosis

- At the end of interphase, the cell continues to grow and make proteins in preparation for mitosis and cytokinesis.

## Mitosis

- Mitosis is the shortest stage of the cell cycle where the nuclear contents divide, and two daughter nuclei are formed. It occurs in 4 stages: Prophase, Metaphase, Anaphase and Telophase.
- As the nucleus prepares to divide, replicated DNA in interphase joins to form sister chromatids, joined by a centromere.

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# Stages of Mitosis

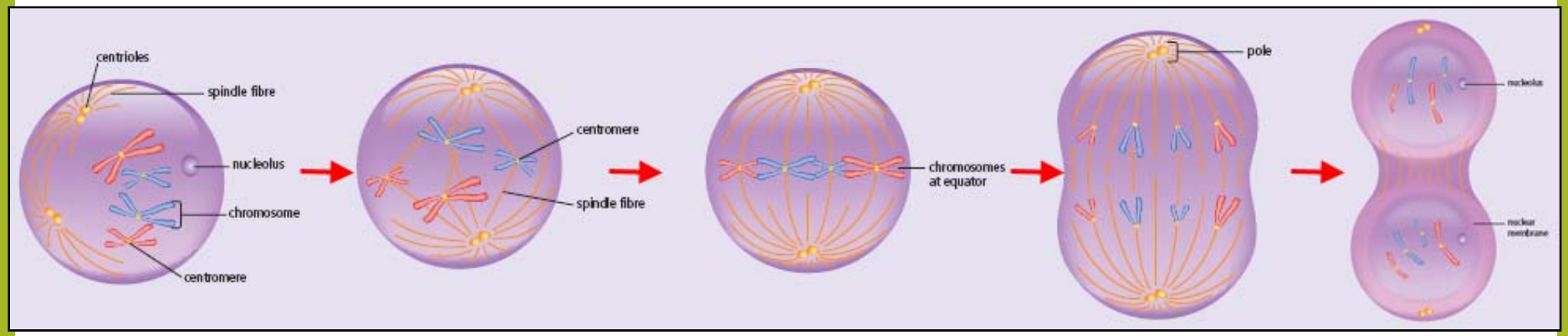
Early Prophase - nucleolus disappears and spindle fibres form

Late Prophase - spindle fibres attach to centromeres of chromosomes

Metaphase - chromosomes align on equator of cell

Anaphase - spindle fibres pull sister chromatids to opposite poles of cell

Telophase - in this final stage, spindle fibres disappear and a nuclear membrane forms around each separated set of chromosomes.




Cytokinesis is the separation of the nuclei into two daughter cells

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# Cell Cycle Problems

Checkpoints in the cell cycle will prevent division if:

- If the cell is short of nutrients
- If the DNA within the nucleus has not been replicated
- If the DNA is damaged

Mutations in genes involving checkpoints can result in an out-of-control cell cycle. The result can be uncontrolled cell division: cancer.

- Cancer cells have large, abnormal nuclei
- Cancer cells are not specialized, so they serve no function
- Cancer cells attract blood vessels and grow into tumours.
- Cells from tumours can break away to other areas of the body

**Take the Section 5.1 Quiz**



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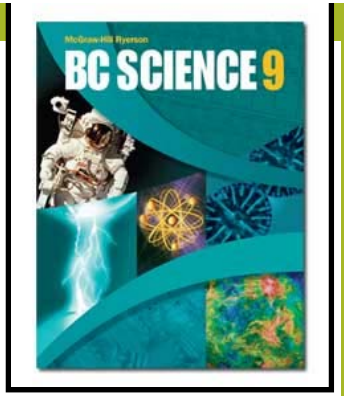


# 5.2 Asexual Reproduction

- A **clone** is an identical genetic copy of its parent
- Many organisms naturally form clones via asexual reproduction
- Cloning is also used in agriculture and research to copy desired organisms, tissues and genes

## Type of Asexual Reproduction

- There are five types of asexual reproduction used by various organisms.

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# Asexual Reproduction

## Advantages and Disadvantages

| Advantages | Disadvantages |
|---|---|
| • Large numbers of offspring are reproduced very quickly from only one parent when conditions are favourable. | • Offspring are genetic clones. A negative mutation can make asexually produced organisms susceptible to disease and can destroy large numbers of offspring. |
| • Large colonies can form that can out-compete other organisms for nutrients and water. | • Some methods of asexual reproduction produce offspring that are close together and compete for food and space. |
| • Large numbers of organisms mean that species may survive when conditions or the number of predators change. | • Unfavourable conditions such as extreme temperatures can wipe out entire colonies. |
| • Energy is not required to find a mate. | |

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# 6.1 Meiosis

- Meiosis is an important aspect of **sexual reproduction**
- Sexual reproduction, through the shuffling of DNA, produces genetic diversity.
- This variation offspring produces individuals that may have advantages over one another.

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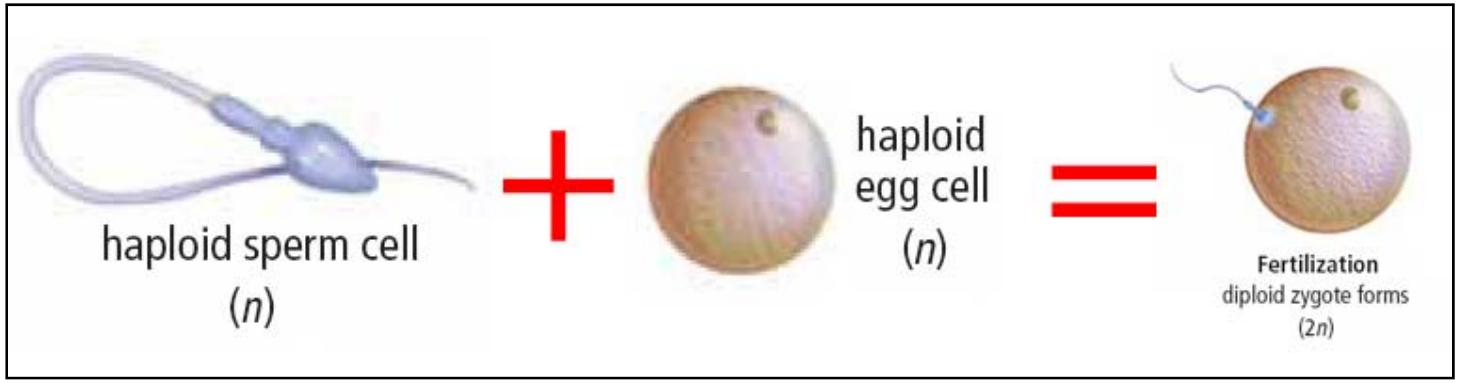
# Role of Gametes

- Normal body cells have a **diploid** chromosome number, meaning chromosomes occur in pairs. In humans, the male and female each contribute 23 chromosomes - when **fertilization** takes place, 23 (egg) + 23 (sperm) = 46 (zygote)
- The zygote goes on to develop into an embryo, and on into a complete individual. When the time comes, the cycle repeats - humans produce **gametes** (either egg or sperm) that have half (**haploid**) the normal number of chromosomes.

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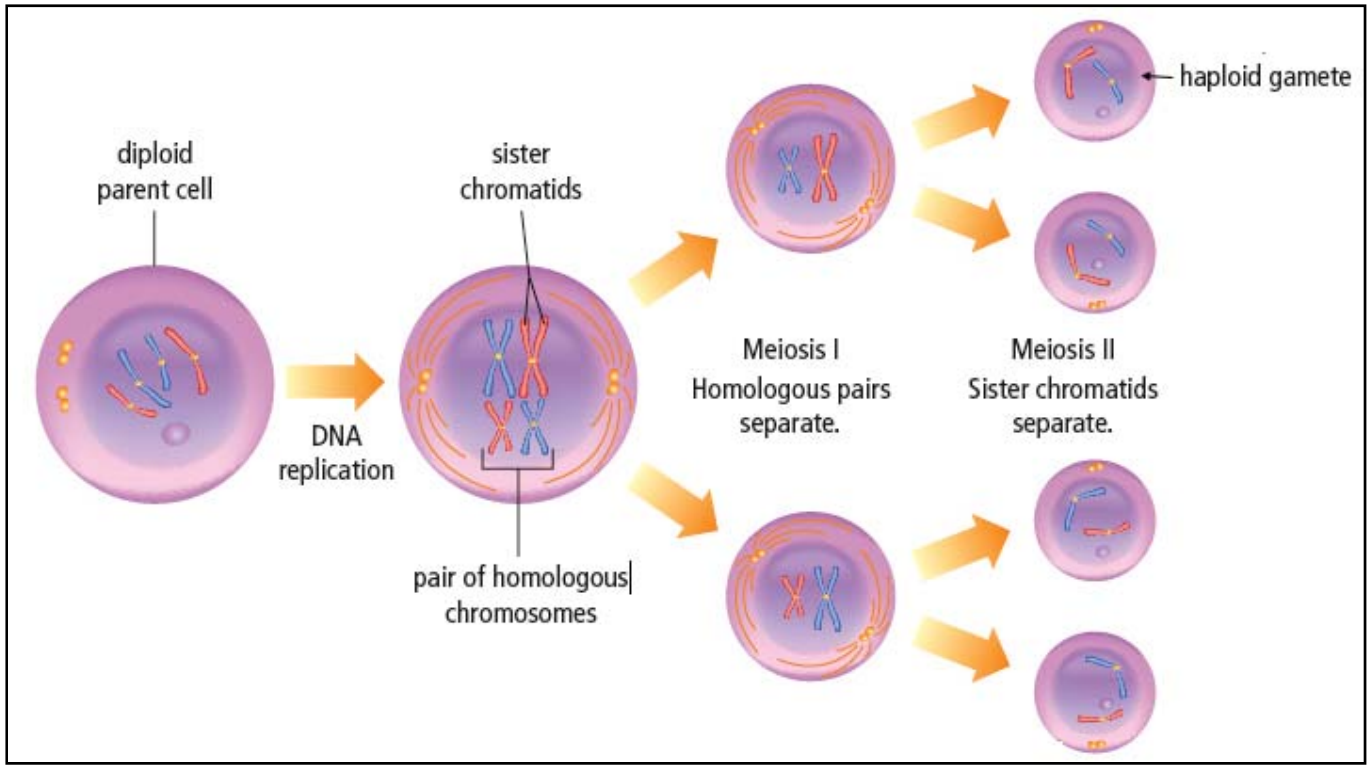
# Meiosis

- Meiosis produces gametes with half the chromosomes compared to body cells:

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# Meiosis Events

**Meiosis I**

- Matching chromosome pairs (homologous chromosomes) move to opposite poles of the cell - two daughter cells result.

**Meiosis II**

- Chromatids of each chromosome are pulled apart - the end result is four haploid cells, each with half the number of chromosomes. These develop into gametes.

**Crossing Over**

- In meiosis I, chromatids of chromosome pairs can cross over each other and exchange DNA segments - this increases genetic possibilities and produces more variation

**Independent Assortment**

- The pairs of chromosomes in meiosis I separate independently, creating many different combinations of chromosomes in the daughter cells

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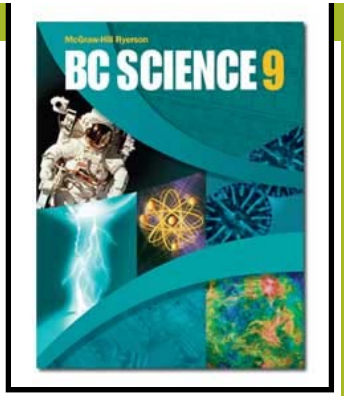


# Meiosis Details

**Gametes do not form equally in males and females**

- In males, all 4 cells resulting from meiosis develop into sperm.
- In females, 1 cell gets most of the cytoplasm and becomes the egg.

**Chromosome mutations sometimes occur spontaneously**

- Chromosome changes during meiosis can cause changes in the genetic information. Parts of chromosomes can be inverted, deleted, duplicated or moved to another spot.

**Cromosome mutations can occur because of mutagens**

- Chromosome changes, sometimes leading to genetic disease or death, can be cause by mutagens such as radiation or chemicals.

**Failed separation of chromosomes in meiosis has serious consequences**

- Failed separation means that a gamete may end up with no chromosome or too many of a chromosome. Zygotes that result from these gametes rarely survive, and if they do, they will have serious genetic disorders.

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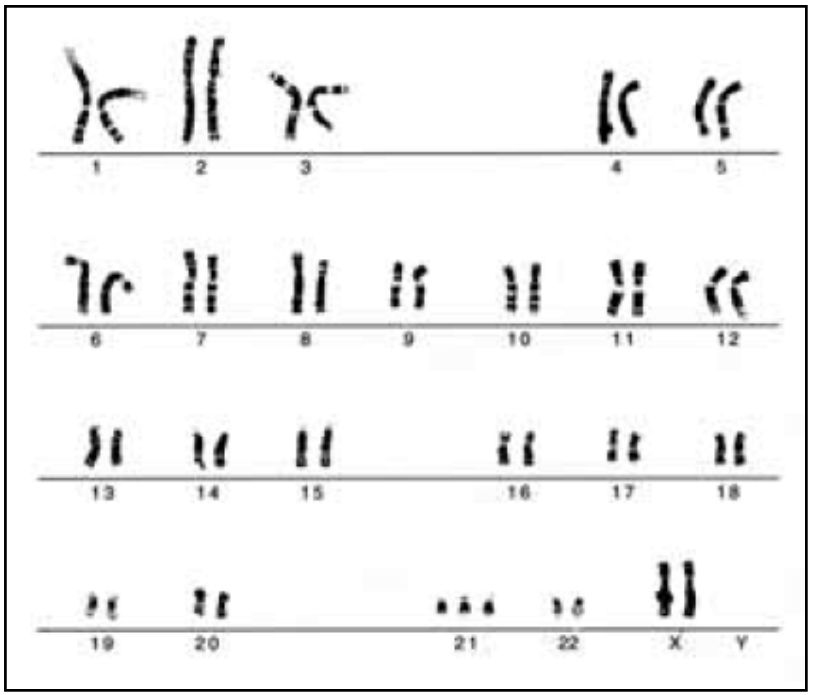
# Genetic Disorders

## The chromosomes of an individual can be studied

- By using a karyotype, geneticists can view an individual's chromosomes.
- Certain genetic disorders or syndromes occur when there are specific chromosomes extra or missing
- Down syndrome usually occurs when there is an extra 21st chromsome




Down syndrome karyotype

**Take the Section 6.1 Quiz**



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# 6.2 Sexual Reproduction

Sexual reproduction brings non-identical gametes together to form a new organism - it occurs in 3 stages:

- Mating - the process by which gametes are bought together at same place and same time
- Fertilization - process by which egg and sperm join to form a new organism
- Development - the process by which an organism develops as an embryo

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# External Fertilization
## * don't need to know in too much detail *


- In external fertilization, sperm and egg join outside parents

**Advantages**

- Very little energy required to mate
- Large numbers of offspring produced
- Offspring can be spread widely in the environment - less competition between each other and parents

**Disadvantages**

- Many gametes will not survive
- Many eggs will not be fertilized
- Offspring are often not protected by parents, so many of them die

Frog Eggs - GNU Free Doc Photo

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# Internal Fertilization

## * don't need to know in too much detail *


- In internal fertilization, sperm and egg join inside parents, embryo is nourished inside mother

**Advantages**

- Embryo protected from predators
- Offspring more likely to survive, as many species will protect their them while they mature

**Disadvantages**

- Much more energy required to find mate
- Fewer zygotes produced, resulting in less offspring
- More energy required to raise and care for offspring

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# Sexual Reproduction Advantages and Disadvantages


| Advantages | Disadvantages |
|---|---|
| • Very little energy required to find a mate (external fertilization). | • More energy generally required to find a mate (internal fertilization). |
| • Greater numbers of offspring can repopulate an area after a disaster (external fertilization). | • Fewer offspring produced, so if the number of predators increases a population will decline (internal fertilization). |
| • More protection is given to the embryo and more parental care is given to offspring (internal reproduction). | • Gametes, embryos, and offspring are unprotected and are often preyed upon (external fertilization). |
| • Offspring are genetically different from their parents, so they may survive new diseases or other threats that appear in a population. | |

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