Cell Division (mitosis and meiosis) and Stem Cell Notes

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Cells need to divide to make more of themselves. They do this for a number of different reasons. There are two ways that cells can divide, **mitosis** and **meiosis**. Both are types of cell division but both have very different roles.
Let's look at mitosis in detail first 😊

Mitosis: a process of cell division that produces **two genetically identical, diploid daughter cells in one division**. Mitosis is part of the cell cycle. Diploid means that the cell has the full set of chromosomes that it should have.

The Cell Cycle: the growth and division of cells.

Role of Mitosis: the growth and repair of cells and as a method of asexual reproduction.

Stages of Mitosis

There are four stages of mitosis: **Prophase, Metaphase, Anaphase and Telophase**. I use P-MAT to remember the order. Questions on the order can be asked in exams so make sure you learn it. 😊

Really important note: Interphase (which is actually before Prophase) is not a stage of Mitosis! BUT! The cell uses interphase to get ready for mitosis. The DNA and centrioles are both **replicated** in interphase.

Exam note: for AQA you do not need to know about the stages of mitosis. However, if you don't know the stages you can't know mitosis in any detail so I have included them below to increase your knowledge 😊

Before we look at what happens in each stage of mitosis here are some definitions of key terms that will be used a lot in the explanation of the stages.

Nuclear membrane: the membrane that surrounds the nucleus. It keeps the DNA inside and controls what enters and leaves the nucleus.

Chromatin: a mix of DNA and proteins found in the nucleus. It holds the instructions for how the cell works and becomes chromosomes when the cell is dividing by mitosis.

Chromosome: a thread like structure made of DNA, found in the nucleus of the cell. Each chromosome carries genes that control how the cell operates.

Centrioles: are small structures found near the nucleus in animal cells. During mitosis these act like anchors at either pole of the cell and help organise the movement of chromosomes during mitosis.

Spindle fibres: are tiny rope like structures made of protein that form during cell division. They are made by the centrioles and attach to chromosomes to help pull them apart to opposite sides of the cell.

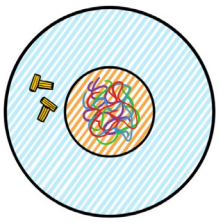
Centromere: the region of a chromosome where the two chromosomes are joined together. It is also the point where spindle fibres attach during cell division to help pull each of the chromosomes apart.

Cytokinesis: when the two daughter cells fully separate and move apart.

Interphase – not a stage of mitosis

What is Interphase? It is part of the cell cycle where the cell is doing its normal processes such as producing proteins. The DNA is in a jumble called **chromatin.**

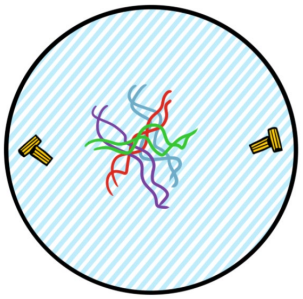
What happens in Interphase to get ready for mitosis? The DNA and centrioles are both replicated in interphase. If this was a human cell, after DNA replication it would still have 46 chromosomes, but each chromosome would now be made of two parts.



The figure shows a cell in interphase

Prophase

What is prophase? It's the first phase of mitosis. It's the phase where the chromosomes become visible. The figure shows a cell in prophase.

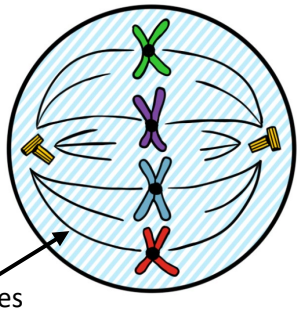


What happens in prophase?

1. The nuclear membrane breaks down.
2. The chromatin condenses into chromosomes.
3. The centrioles begin to move to opposite poles of the cell.

Metaphase

What is metaphase? It's the second stage of mitosis.
The figure shows a cell in metaphase

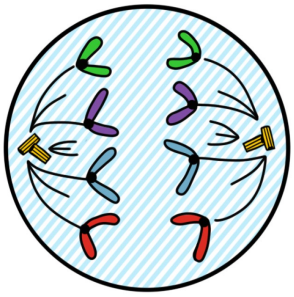


What happens in metaphase?

1. The chromosomes line up along the equator of the cell.
2. The spindle fibres attach to the chromosomes at a point in the middle of the chromosomes called the centromere.

Anaphase

What is anaphase? It's the third phase of mitosis.



What happens in anaphase?

1. The spindle fibres shorten, this pulls one copy of each chromosome to either pole of the cell.

The figure shows a cell in anaphase

Telophase

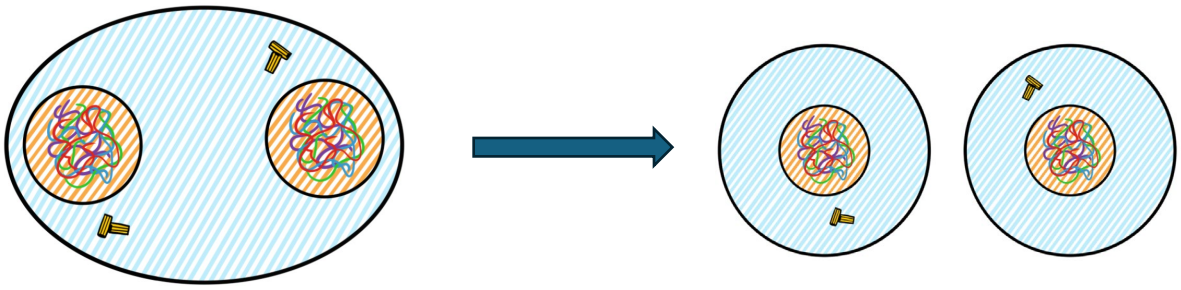
What is telophase? It's the final stage of mitosis. This is where the cell splits into two daughter cells.

What happens in telophase?

1. The nuclear membrane reforms.
2. The spindle fibres break down.
3. The cells split into two in a process called cleavage.
4. The two cells then move apart by cytokinesis.

Each daughter cell is genetically identical to the other. Both are diploid.

The figure below shows a cell in telophase



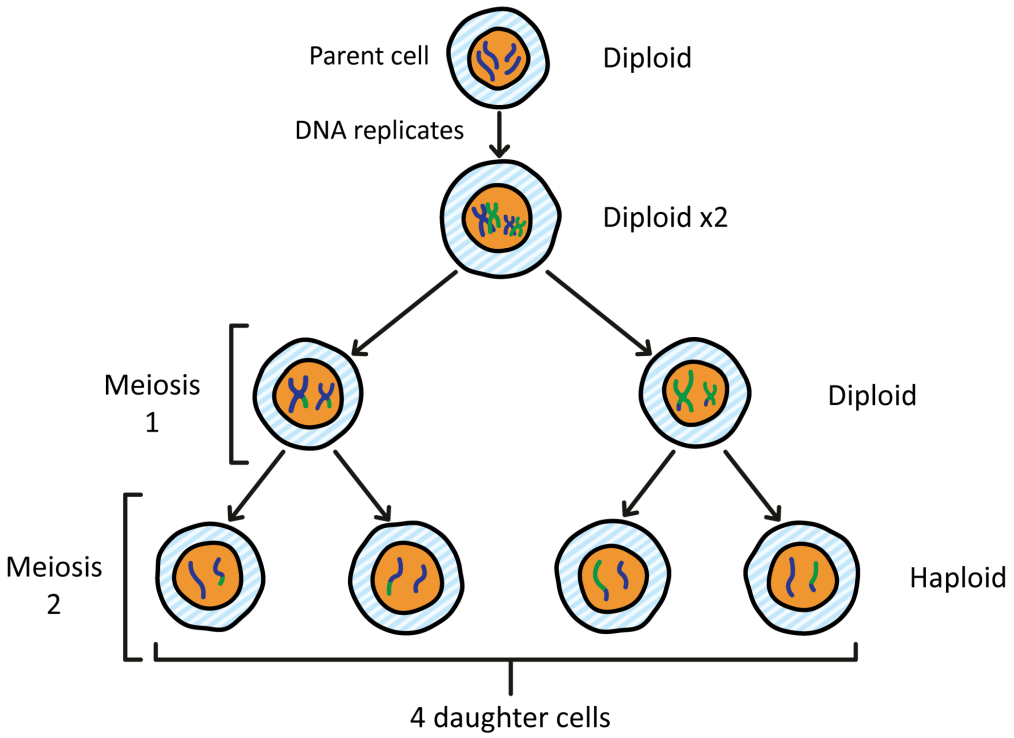
Meiosis

Meiosis: a process of cell division that produces **<u>four genetically different haploid daughter cells in two divisions</u>**. **<u>Meiosis is used to produce gametes</u>** (sex cells). It occurs in the ovaries of females and the testes of males.

Meiosis happens in **two divisions**, meaning the original cell divides twice to produce four daughter cells. The stages of meiosis have the same names as mitosis, **prophase**, **metaphase**, **anaphase** and **telophase**. But because meiosis has two divisions both with the same stages we give the stages numbers to tell them apart.

The first meiosis division goes through **prophase 1**, **metaphase 1**, **anaphase 1** and **telophase 1** and the second meiosis division goes through **prophase 2**, **metaphase 2**, **anaphase 2** and **telophase 2**. I hope that helps 😊

The figure below shows the overall process of meiosis to produce four haploid daughter cells.



For GCSE we don't need to know anything else about meiosis. There's a bit more for A level but nothing too tough 😊

For the AQA GCSE biology specification we don't need to know anything about the processes that occur in meiosis prophase 1 that lead to genetic variation in the daughter cells.

Comparison Question

We could see a four, five or six mark question in exams asking us to compare mitosis and meiosis. A great question! If that does come up simply state what each type of cell division is and what it does. Use the ideal answer below 😊

Mitosis is a process of cell division that produces **<u>two genetically identical, diploid daughter cells in one division</u>**. Mitosis produces somatic (body) cells.

Meiosis is a process of cell division that produces **<u>four genetically different haploid daughter cells in two divisions</u>**. **<u>Meiosis is used to produce gametes</u>** (sex cells).

This will fully cover a comparison question if it comes up. Always read the question carefully 😊

Growth

During the course of an animal's life its cells grow, they reproduce and they differentiate.

Growth: an increase in size as a result of an increase in the number and size of cells. This is due to cell division.

Animals also have many different types of cells. All cells in the body come from just a single cell which is the fertilised egg, the **zygote**. In order to have many different types of cells the cells must differentiate.

Cell differentiation: a less specialised cell becomes more specialised for a particular function.

Stem Cells

Stem cells: unspecialised cells that can form cells which can differentiate into any specialised cells.

There are two different types of animal stem cells:

1. **Embryonic stem cells** – these can differentiate to become any type of cell.

2. **Adult stem cells** – these can differentiate into many, but not all, types of cells. For example, an adult stem cell in the bone marrow can differentiate into various types of blood cells (red blood cells and white blood cells), but it can't become a brain cell.

There is one type of plant stem cell:

1. **Meristems** – cells of the meristem can differentiate to produce all types of plant cells at any time during the life of the plant. The main meristems are close to the tip of the shoot, and the tip of the root.

Potential Benefits and Risks of Stem Cells in Medicine

There is great potential for the use of stem cells in medicine, but we are very much in the early stages of learning how to use them and how they work best. In addition to this there are big ethical issues with using embryonic stem cells, mainly, as using these destroys a potentially viable embryo. There are fewer ethical issues around the use of adult stem cells.

The **benefits** of using stem cells in medicine are:

1. **Treating patients with conditions that we don't currently have a treatment or cure,** for example Type 1 diabetes.
2. **The possibility of growing an organ from someone's own stem cells**. This avoids the risk of "organ rejection" in organ transplants.

Organ rejection: when your own body's immune system attacks the organ that you have received in a transplant. Your immune system is just doing its job, attacking cells it considers to be foreign or non self.

The **risks** of using stem cells in medicine are:

1. **Cancer** – If stem cells keep dividing this can lead to a cancer.
2. **Rejection** – Each individual would need to have a treatment made just for them. Your own stem cells will only work for you and no one else. If the stem cells of another person are used in a treatment for you this could lead to rejection, when the body's immune system attacks and destroys them.