AP BIOLOGY | UNIT 4 | TOPICS 4.5 AND 4.6

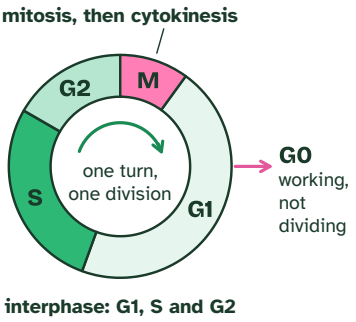
REVISION ON TWO PAGES

The cell cycle and *mitosis*

What to know, what to draw and what to say. Nothing else.

THE ONE IDEA

A cell copies its DNA, then mitosis hands one complete copy to each of two identical daughter cells. Checkpoints decide whether it goes on.



Draw it like this. A ring read clockwise, with G1 the longest stage and M the shortest.

4.5.A START HERE

Around the *cell cycle*

- The **cell cycle** is the sequence a dividing cell goes through again and again. **Interphase** is G1, S and G2. It is about nine tenths of the cycle, and it is not a rest.
- Then **mitosis** divides the nucleus and **cytokinesis** divides the cytoplasm. Each daughter cell starts again in G1.
- A cell can leave G1 for **G0**: alive and working, but not dividing. Most nerve cells and mature muscle cells stay there for life; liver cells reenter the cycle after damage. A cell can also be held at a stage until conditions are right.

THE ORDER OF THE CYCLE

Giraffes Sing, Gorillas Make Chili

G G1 grows: proteins and organelles	**S** S the DNA is copied	**G** G2 grows more, ready to divide	**M** Mitosis the nucleus divides	**C** Cytokinesis the cytoplasm divides

4.5.B WHY CELLS DIVIDE

One cell, *two copies*

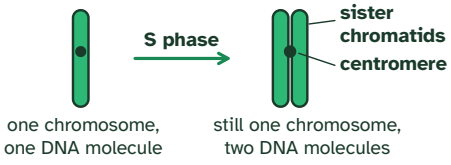
- New cells come only from existing cells dividing: a parent cell ends as two daughter cells.
- In eukaryotes, **mitosis** hands a complete copy of the genome, every chromosome, to each daughter cell. So the daughters are **genetically identical** to each other and to the parent.
- It alternates with interphase: copy the DNA, divide, copy, divide.

JOB 1	JOB 2	JOB 3
Growth One cell becomes tens of trillions.	**Tissue repair** Cells around a wound replace those lost.	**Asexual reproduction** A yeast buds; a strawberry sends out runners.

4.5.B CHROMOSOMES AND CHROMATIDS

Copied, then *coiled*

- A **chromosome** is one long DNA molecule wound around proteins called histones. DNA with its histones is **chromatin**.
- Before a cell divides it copies every chromosome. The two copies stay joined as **sister chromatids**, held together at the **centromere**.
- As division begins the chromatin **condenses**: short, thick chromosomes can be moved without tangling.



4.5.B THE PHASES

Mitosis: four phases, *one smooth process*



	PROPHASE	METAPHASE	ANAPHASE	TELOPHASE
What happens	Chromosomes **condense**, each as two sister chromatids. The nuclear envelope breaks down and the spindle starts to grow.	Microtubules from both poles attach at each centromere. Chromosomes line up in **one row across the middle**.	The **centromeres split**. Sister chromatids are pulled to opposite poles: one copy of each chromosome to each end.	A nuclear envelope forms around each group: **two nuclei** in one cell. Chromosomes uncoil and the spindle breaks down.
Spot it	Thick threads; the envelope going.	A line across the middle.	Two groups moving apart.	Two nuclei, still one cell.

Each chromosome lines up on its own: matching chromosomes pair only in meiosis.

In order: *Penguins March Across Town*

Counting, cytokinesis and the *controls* on the cycle

4.5.B COUNT CENTROMERES

Keep *count* through the cycle

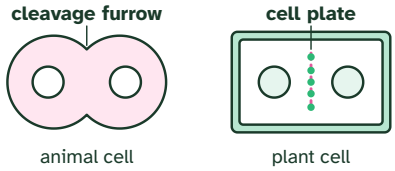
A HUMAN BODY CELL	CHROMOSOMES	CHROMATIDS	DNA MOLECULES
G1	46	Not copied yet.	46
G2 to metaphase	46	92	92
Anaphase	92	Separated.	92
Each daughter cell	46	Not copied yet.	46

Count **centromeres** to count chromosomes. From anaphase, each chromatid is a chromosome of its own.

4.5.A STARTS IN TELOPHASE

Cytokinesis splits the cytoplasm

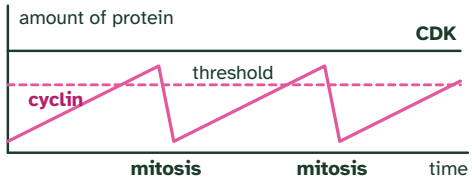
- **Animal cells:** a ring of actin and myosin tightens and pulls the membrane into a **cleavage furrow**.
- **Plant cells:** the wall cannot bend, so Golgi vesicles fuse into a **cell plate** that becomes a new wall.



4.6.A

Checkpoints: *stop*, or go

- At **checkpoints** a cell checks its own state and goes on only if all is well.
- **Cyclin-dependent kinases (CDKs)** are always present, but inactive alone. **Cyclins** come and go: once enough of one has built up, it binds and activates its CDK.
- The active CDK **phosphorylates** proteins that start the next stage. Then the cyclin is broken down and the CDK falls quiet.



GROWN?
G1 checkpoint
Big enough, with nutrients, signals and undamaged DNA? If not, the cell waits or enters G0.

GENOME COPIED?
G2 checkpoint
Has all the DNA been copied, without damage?

MOORED?
M checkpoint
No anaphase until the spindle holds every chromosome from both poles.

4.6.B

When cells *ignore the rules*

- **Cancer** is cells that divide when they should not and pass checkpoints they should fail. It usually takes several mutations, in both kinds of gene.
- A **benign** tumor stays where it formed; a **malignant** one invades nearby tissue and can spread in the blood.
- **Apoptosis**: a cell with damage it cannot repair takes itself apart in an orderly way. Many cancer cells cannot trigger it.

Proto-oncogenes the accelerator
Proteins that push a cell to divide when signaled. A mutation can make an **oncogene**, stuck on.

Tumor suppressor genes the brakes
Proteins that hold a damaged cell at a checkpoint. A mutation that breaks one removes a brake.

WATCH OUT

Five mistakes that *cost points*

- ✕ **Copying DNA does not double the chromosome number:** a copied chromosome still has one centromere.
- ✕ **Interphase is not a rest:** the cell grows and copies its DNA.
- ✕ **Cytokinesis is not a phase of mitosis.** Mitosis divides the nucleus; cytokinesis divides the rest of the cell.
- ✕ **Cyclins come and go, not CDKs.** The CDK is always there.
- ✕ **Cancer is not one mutation.** One mutated gene seldom makes a cell cancerous.

COVER THE SHEET

Can you *answer these?*

1. Describe what a cell does in G1, S and G2.
2. Explain why mitosis gives genetically identical cells.
3. Calculate the chromatids made from 8 chromosomes.
4. Identify the phase in which the centromeres split.
5. Predict where a cell with no spindle stops in mitosis.
6. Explain why a plant cell cannot form a cleavage furrow.
7. Explain how a CDK is switched on and off.
8. Predict the effect of losing a tumor suppressor gene.

IN THE EXAM

Counting? Count centromeres; chromatids exist only from S phase to anaphase. **A broken control?** Name the checkpoint that fails, then what the cell does next.

GO FURTHER

Animated figures, a dry lab and a marked Check are in the full guide online.