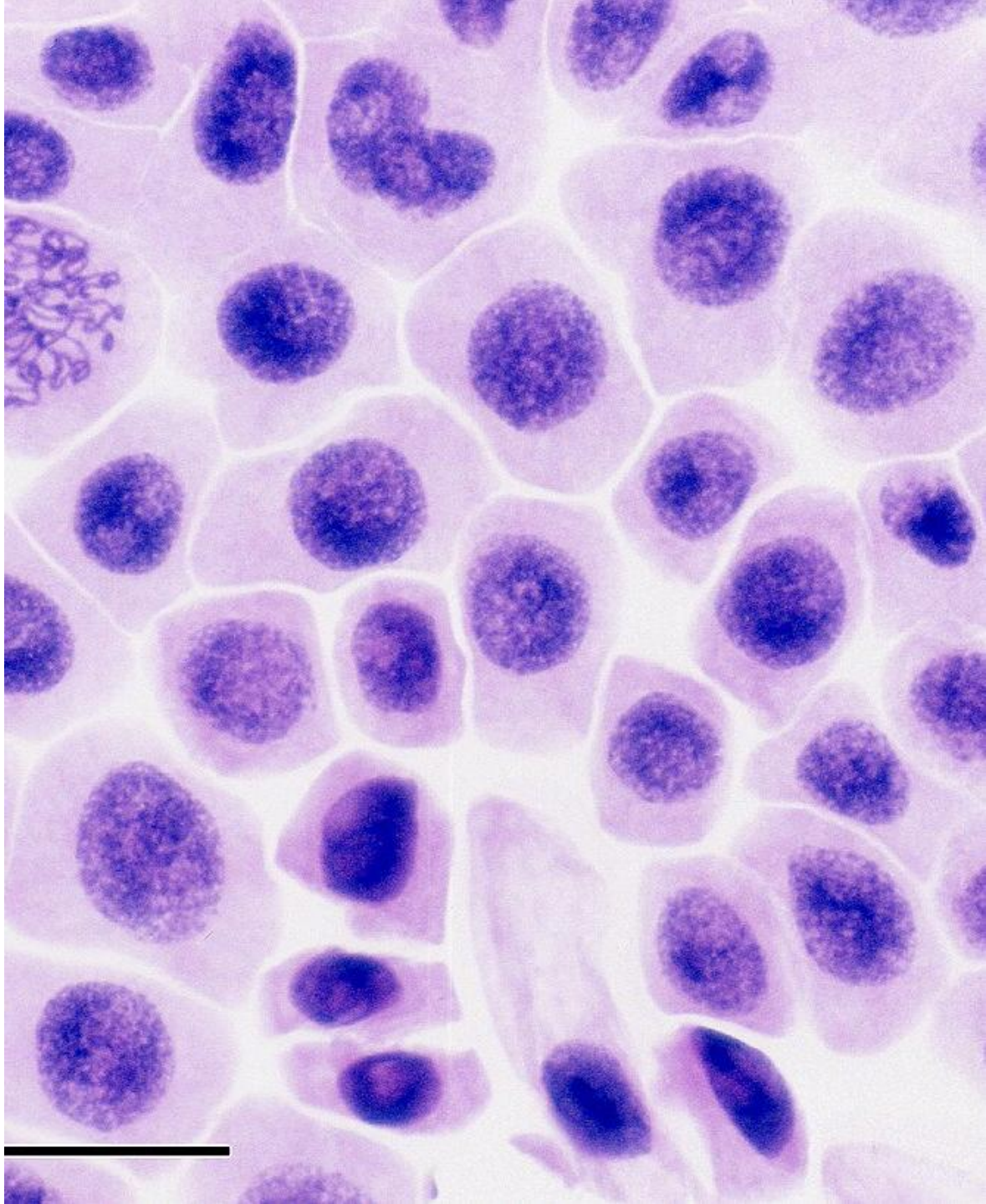
DP Biology – D2.1 (HL extension)

The cell cycle and cancer

- How do cells make many identical copies of themselves?
- How do eukaryotes make genetically varied cells that can become gametes?

HL statements D2.1.12–17. Textbook pp. 662–669.
Image: dividing cells in an onion root tip. CC BY-SA 3.0.

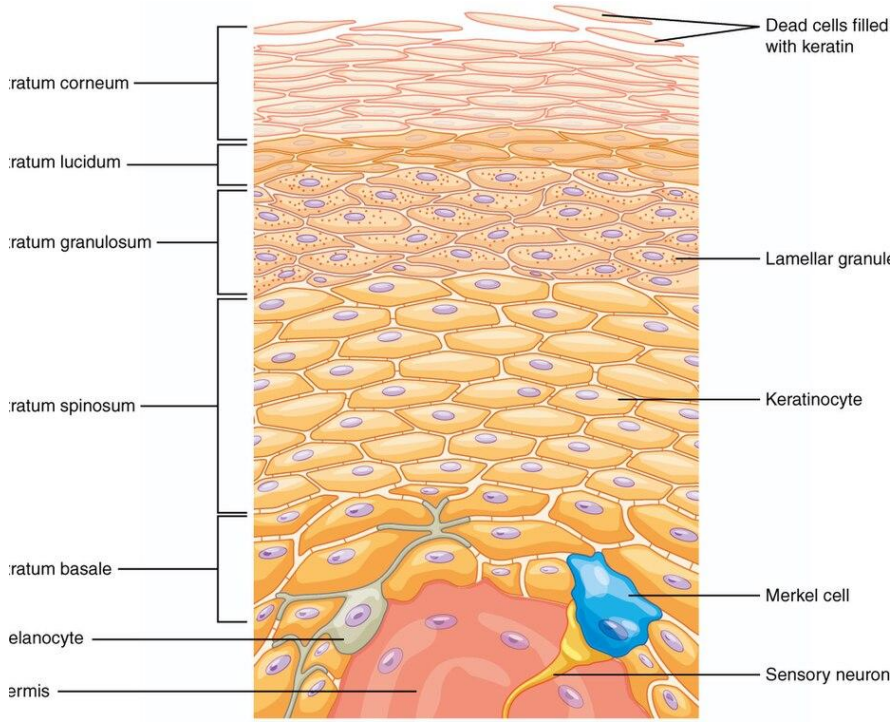


Objectives for each class

Class	Statements	By the end of the class, you can...
1	D2.1.12–14	Explain why cells proliferate, and describe the cell cycle and growth in interphase
2	D2.1.15	Explain how rising and falling cyclins control the cell cycle
3	D2.1.16–17	Explain how mutations in oncogenes and tumour suppressor genes cause cancer, and compare benign and malignant tumours

Why cells proliferate

Purpose	Example
Growth	Plant meristems at shoot and root tips; early animal embryos
Replacement	Skin: cells made in the basal layer replace those lost at the surface
Repair	Healing a wound in the skin



Layers of the epidermis. OpenStax, CC BY 3.0.

Key idea

Cell proliferation is a rapid increase in cell number by repeated cell cycles. It must be controlled: too little and tissues are not repaired; too much and tumours form.

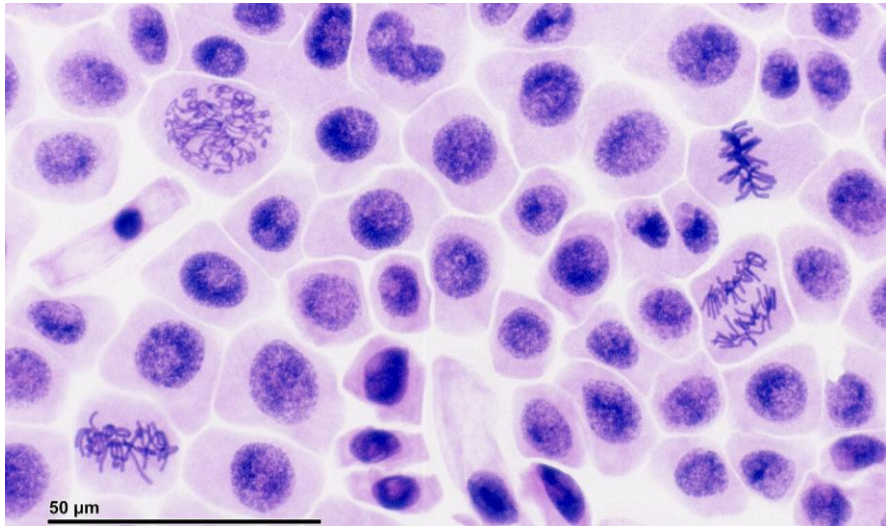
The cell cycle

G1: cell grows; proteins and organelles made → **S: DNA replicated** → G2: more growth; preparation for division → Mitosis: nucleus divides → Cytokinesis: cytoplasm divides

G1, S and G2 together make interphase, the longest part of the cycle.

G0

Some cells leave the cycle after mitosis and stop dividing, either for a while (liver cells) or for good (most nerve cells). They stay in G0 but remain fully active.



Onion root tip: most cells are in interphase. CC BY-SA 3.0.

Interphase is a busy time

D2.1.14

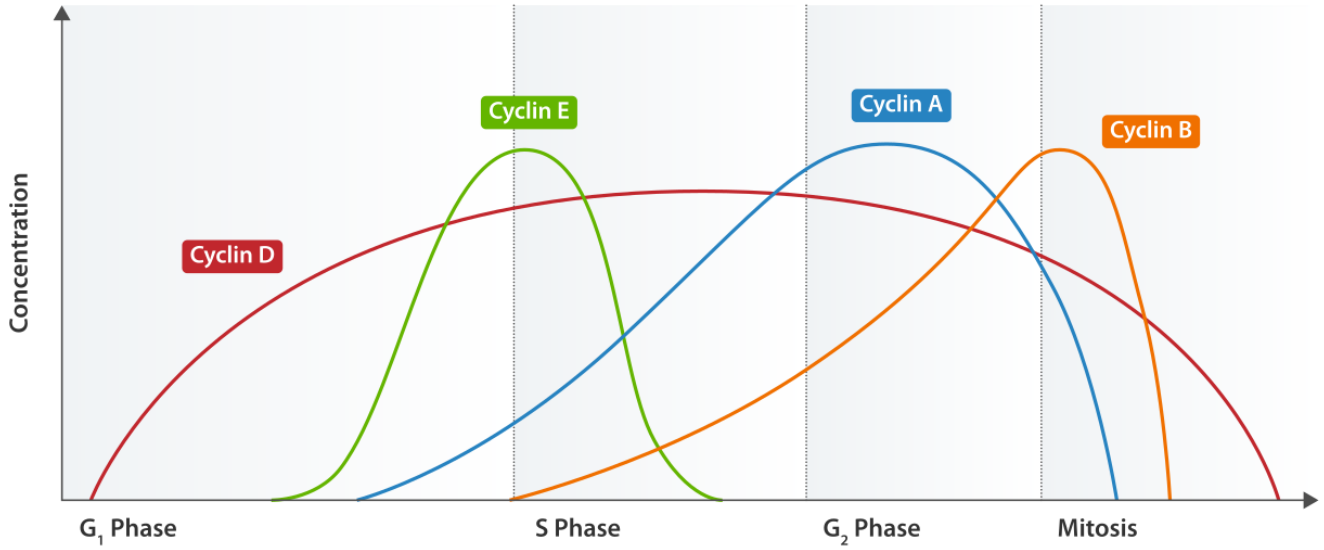
- Interphase is metabolically active, not a resting stage
- The cell makes proteins, including enzymes, and new membranes
- DNA is replicated in the S phase
- Mitochondria and chloroplasts grow and divide, so each daughter cell gets enough
- Ribosomes are made in the nucleolus

Activity

Count the cells in each stage in a photo of an onion root tip. Calculate the mitotic index: cells in mitosis divided by total cells. Why is it high in a root tip?

Cyclins control the cycle

D2.1.15



Concentrations of four cyclins through the cell cycle. Public domain.

- Cyclin concentrations rise and fall during each cycle
- Each cyclin binds and activates a cyclin-dependent kinase (CDK)
- A threshold level of a specific cyclin is needed to pass each checkpoint
- After the checkpoint, the cyclin is broken down

Checkpoints

At G1 the cell checks it is large enough and conditions are right; at G2 that DNA is replicated correctly; in mitosis that chromosomes are attached to the spindle. If not, the cycle pauses. Cyclins were found in sea urchin eggs; the discovery won a Nobel Prize in 2001.

When cell cycle genes mutate

D2.1.16

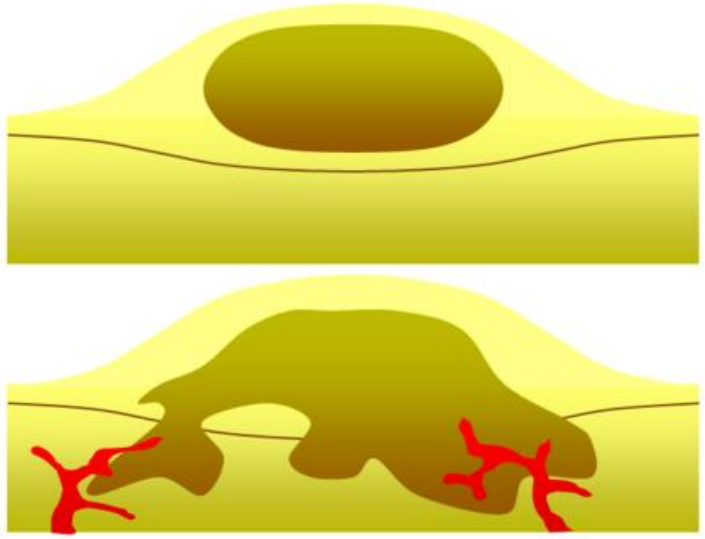
	Proto-oncogene	Tumour suppressor gene
Normal role	Stimulates the cell cycle when signalled	Stops the cycle, for example if DNA is damaged
Mutation	Becomes an oncogene: permanently on	Stops working
Copies affected	One mutated copy is enough	Usually both copies must be mutated
Example	Ras	p53

Result

Cells divide without control. Usually several mutations are needed before a cell becomes cancerous.

Benign and malignant tumours

D2.1.17



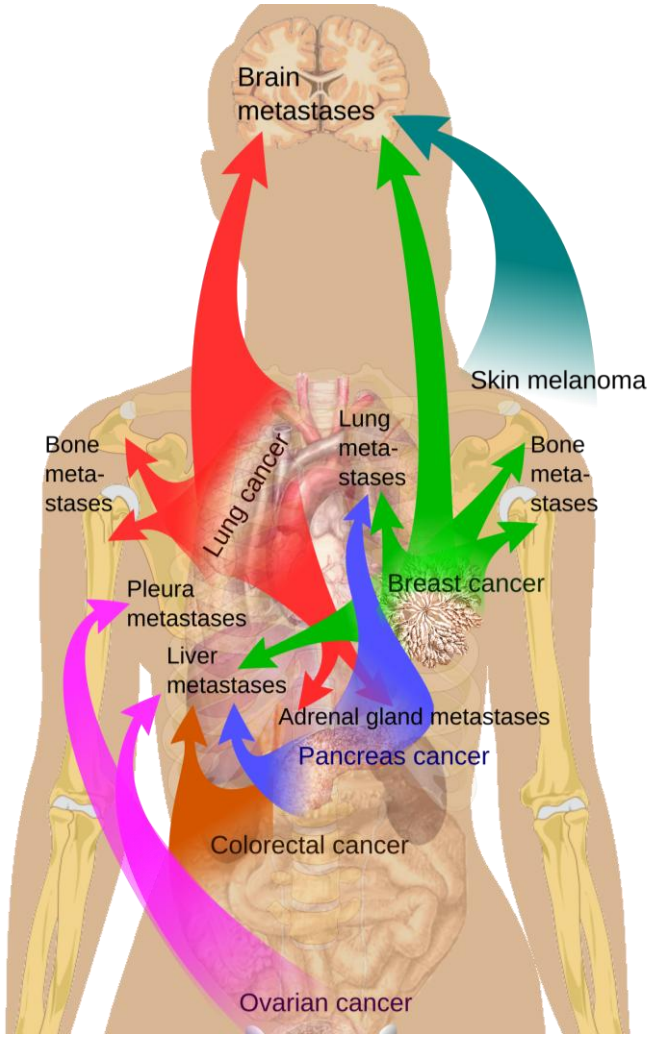
Benign (top) and malignant (bottom). CC BY-SA 3.0.

	Benign	Malignant
Growth	Slow	Fast
Edges	Contained, often in a capsule	Invades neighbouring tissues
Spread	Stays in one place	Metastasis: cells spread to form secondary tumours
Cancer?	No	Yes

Primary and secondary

A primary tumour forms where the first cells became abnormal. Cells that break away can travel in blood or lymph and start secondary tumours elsewhere. Benign tumours can still be dangerous if they press on organs such as the brain.

Where cancers spread



Common sites of metastasis. M. Haggstrom, CC0.

- Malignant cells lose their adhesion to neighbours
- They invade blood or lymph vessels and travel round the body
- Some settle and divide in new organs, forming secondary tumours
- Common sites are the lungs, liver, bone and brain, which have rich blood supplies

Think about it

Why is a cancer much harder to treat once it has metastasized?

Check that you can explain

1. Three reasons for cell proliferation, with examples
2. The phases of the cell cycle
3. What happens during interphase
4. How cyclins and checkpoints control the cycle
5. How proto-oncogenes and tumour suppressor genes can lead to cancer
6. Benign, malignant, primary and secondary tumours

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. List the three stages of interphase in order.
2. Explain how cyclins control progress through the cell cycle.
3. Distinguish between a benign and a malignant tumour.

Image credits

Mitosis (261 13) Pressed; root meristem of onion (cells in prophase, metaphase, anaphase, telophase).jpg – Doc. RNDr. Josef Reischig, CSc. – CC BY-SA 3.0

502 Layers of epidermis.jpg – OpenStax College : J. Gordon Betts, Peter Desaix, Eddie John – CC BY 3.0

Cyclin Expression.svg – Cyclinexpression_waehrend_Zellzyklus.png: Original uploader – Public domain

BENIGN AND MALIGNANT TUMOUR.png – Simon Caulton – CC BY-SA 3.0

Metastasis sites for common cancers.svg – Mikael Häggström – CC0

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