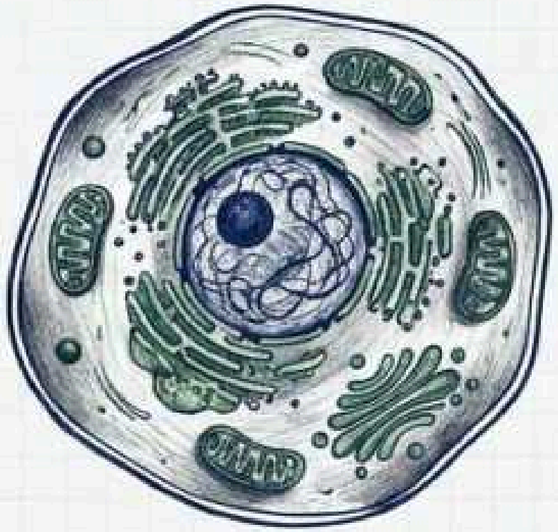
¶ 6.1

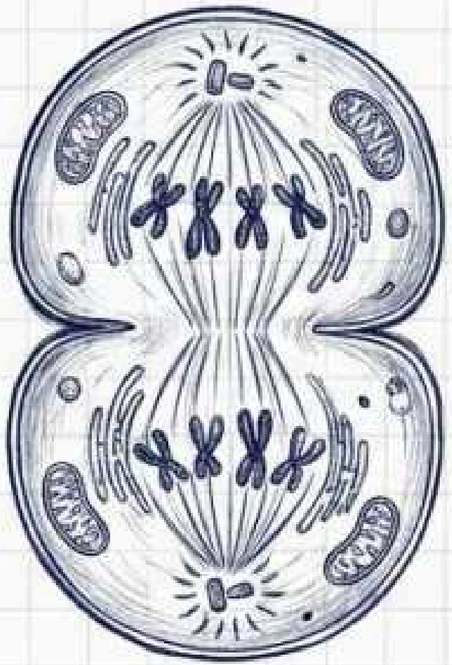
Biology 120 B: Lecture 6

The Cell Cycle, Cancer, and the Molecular Toolkit



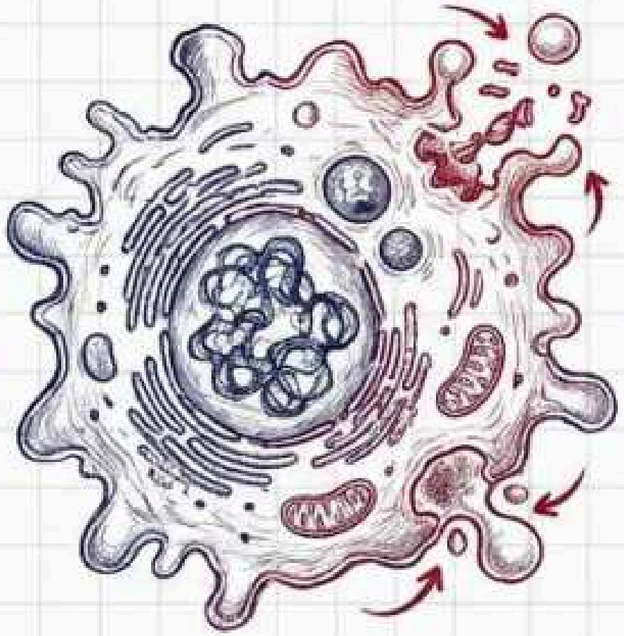
START

The Cell Cycle



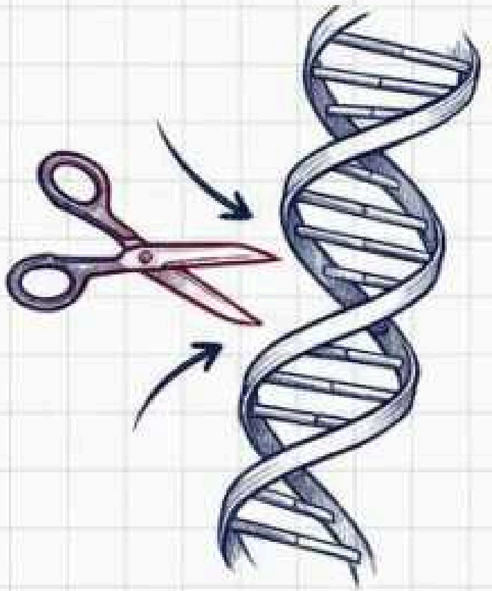
Birth to Division

Cancer & Apoptosis



When Controls Fail

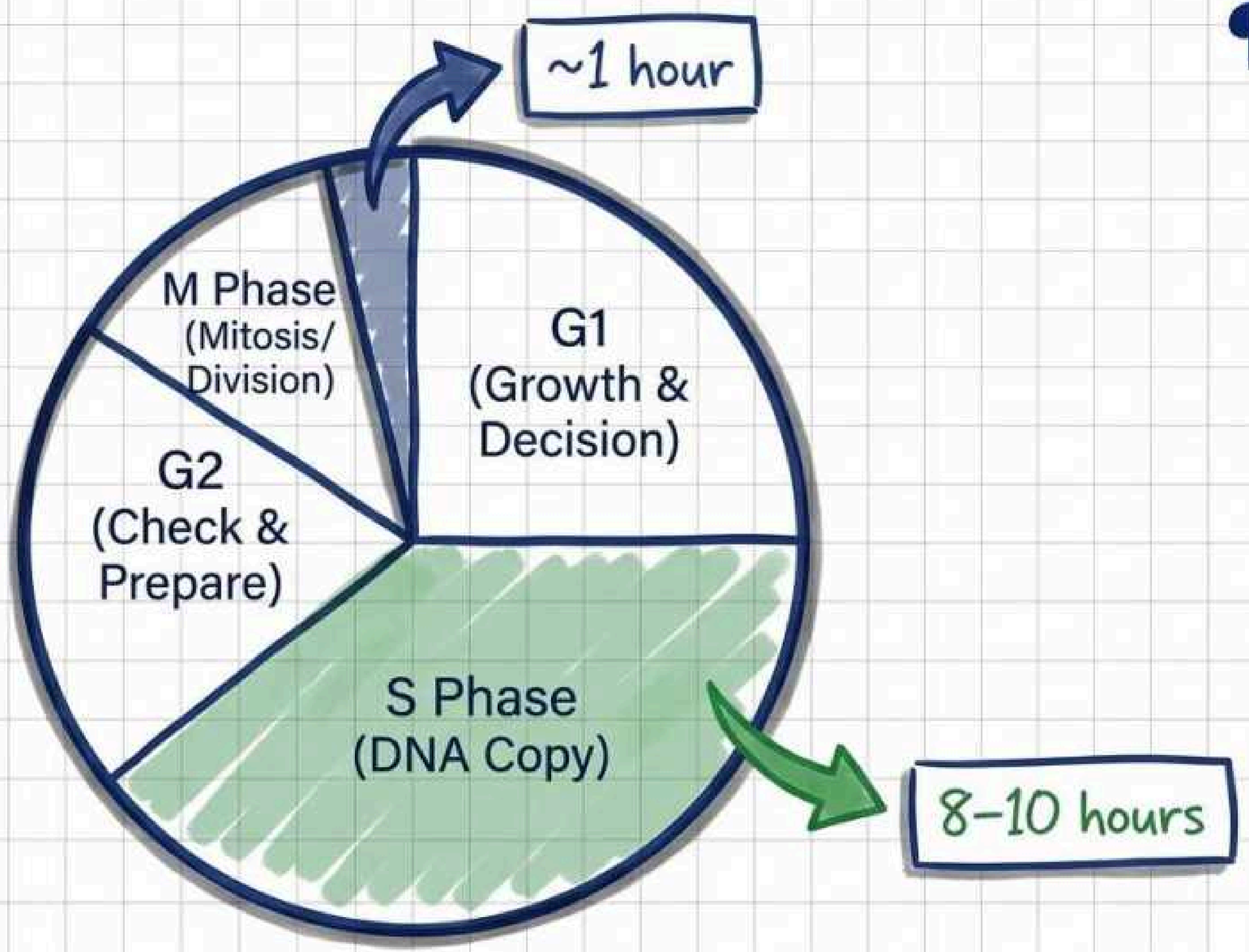
The Molecular Toolkit



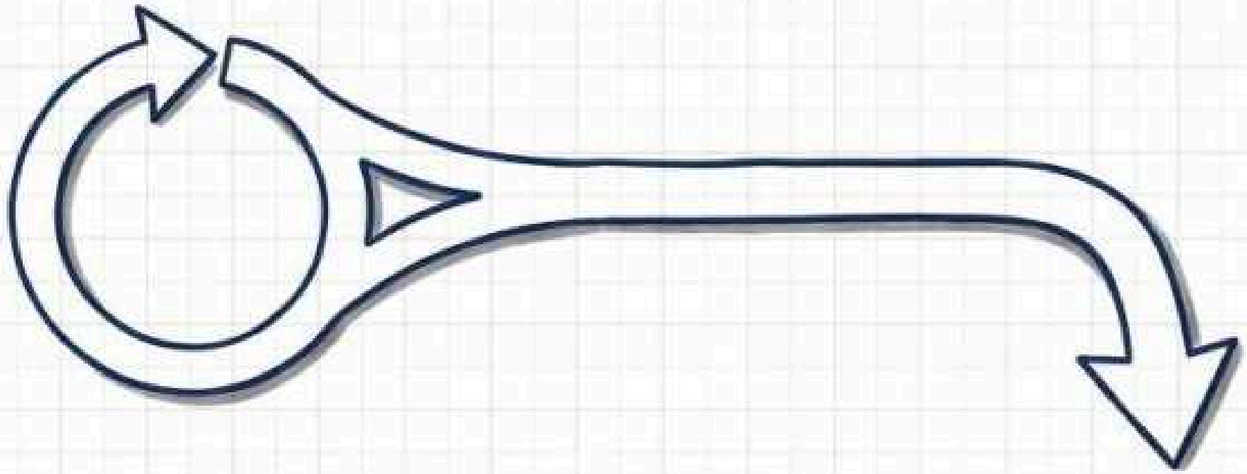
Read, Copy, Edit:
PCR, Sequencing, CRISPR

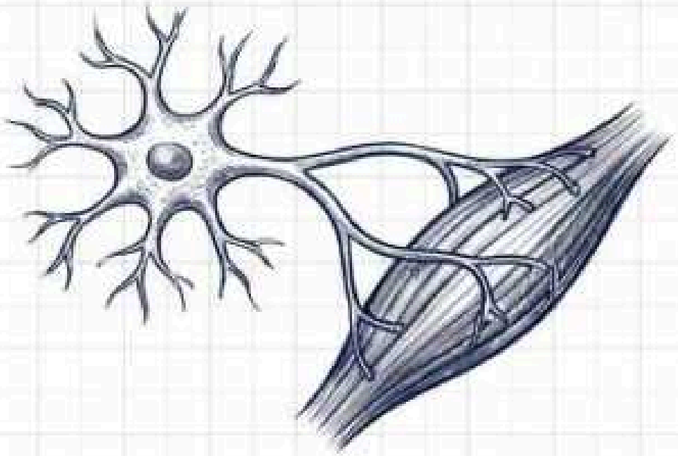
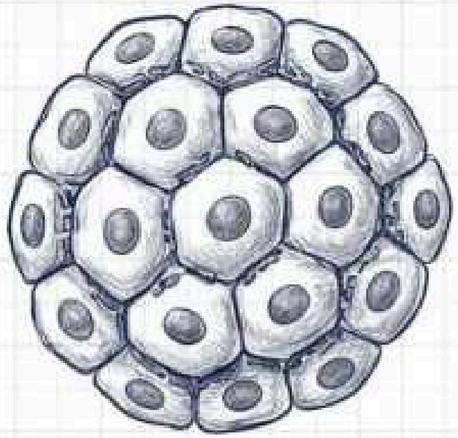
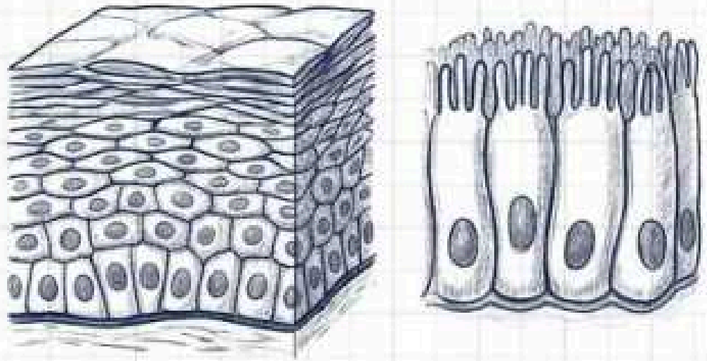
"This final lecture takes a cell from birth to division, examines what happens when controls fail, and explores the tools that let us rewrite the rules."

¶6.3



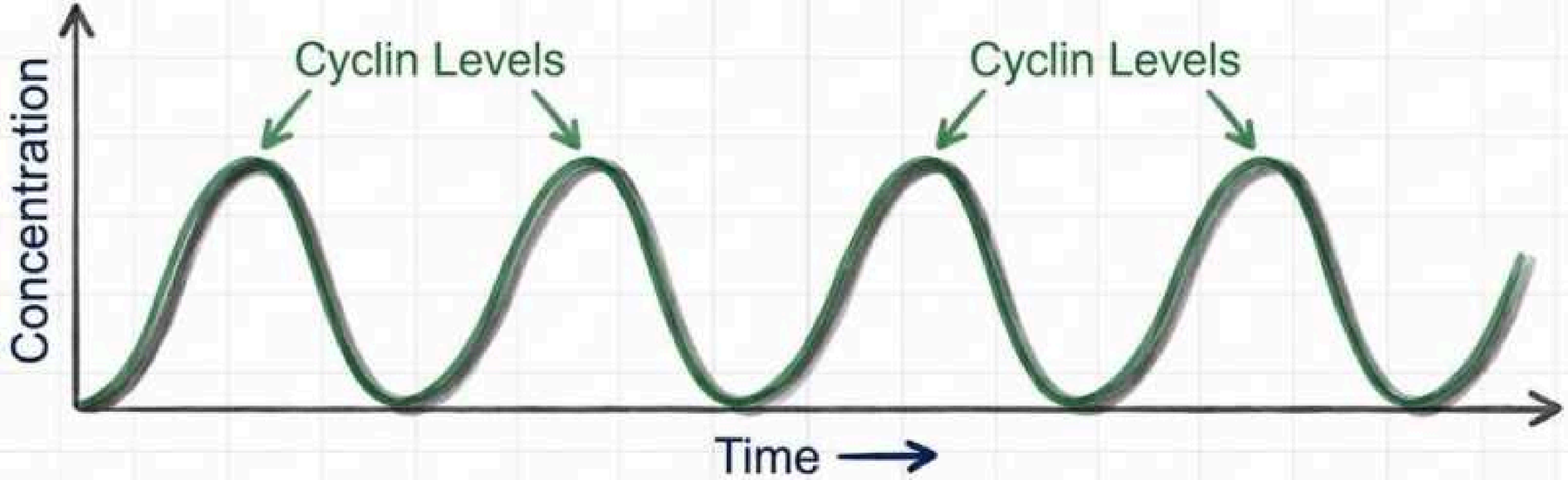
Note: This 24-hour cycle applies to a typical cultured human cell.

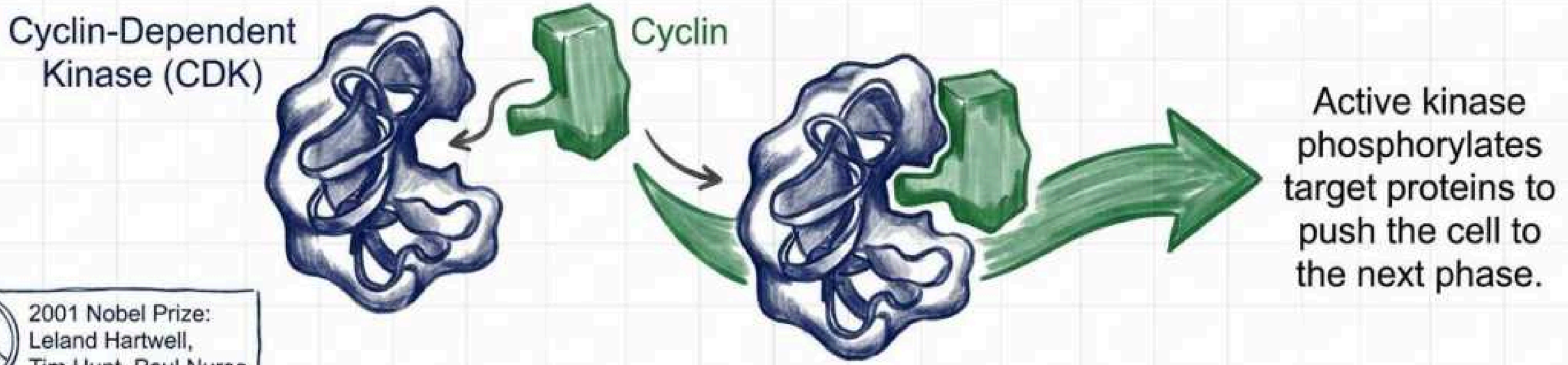


Permanent Exit (G0 State)	Reversible Exit	Continuous Cyclers
		
Never divide again.	Return only when signaled.	Never exit; cycle continuously.

From Lecture 3: Cellular division is strictly dependent on incoming signals.

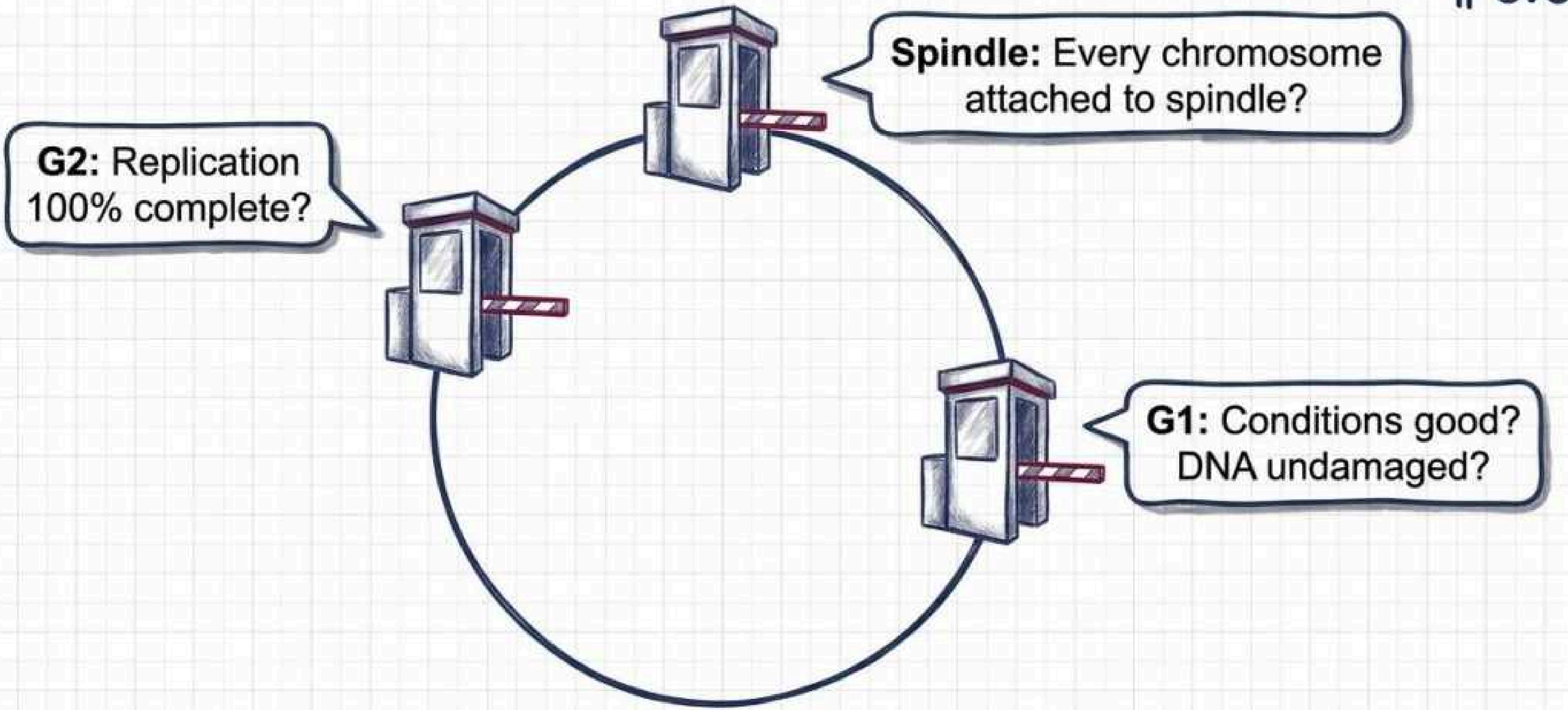
¶6.5







2001 Nobel Prize:
Leland Hartwell,
Tim Hunt, Paul Nurse



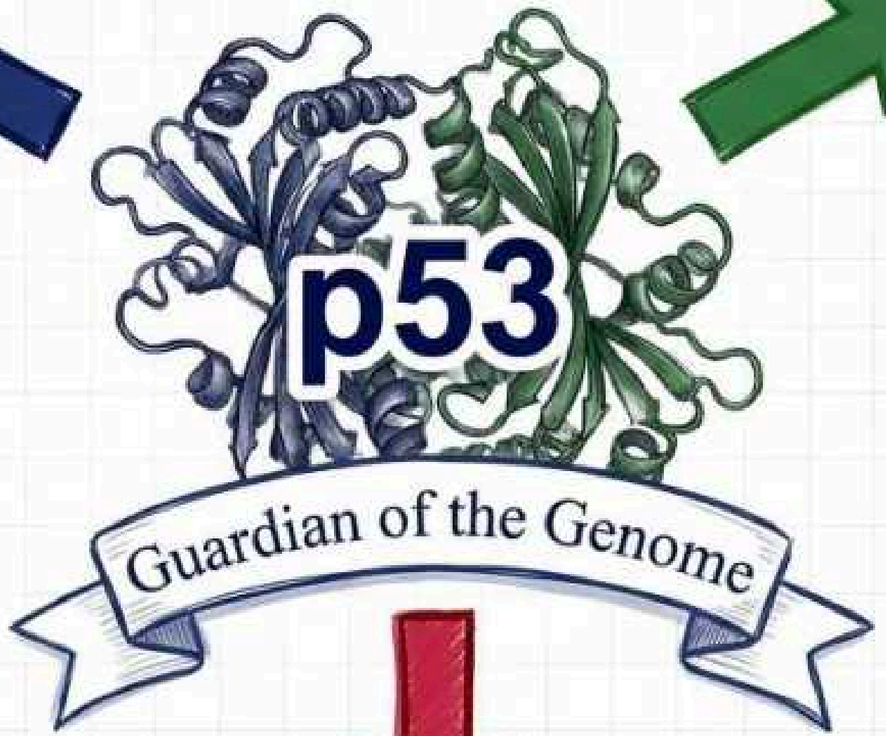
If NO -> Pause.

A cell would rather wait than make a faulty copy.

¶6.7

Halt Cycle

Activate Repair

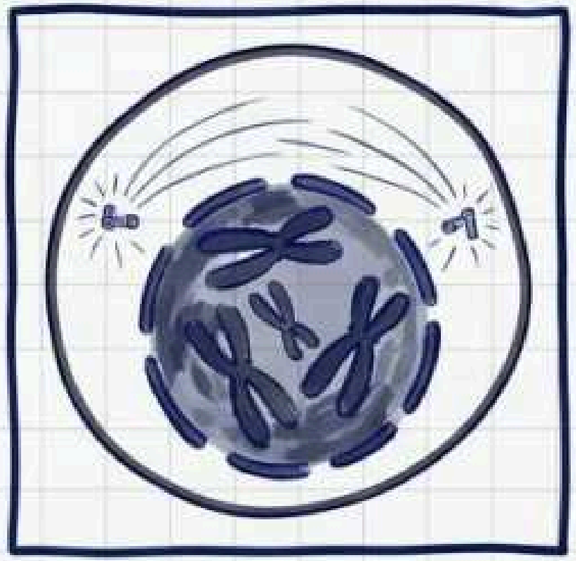


Trigger Cell Death

- Present in ~50% of all human cancers
- Inheriting one faulty copy creates a high lifetime cancer risk.

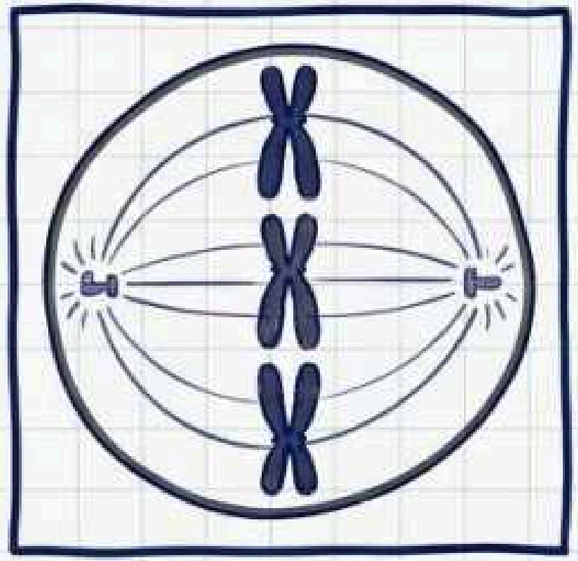
¶ 6.8

Prophase



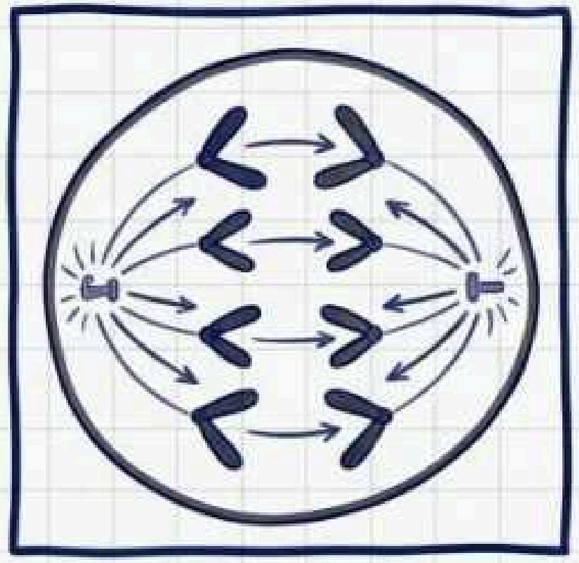
Chromosomes condense, spindle forms.

Metaphase



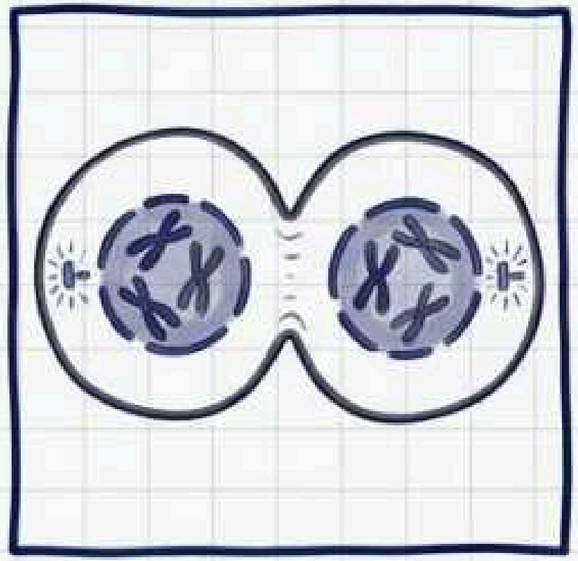
Chromosomes line up perfectly in the middle.

Anaphase



Shortening microtubules pull paired copies toward opposite poles.

Telophase



Two new nuclei form, cell pinches in two.

1 Parent (46 chromosomes) = 2 Identical Daughters (46 chromosomes)

¶ 6.9

Signal Received

↓

Caspase Enzymes Activated

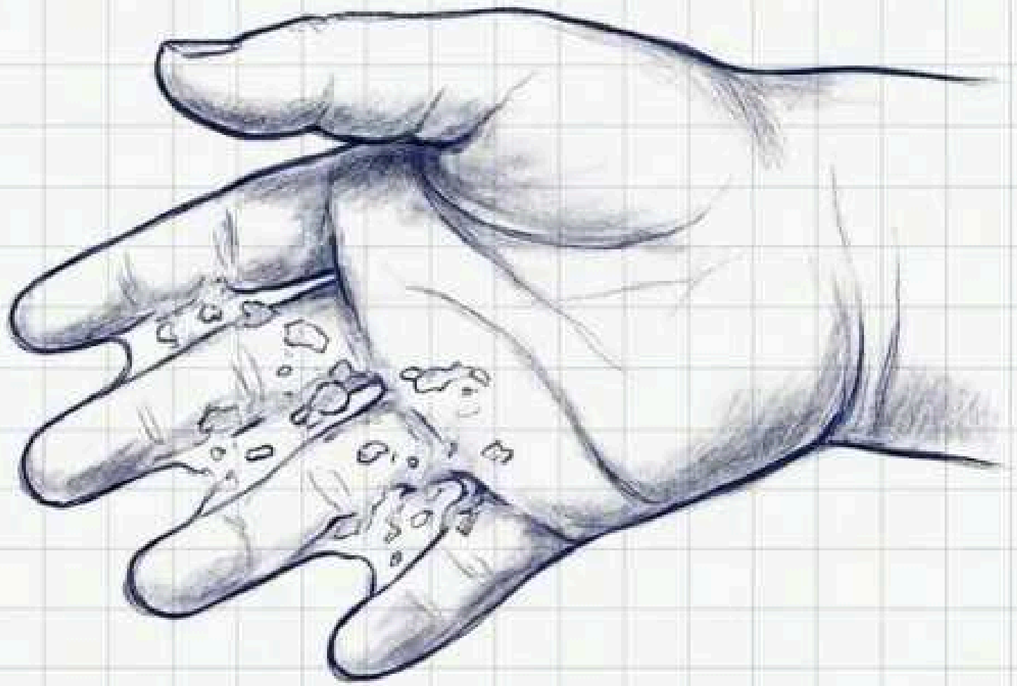
↓

Neat Dismantling

↓

Eaten by Neighbors (No Spillage)

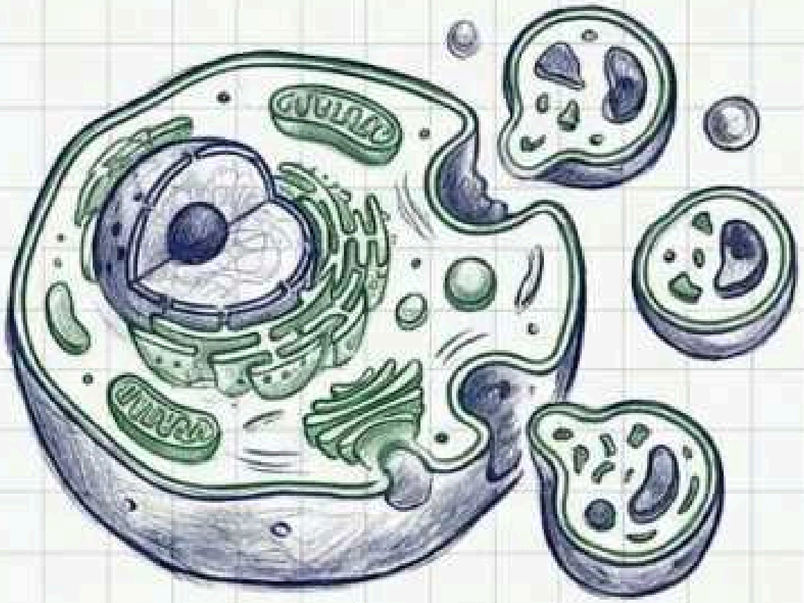
An adult human loses roughly 50 to 70 Billion cells every day to apoptosis.



¶6.10

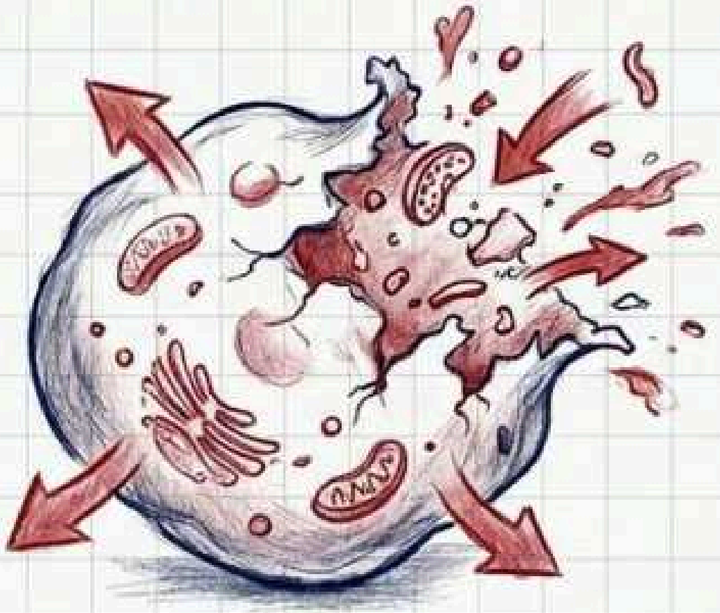
Apoptosis

- Protective
- Neat & controlled
- Prevents cancer



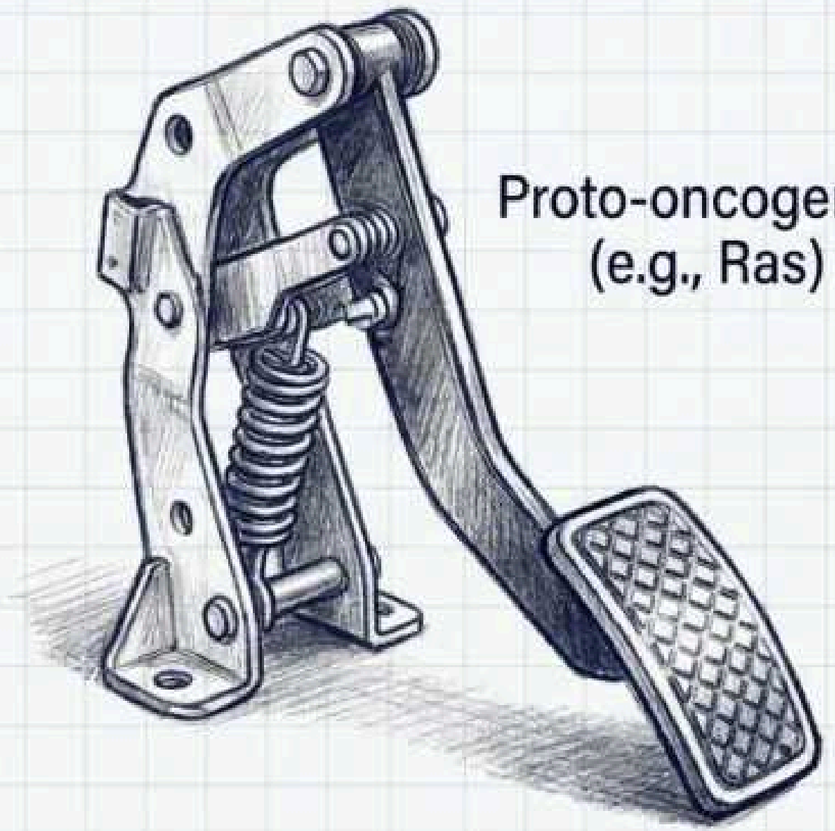
Necrosis

- Uncontrolled
- Caused by injury
- Leads to inflammation



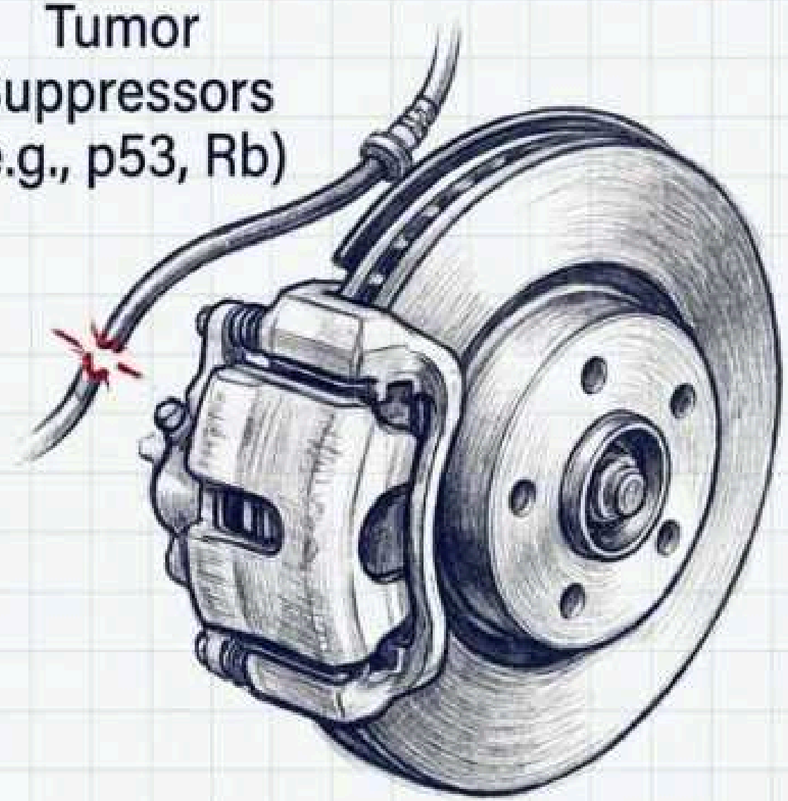
Cells that evade apoptosis become dangerous.
Modern cancer drugs aim to restore this pathway.

The Accelerator



Mutation turns them into Oncogenes
= Pedal stuck down.

The Brakes



Mutation (loss of both copies)
= Cut brake lines.

Cancer arises when a cell accumulates mutations that remove its division controls.

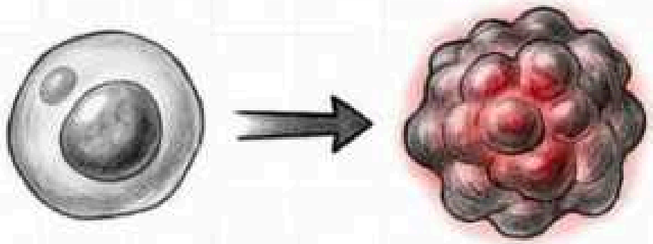
Knudson's Two-Hit Hypothesis

¶ 6.12

Inherited: Starts with 1 faulty copy

I

Needs only 1 more hit.

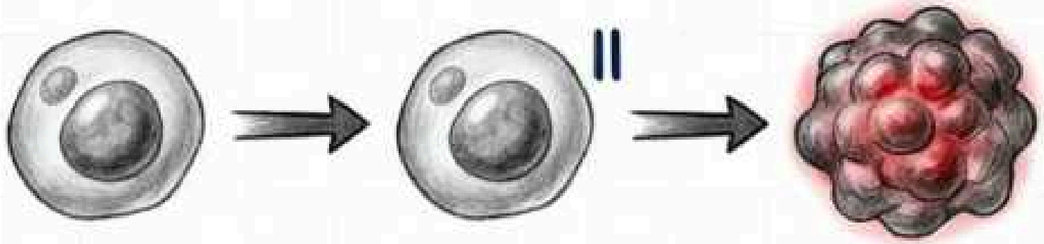


Cancer develops at an earlier age.

Normal: Starts with 2 good copies

(0 tallies)

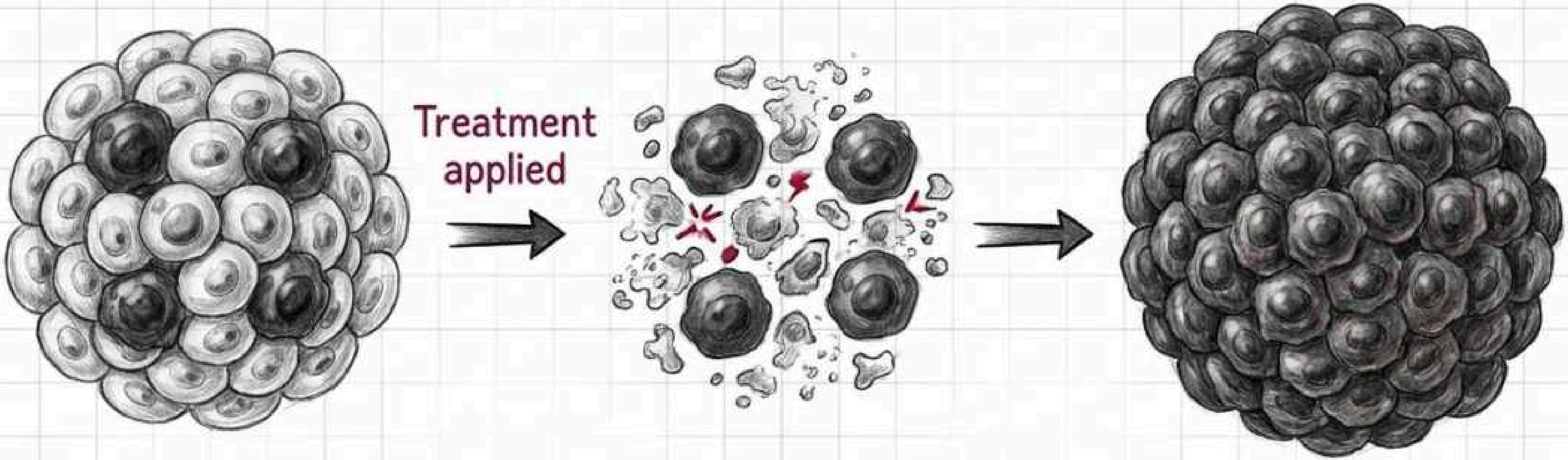
Needs 2 distinct hits.



Cancer takes longer to develop.

Cancer requires multiple mutations building up in a single lineage of cells.

¶ 6.13



Mixed tumor
cell population.

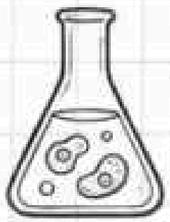
Most die.
Resistant cells survive.

Resistant cells
multiply rapidly.

Natural selection acting inside a body.

This is why cancers return, and why combination therapies out-perform single drugs.

¶ 6.14

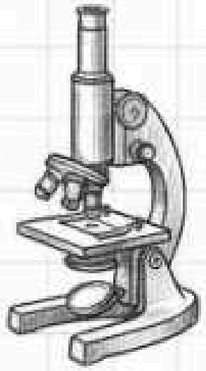


1951: HeLa Cell Line Established



Polio Vaccine Development



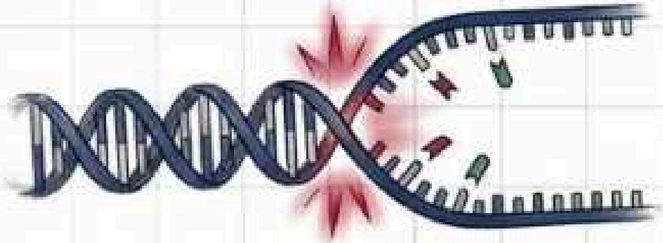


Countless Cell Biology Advances

HeLa cells were taken without her knowledge. Her legacy forced necessary changes in how researchers obtain consent and acknowledge biological donors.

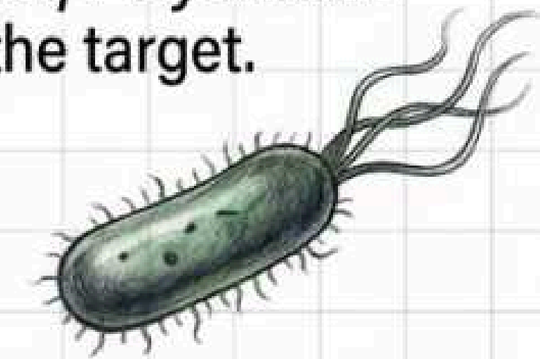
¶ 6.15

Heat: Separates the two target DNA strands.



Temperature

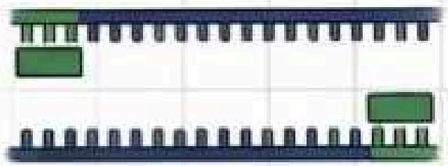
Warm: *Taq Polymerase* copies the target.

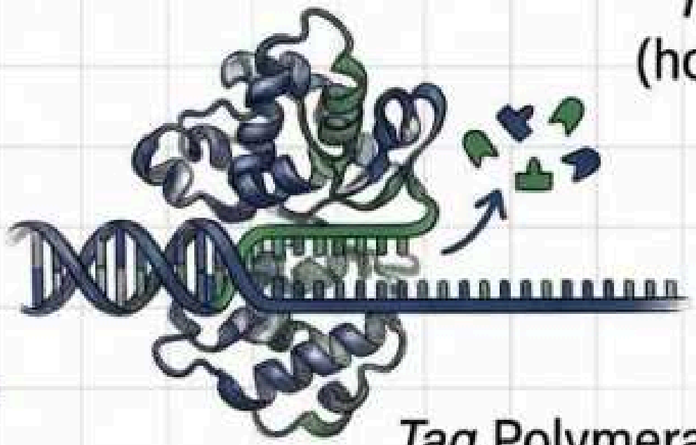


Thermus aquaticus (hot-spring bacterium)

1993 Nobel Prize: Kary Mullis

Cool: Short primers bind.



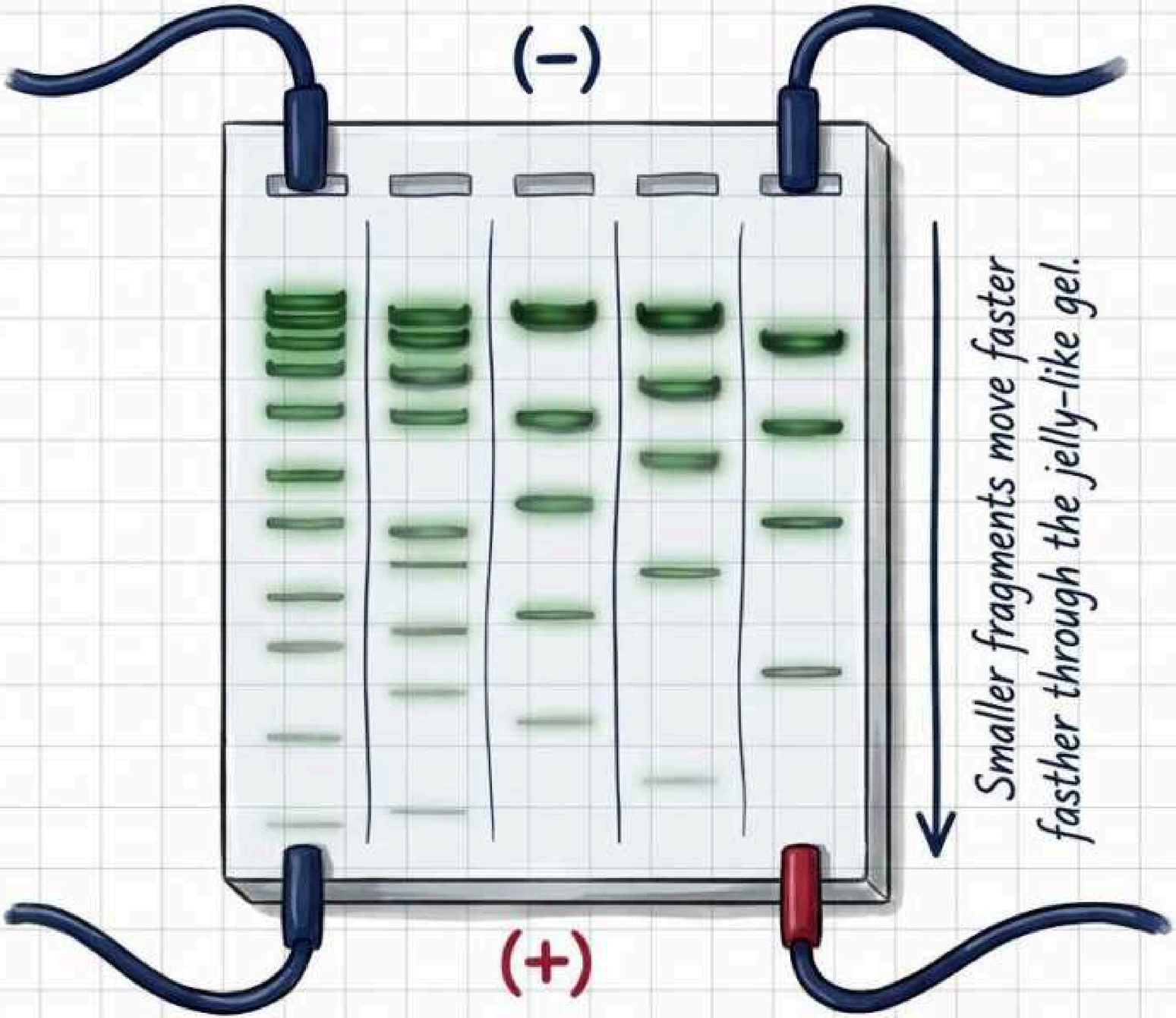


Taq Polymerase

$$N = 2^n$$

1 cycle =	2 copies
10 cycles =	1,024 copies
30 cycles =	**1,073,741,824**

More than a billion copies in roughly an hour. This is how trace DNA at a crime scene or a few viral particles on a swab are detected.



Applications:

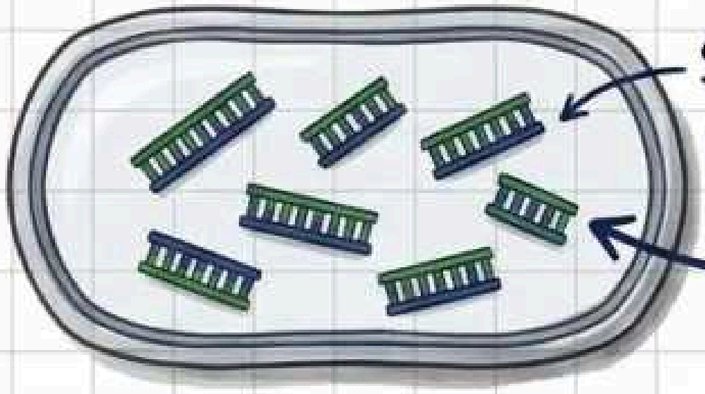
- Compare fragments, check PCR products, map genes (when combined with sequence-specific cutting enzymes).

2003 (Human Genome Project)	Today (Modern Machines)
Cost: Billions of dollars.	Cost: < $1,000.
Time: Years.	Time: < 1 Day (reading millions of fragments at once).

Built on Frederick Sanger's 1977 invention of the chain-termination method.

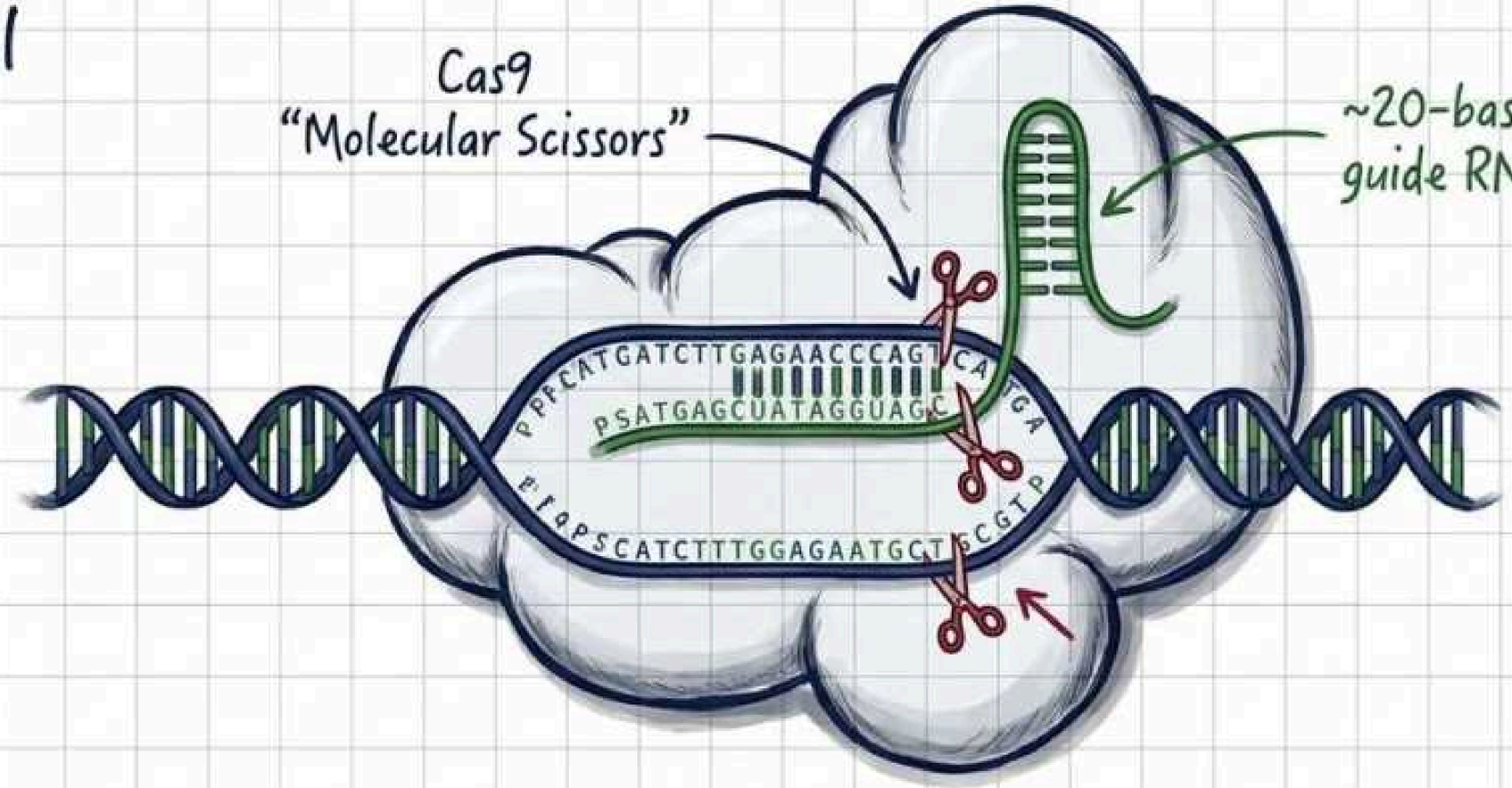
Origins

¶ 6.19



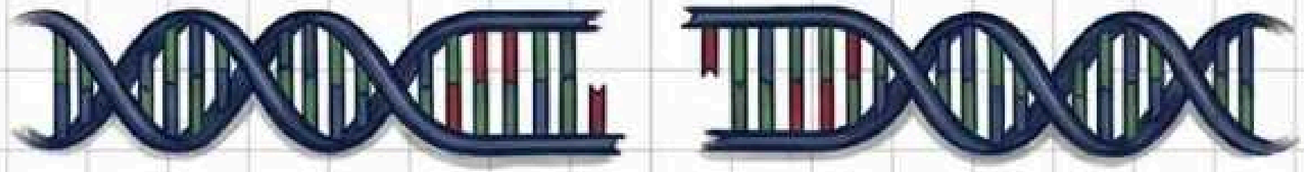
Bacteria store viral DNA as an immune system to recognize invaders.

The Tool



2020 Nobel Prize: Jennifer Doudna & Emmanuelle Charpentier

After the Cas9 Cut

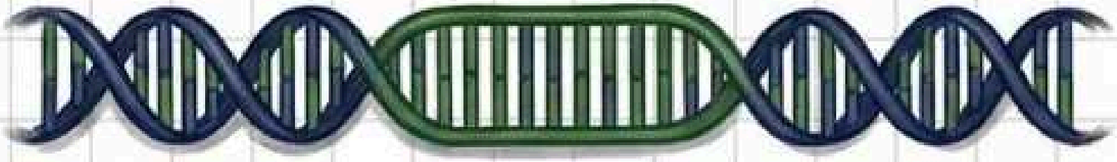


Glue the ends

Provide a template

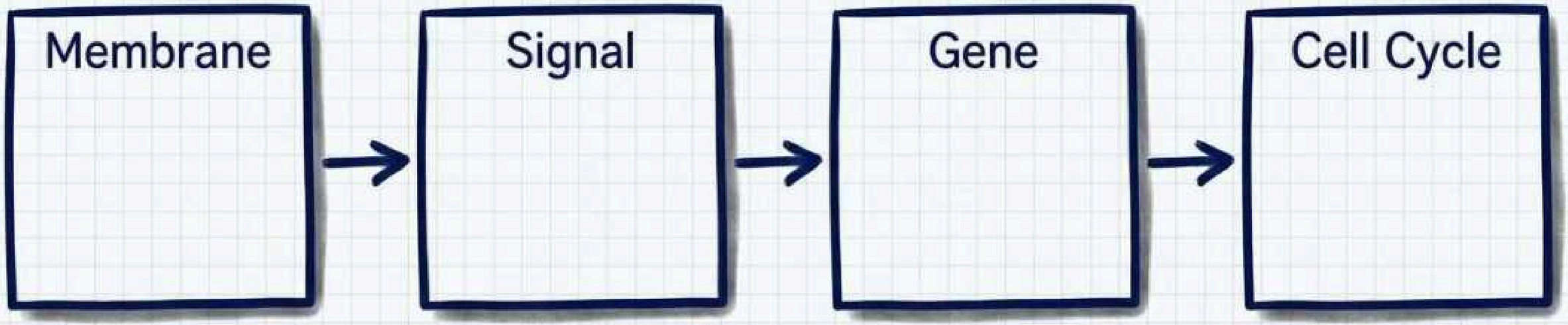


Gene Disabled (NHEJ)



Gene Corrected (HDR)

In 2023, a CRISPR-based therapy was first approved for sickle cell disease. Safety, cost, and heritable changes remain hotly debated.



Choose a disease. Trace it through a membrane, a signal, a gene, and a cell cycle. Explain how PCR, Sequencing, and CRISPR could study or treat it. What do you still need to know?

Thank you for studying with Anderson Academy.

garyanderson@mail.grokbot.com | X: @garyanderson