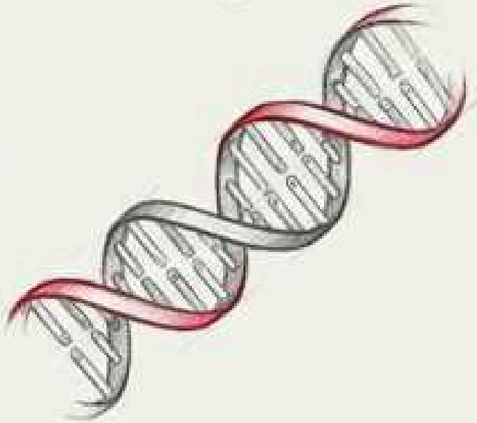
DNA: The Molecule of Inheritance

The Molecule of Inheritance



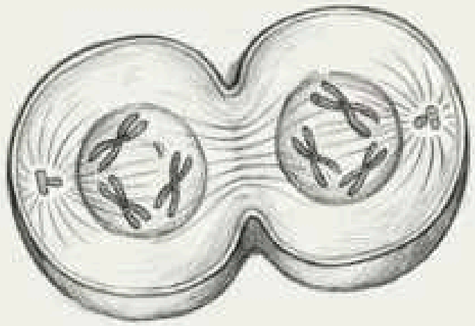
The Material

What is the genetic material made of, and how did scientists decide it was DNA?



The Architecture

What does the double helix look like, and how did Watson, Crick, and others work it out?



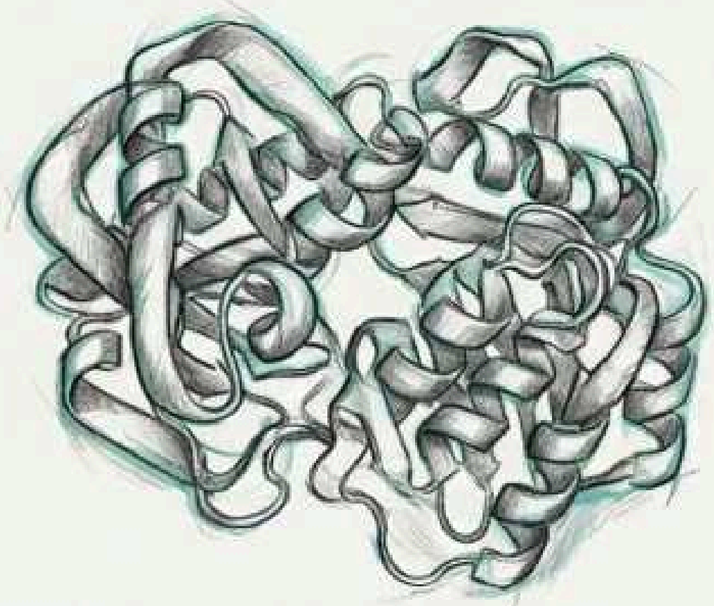
The Mechanism

How does the cell copy DNA so each new cell receives a full set of instructions?

The Early Debate: Protein vs. DNA

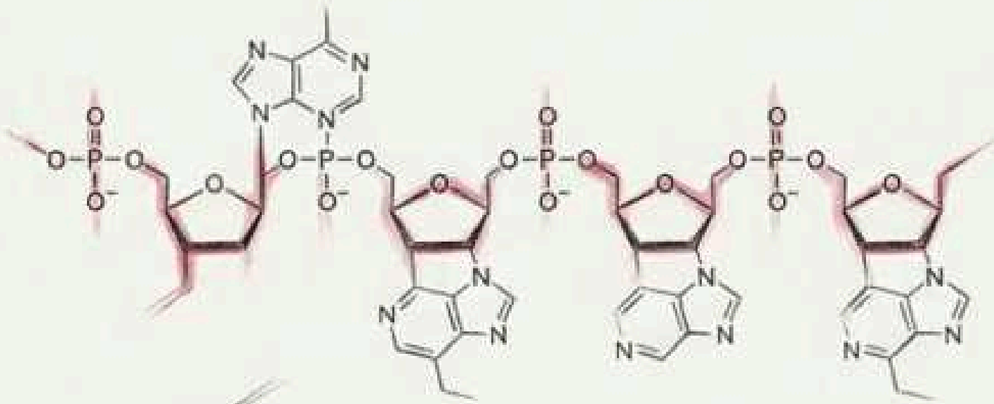
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Proteins (The Favorite)



Assumed by most scientists for decades to be the **genetic material** because they come in so many complex forms.

DNA (The Underdog)

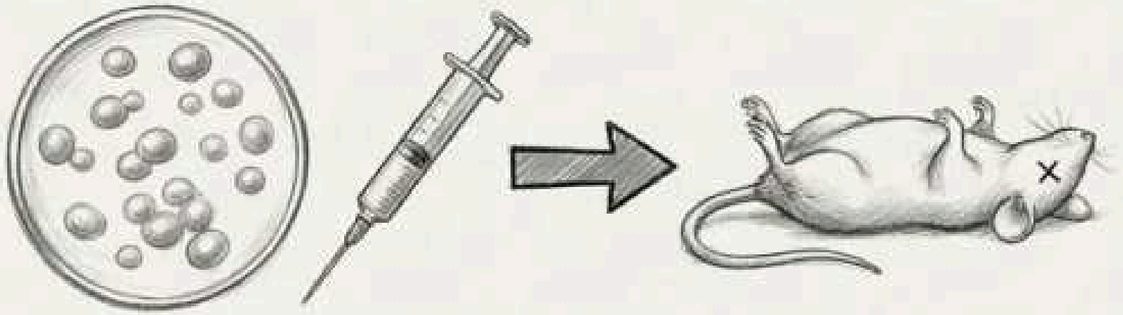


Viewed as too simple.

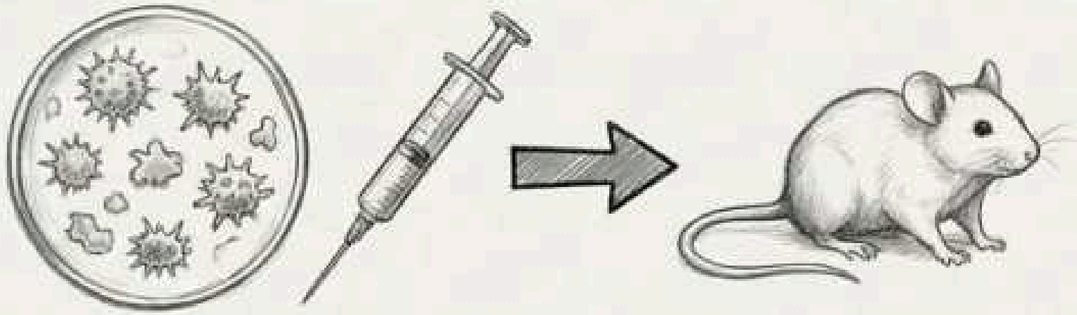
Discovered in 1869 by Swiss chemist Friedrich Miescher, who isolated this phosphorus-rich substance from the nuclei of pus cells.

1928: The Griffith Experiment

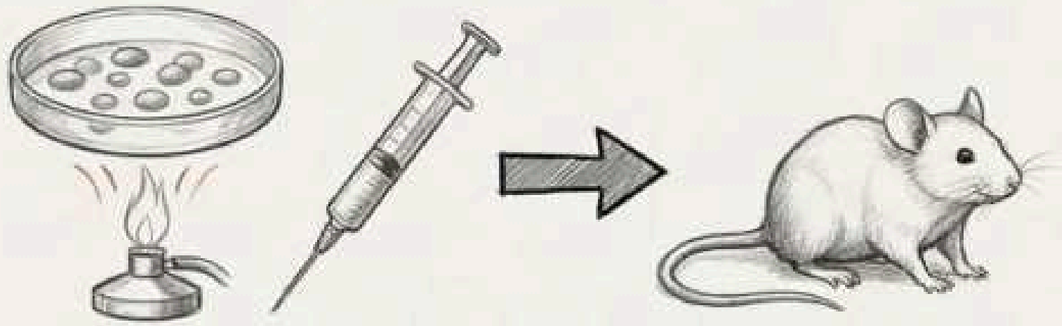
The Setup: British physician Frederick Griffith tested pneumonia bacterial strains on mice.



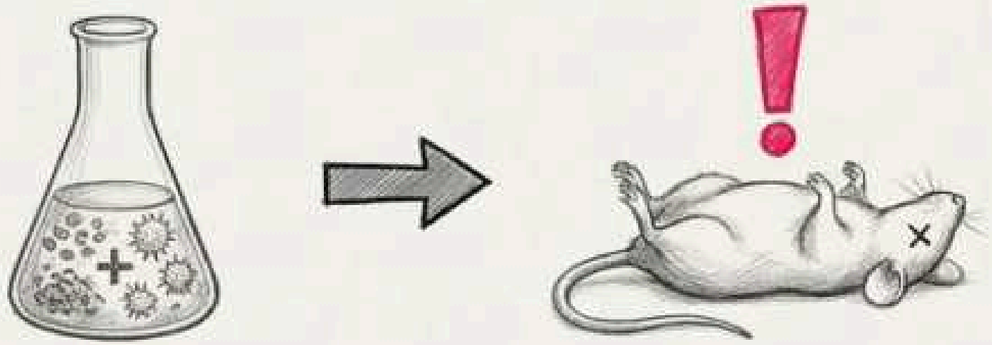
Smooth bacteria -> Dead mouse



Rough bacteria -> Live mouse



Heat-killed smooth bacteria -> Live mouse



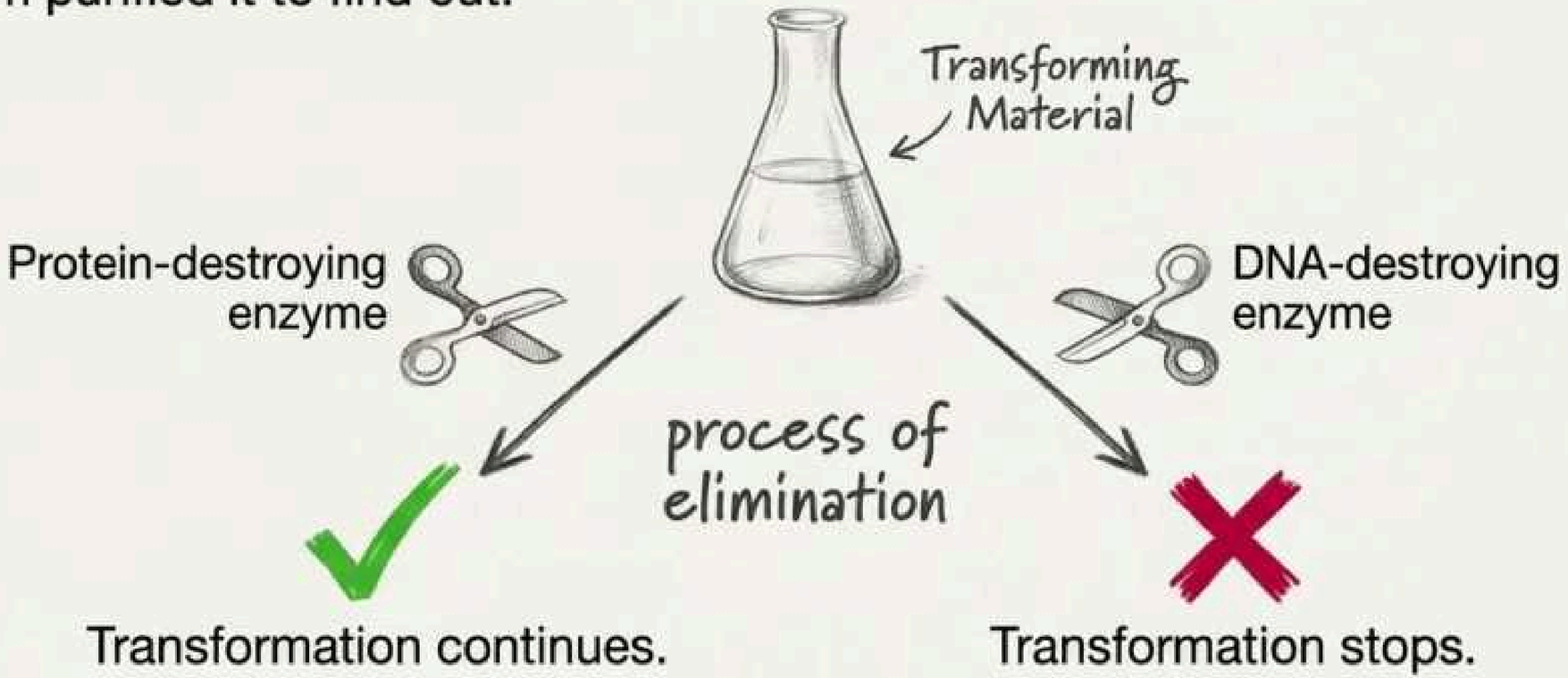
Heat-killed smooth + Living rough -> Dead mouse

The Observation: Living smooth bacteria miraculously appeared in the final mixture.

The Conclusion: The harmless rough strain had been changed by something in the dead smooth strain.

1944: Avery, MacLeod, & McCarty

The Concept: Griffith called it "transformation," but the substance was unknown. Avery's team purified it to find out.

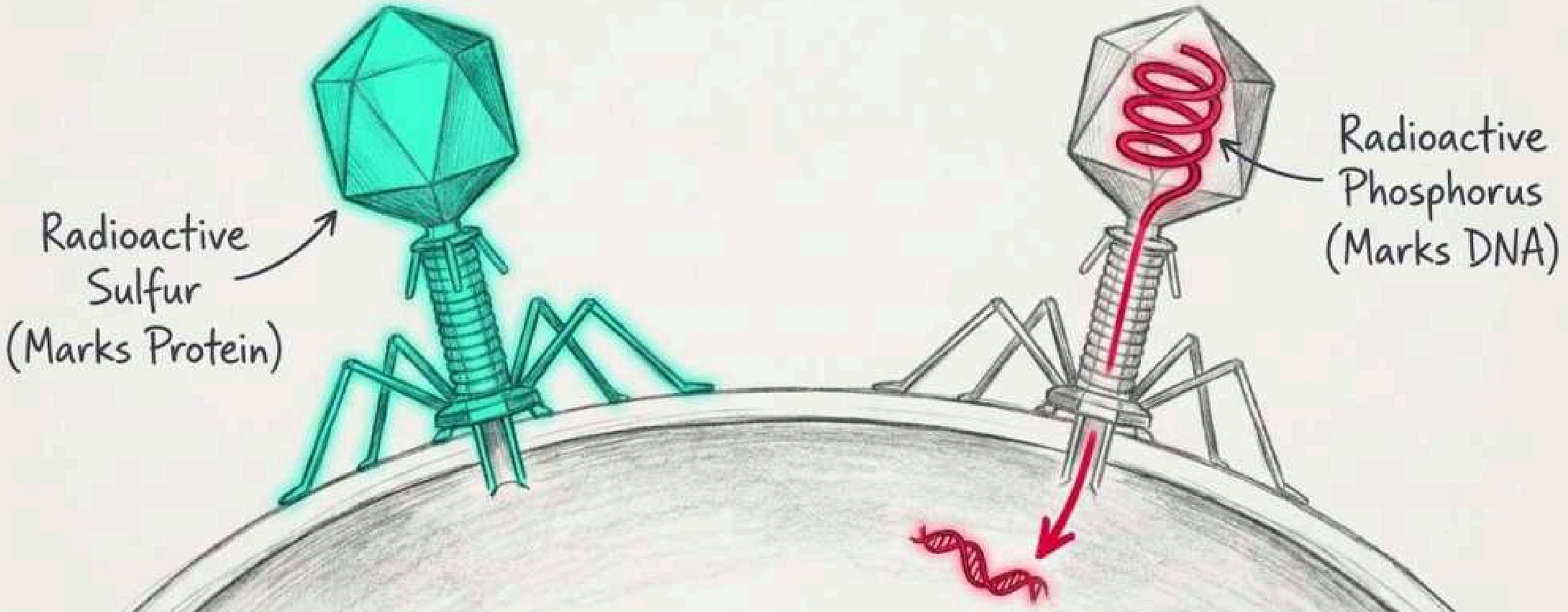


The Proof: Enzymes that destroyed protein did not stop the transformation. An enzyme that destroyed DNA did.

The Verdict: DNA is the transforming material.

1952: The Decisive Test (Hershey & Chase)

The Subject: Phage viruses, constructed entirely of just protein and DNA.

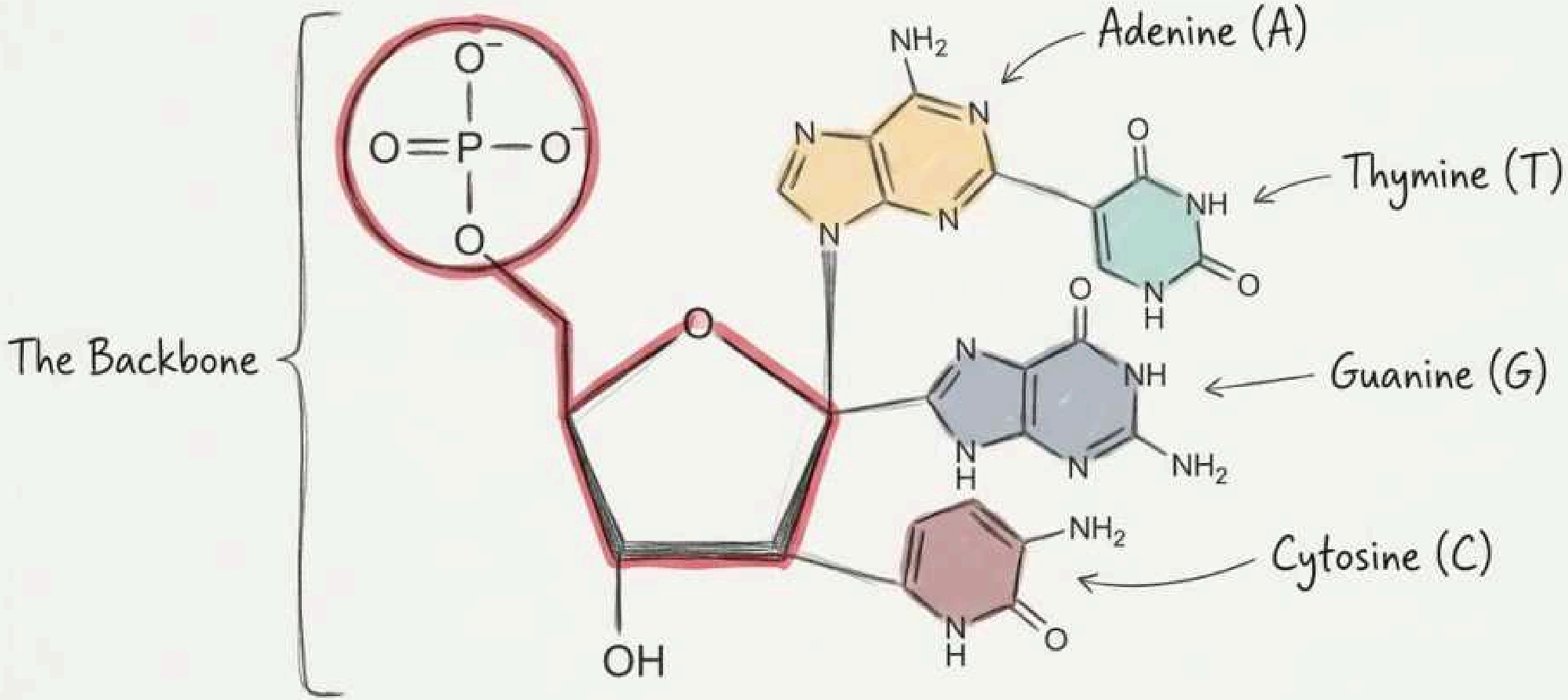


The Result: Mainly the radioactive DNA (Phosphorus), not the protein (Sulfur), entered the bacteria.

The Verdict: DNA definitively carries the genetic instructions.

The Building Blocks: Nucleotides

The Structure: DNA is a long chain of repeating units.



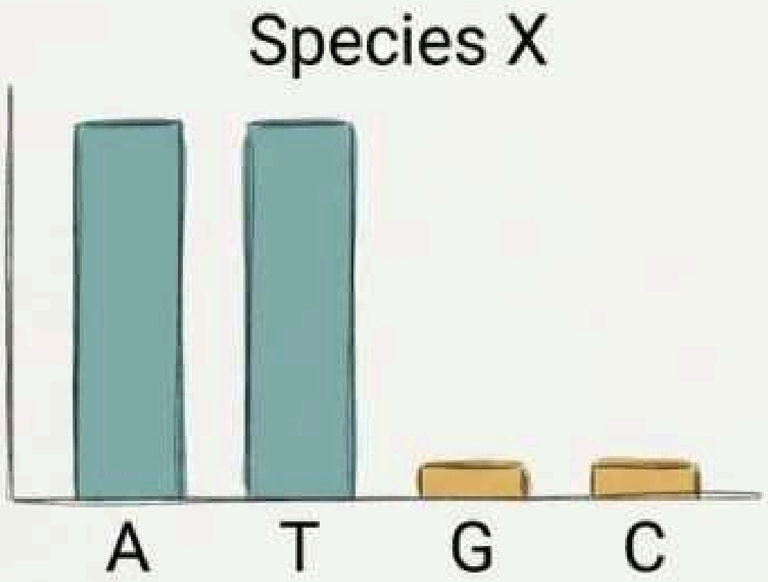
The Backbone: Formed by a sugar and a phosphate.
The Bases (The Rungs): Stick out sideways.

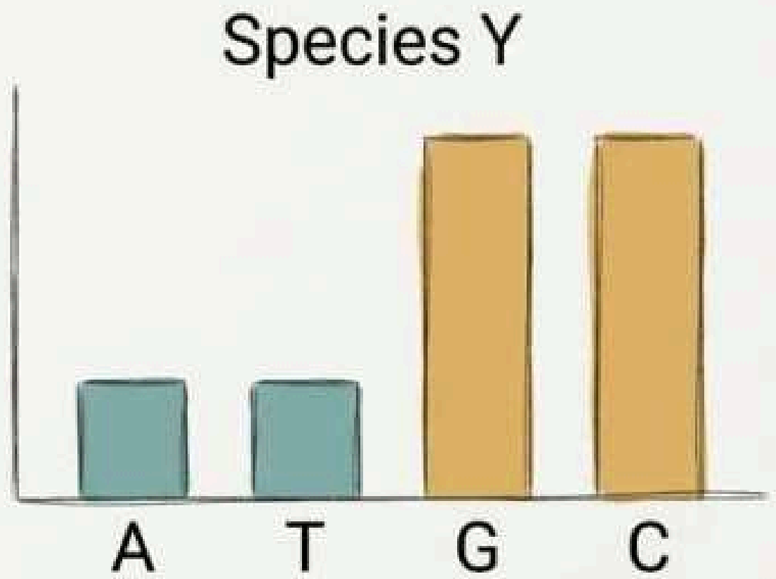
Late 1940s: Chargaff's Rules

The Discovery: Biochemist Erwin Chargaff measured the bases in many species. The ratio of A/T to G/C differs across species, but the matching pairs never do.

[A] = [T]

[G] = [C]





The Vital Hint: The amount of adenine always matches thymine; guanine always matches cytosine.

May 1952: The Visual Evidence (Franklin & Wilkins)

The Technique: X-ray crystallography of DNA fibers at King's College London.

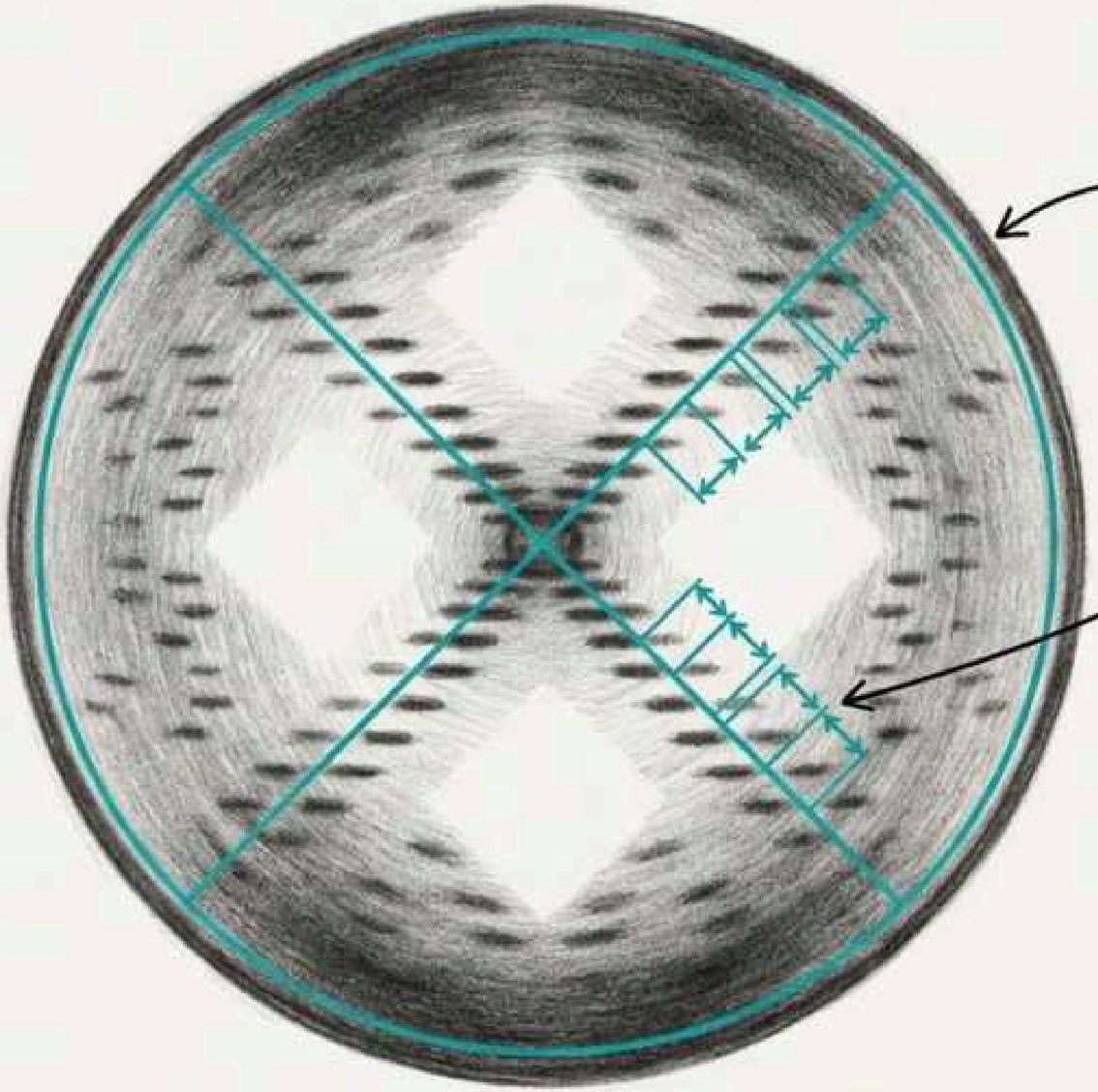
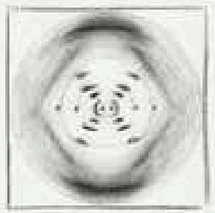


Photo 51: The sharp crossed pattern definitively proved DNA is a helix.

The Data: Franklin's precise measurements revealed the exact width and the internal spacing of its parts.

1953: The Cambridge Model

Franklin's X-ray Data

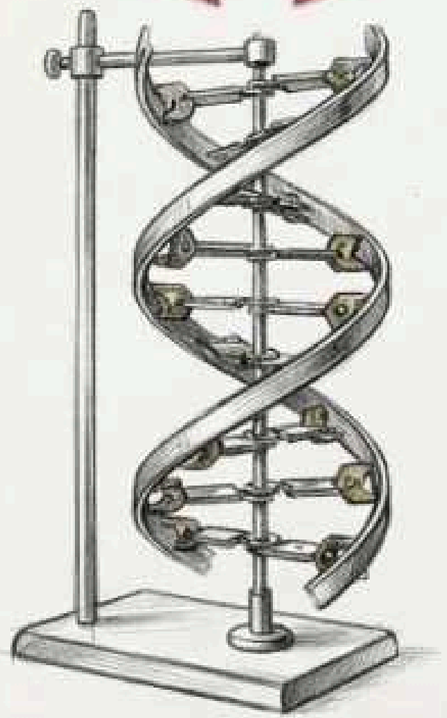


(Structural Dimensions)

Chargaff's Rules

[A] = [T]
[G] = [C]

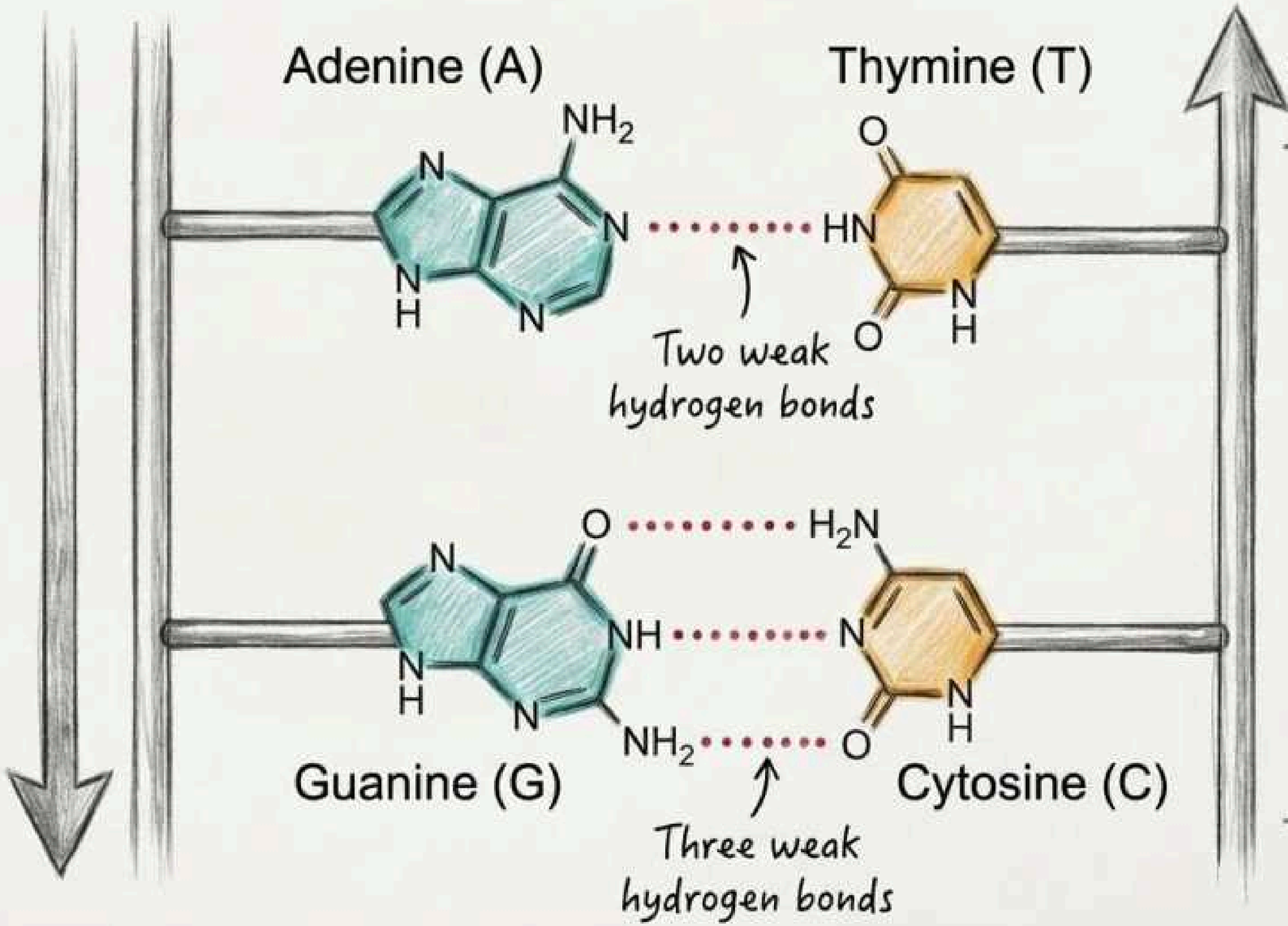
(Chemical Ratios)



The Synthesis:
James Watson and Francis Crick built physical models, combining structural data with chemical ratios.

The Result:
A physical model of two chains twisted around each other in a double helix. Described in *Nature* on 25 April 1953.

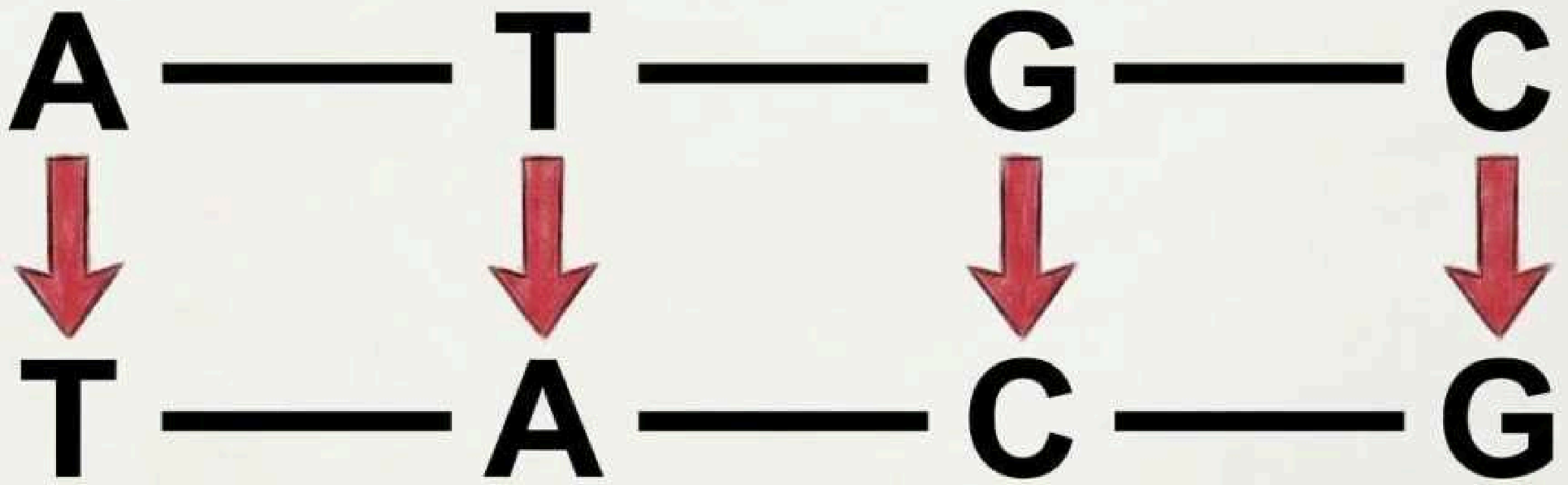
The Beauty of the Helix



Anti-parallel:
The two chains run in opposite directions.

The Design:
Purine (Large) + Pyrimidine (Small) = Uniform Width.
Every rung has exactly the same width throughout.

The Key to Heredity: Complementary Strands



The Rule:
If you know the order of bases on one strand, you can perfectly predict the order on the other.

The Implication:
As Watson and Crick noted, this pairing mechanism immediately suggests a natural way for the genetic material to copy itself.

Recognition and Legacy





1958

Rosalind Franklin dies of cancer at the age of 37.

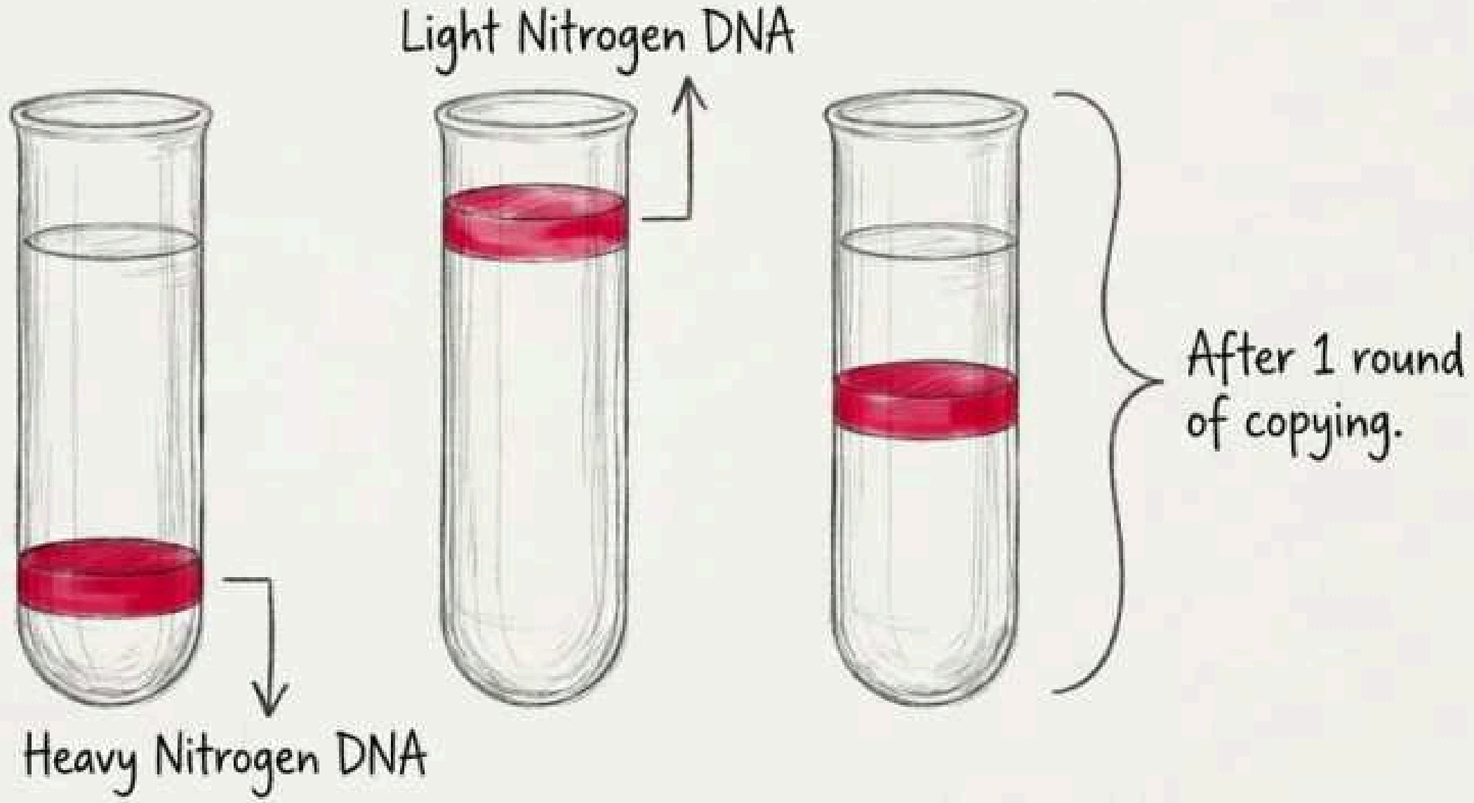
1962

Watson, Crick, and Wilkins share the Nobel Prize (which is not awarded posthumously).

The Lesson: Historians continue to debate the attribution of credit, making Franklin's story a cornerstone lesson in how scientific contributions are recognized.

1958: How Does Copying Work?

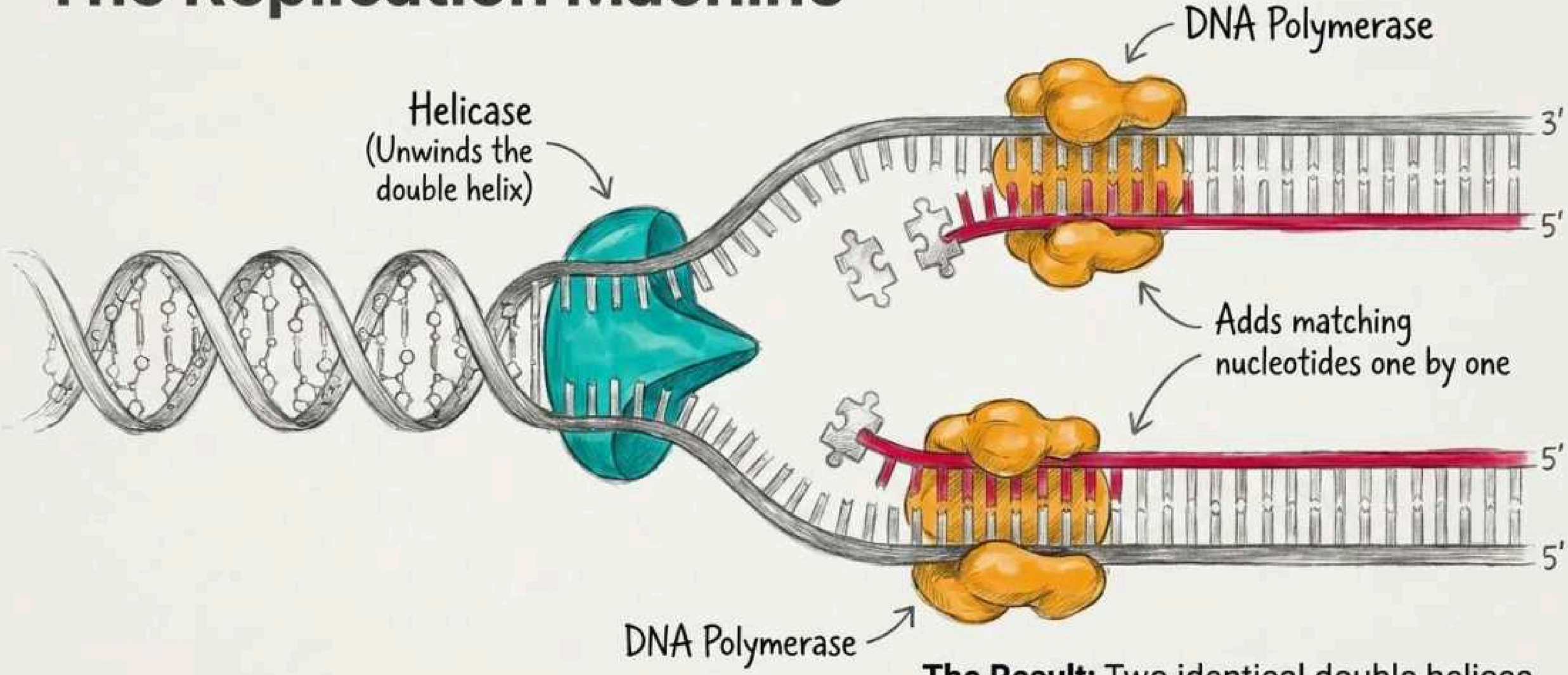
The Proof: Matthew Meselson and Franklin Stahl tested bacteria grown on heavy nitrogen to validate the semiconservative model.



The Semiconservative Model: Each new double helix keeps one old strand and builds one new strand.

Result: After one replication cycle, all DNA had a "medium" weight, perfectly proving the theory.

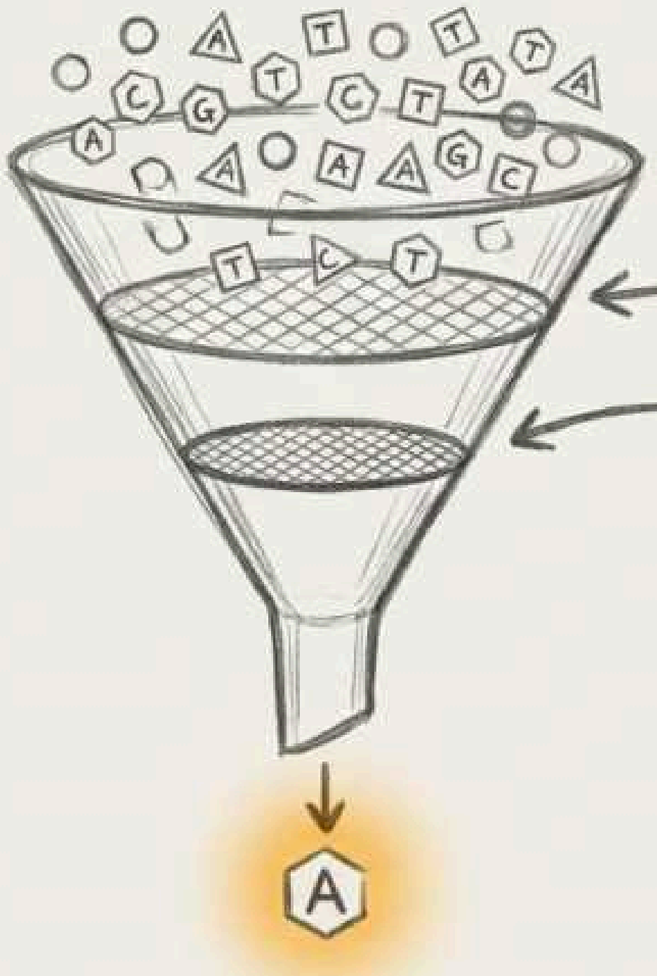
The Replication Machine



The Result: Two identical double helices where there was only one.

Unrivaled Accuracy & Proofreading

The System: Polymerase checks its work in real-time, and repair enzymes provide a second layer of inspection.



Step 1: DNA Polymerase Checks
(Removes wrong bases as it builds)

Step 2: Repair Enzyme Inspection
(Catches leftover mismatches)

1 Error : 1,000,000,000 Bases

The Error Rate: After all proofreading, the cell makes roughly **one mistake for every billion bases** copied. Yet, a few mistakes survive every cell division.

Mutations: The Engine of Variation

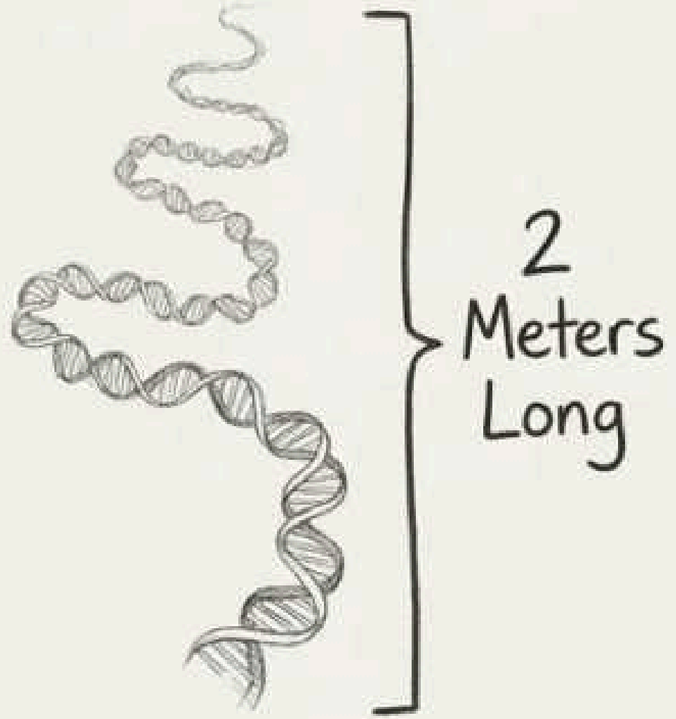
What are they? Uncorrected sequence changes. The ultimate source of new alleles.



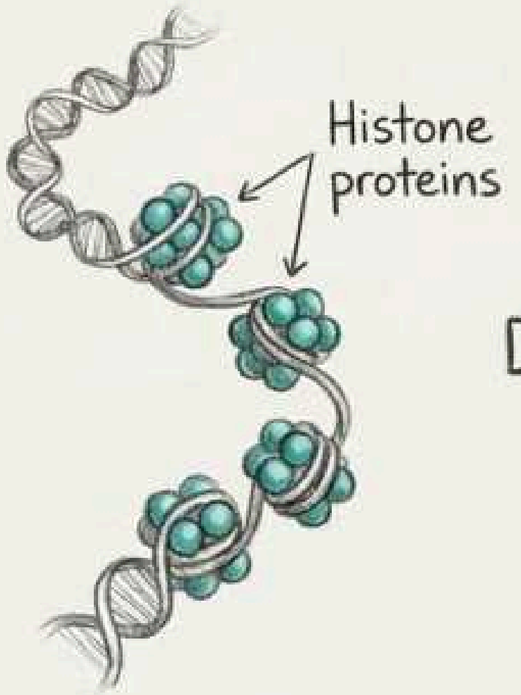
The Human Reality: A typical person is born with a few dozen new mutations that neither parent had.
The Result: Without these tiny changes, all genetic variation would be impossible.

Startling Scale & Packaging

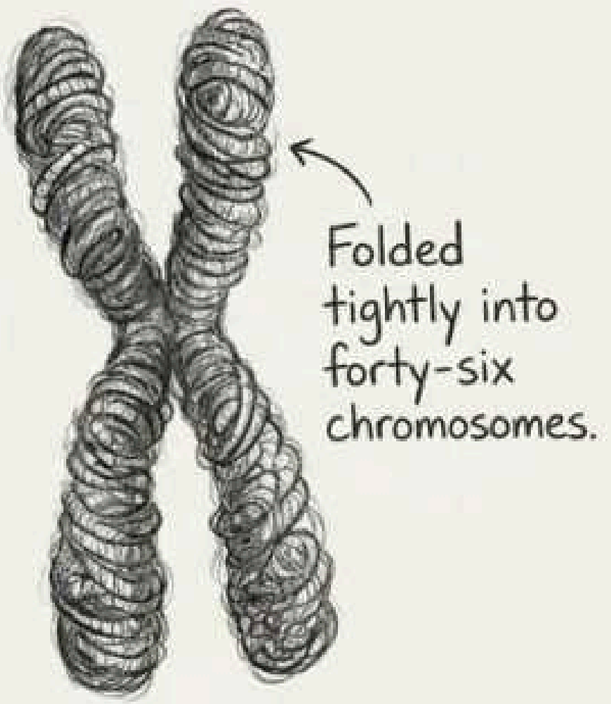
The Genome: Contains about three billion base pairs in a single set of chromosomes.



Stretched out, the DNA in just one human cell.



Wound like spools.

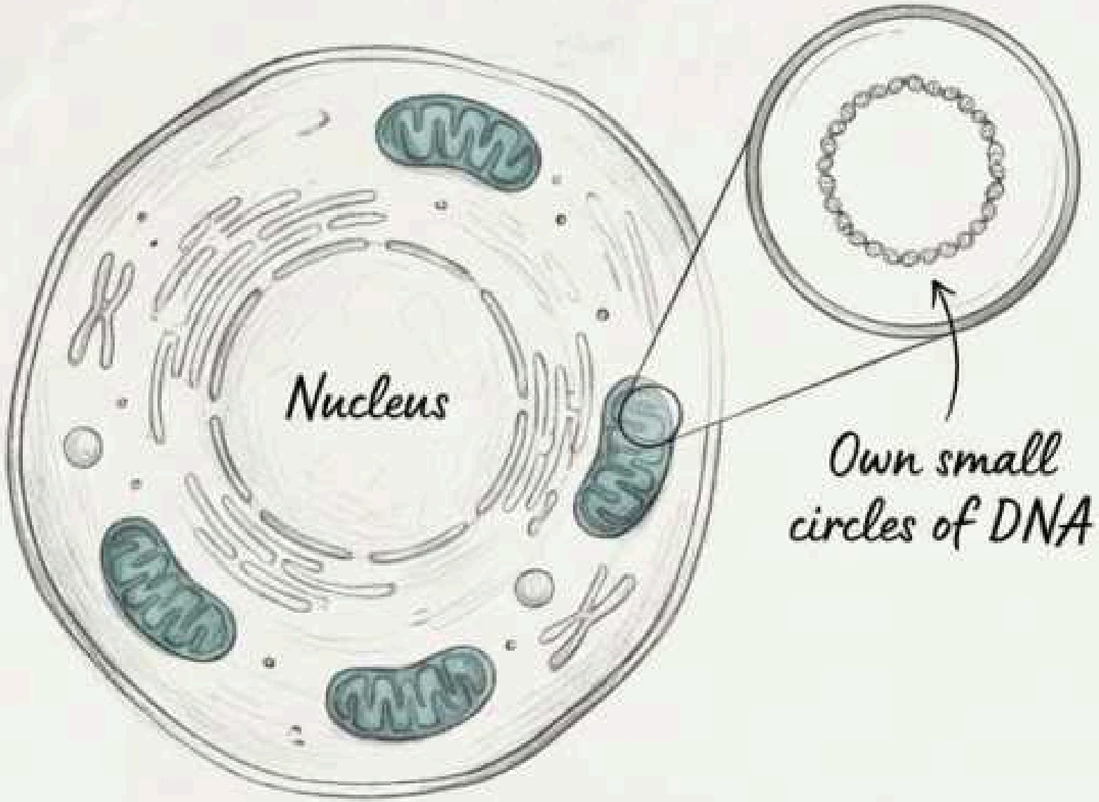


Folded tightly into forty-six chromosomes.

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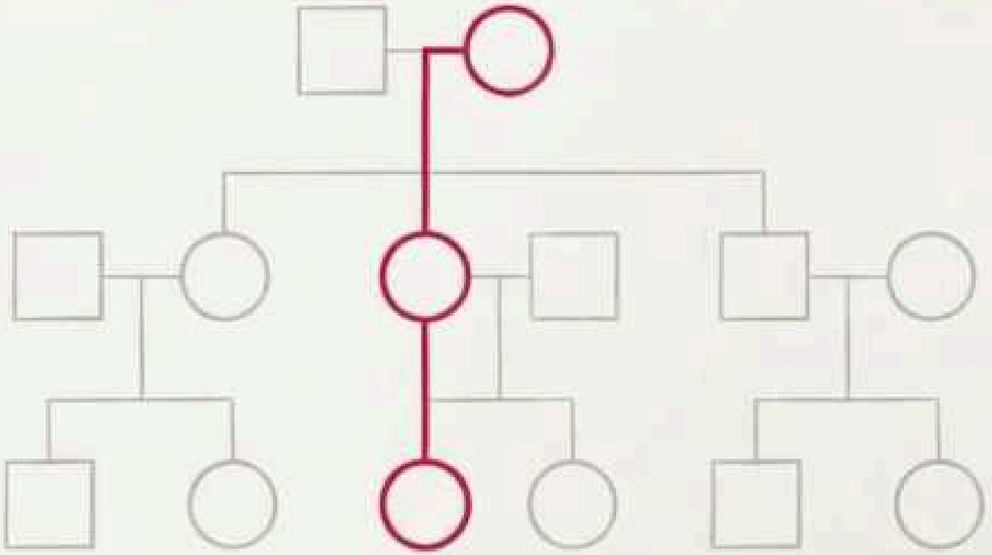
Beyond the Nucleus: Mitochondrial DNA

The Structure



Mitochondria (energy suppliers) contain their own unique DNA.

The Inheritance



Inherited almost entirely from the mother (eggs supply mitochondria; sperm rarely do).

Application: Scientists trace unbroken maternal lines of descent using this mtDNA.

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The Grand Synthesis

Lecture Summary

The Discoverers

Griffith, Avery, and Hershey & Chase established that DNA is the genetic material.

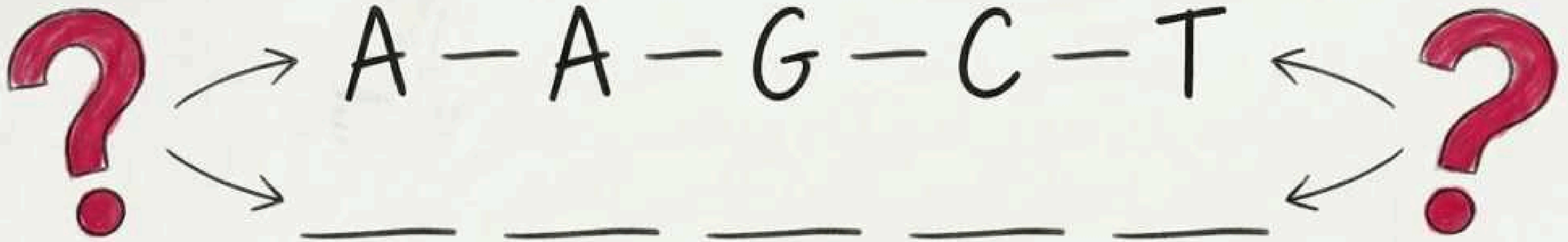
The Structure

Franklin, Wilkins, Watson, & Crick revealed the double helix and its paired bases.

The Function

- Pairing explains copying (each strand is a template).
- Proofreading keeps errors very rare.
- The rare errors that do remain create the variation that heredity works with.

Questions to Consider...



1. Suppose one strand of DNA reads A, A, G, C, T. What is the exact sequence of the matching strand?

2. If a copying mistake changed just one base, what could happen to the organism?

3. Why might a tiny change be completely harmless in one place, but serious in another? (Hint: Think about where the change occurs and what that sequence instructs).