Department of Biotechnology & Microbiology

Topic: DNA as Genetic Material

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RNA World and Origin of Life

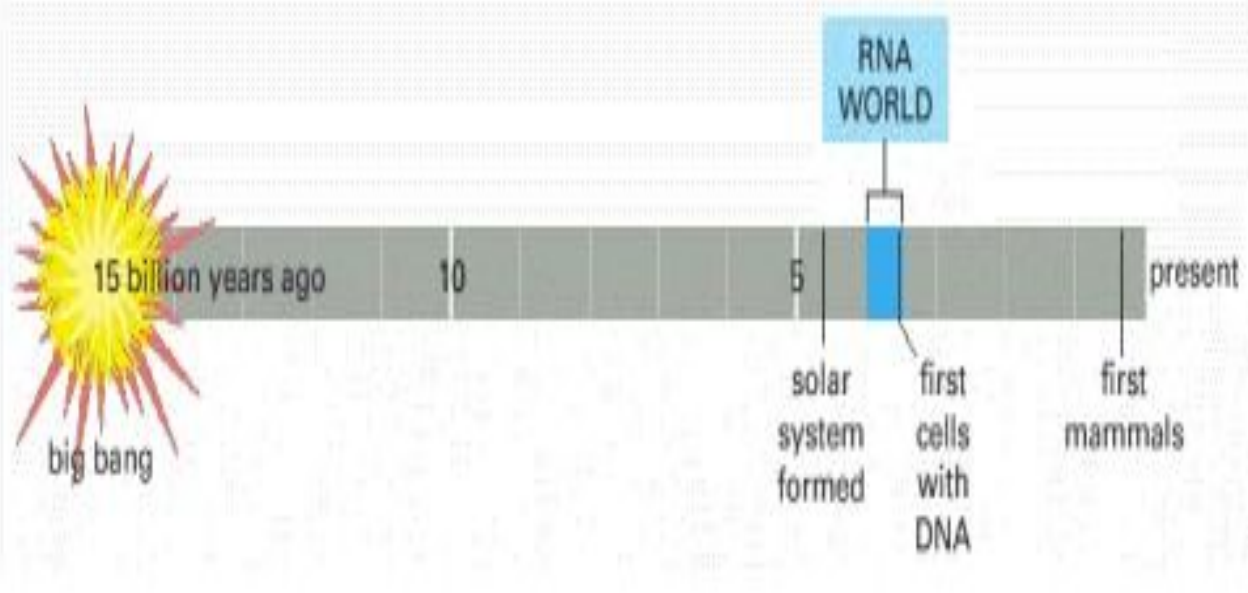
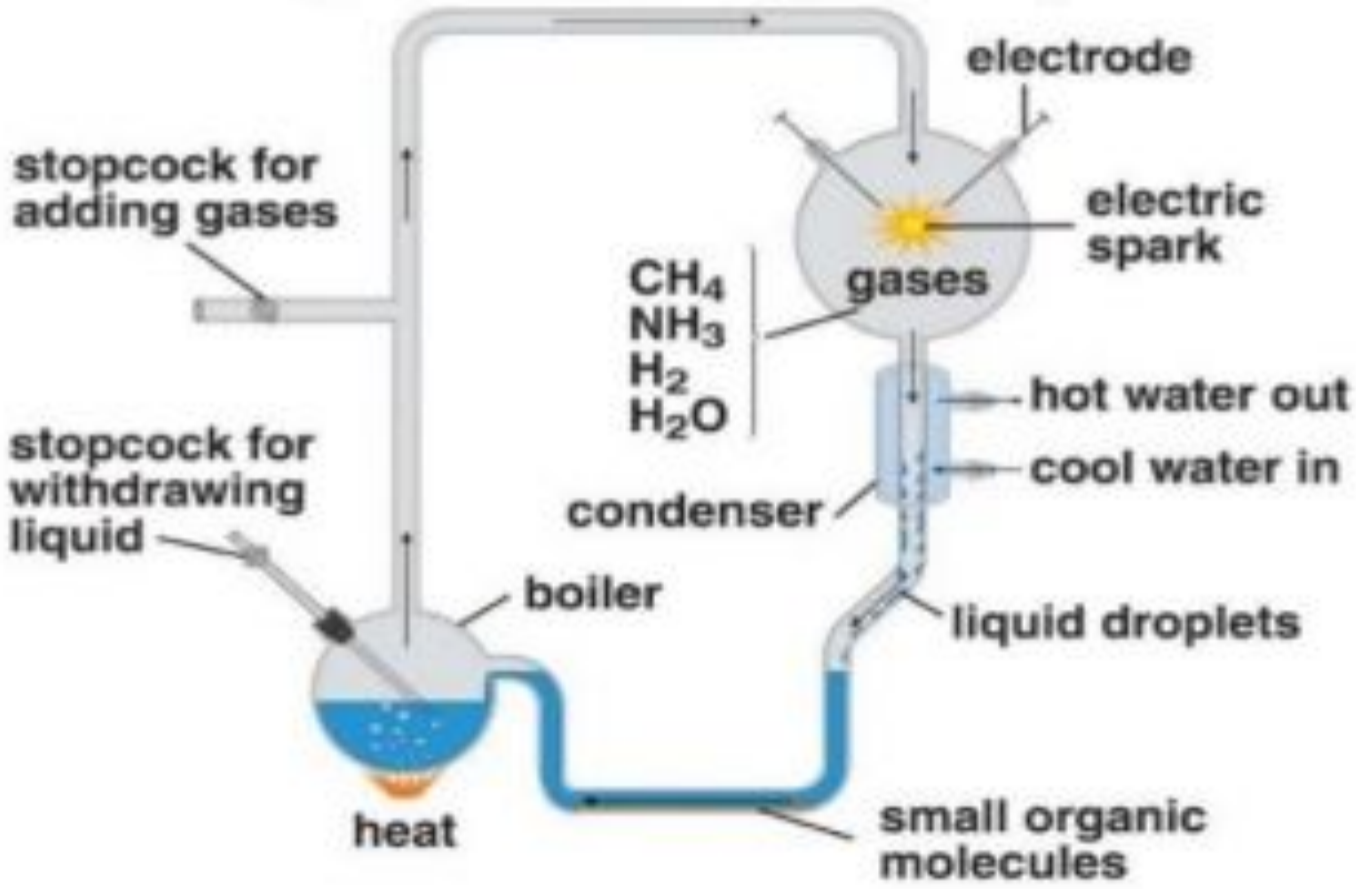


Figure 6-91Time line for the universe, suggesting the early existence of an RNA world of living systems

DNA replaced RNA as genetic material as it was more stable in the present world.

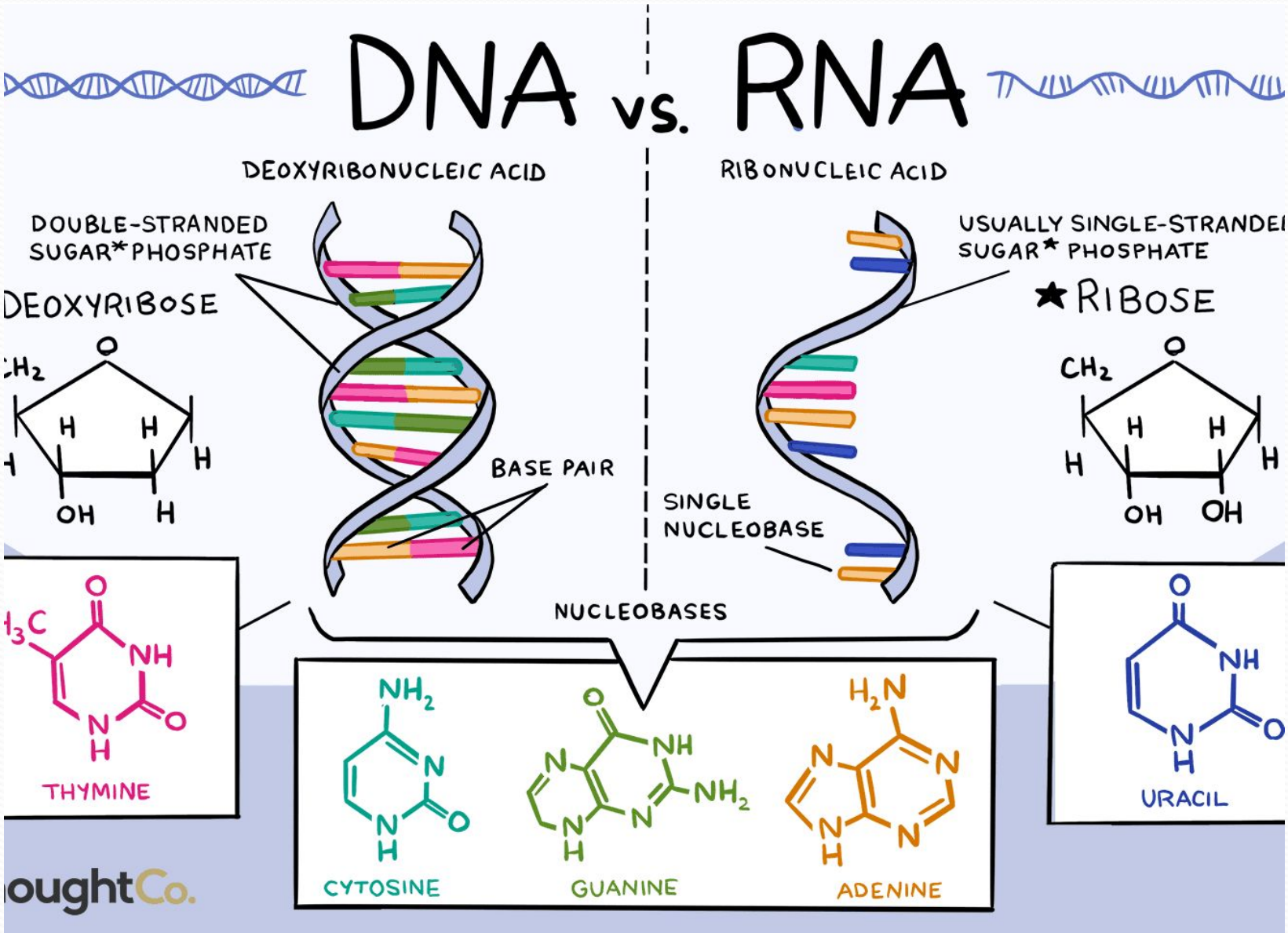
Earth was formed about **4.5 billion years ago,** and the first evidence of life dates to more than **3.5 billion years ago**.

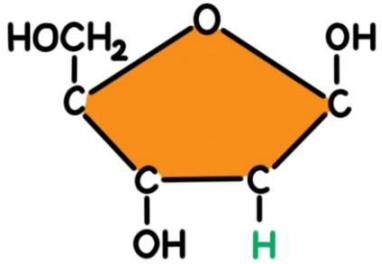
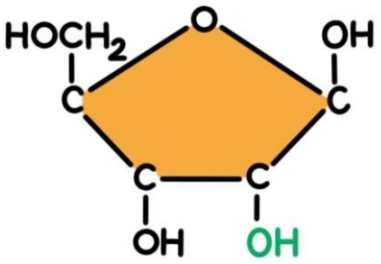
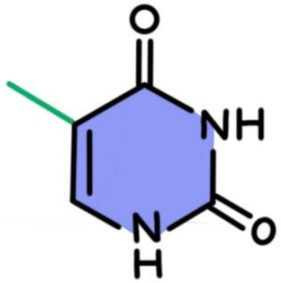
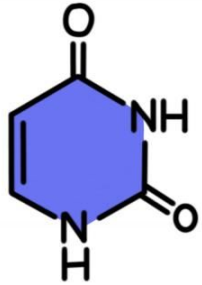
Miller's experiment



- **More refined laboratory experiments** have provided **good evidence** that many of the chemical components of living cells, including polypeptides and **RNA-like molecules,** can form under these conditions.
- **“RNA world” hypothesis:both as catalyst and as information repository.**
- evolution :DNA molecules with sequences complementary to the self-replicating RNA molecules took over the function of conserving the “genetic” information, and RNA molecules evolved to play roles in protein synthesis.

Types of Nucleic acids



	DNA	RNA
SUGAR	 DEOXYRIBOSE	 RIBOSE
BASE	 THYMINE	 URACIL

Chemical Structure of DNA

X-ray diffraction patterns produced by DNA fibers – Rosalind Franklin and Maurice Wilkins

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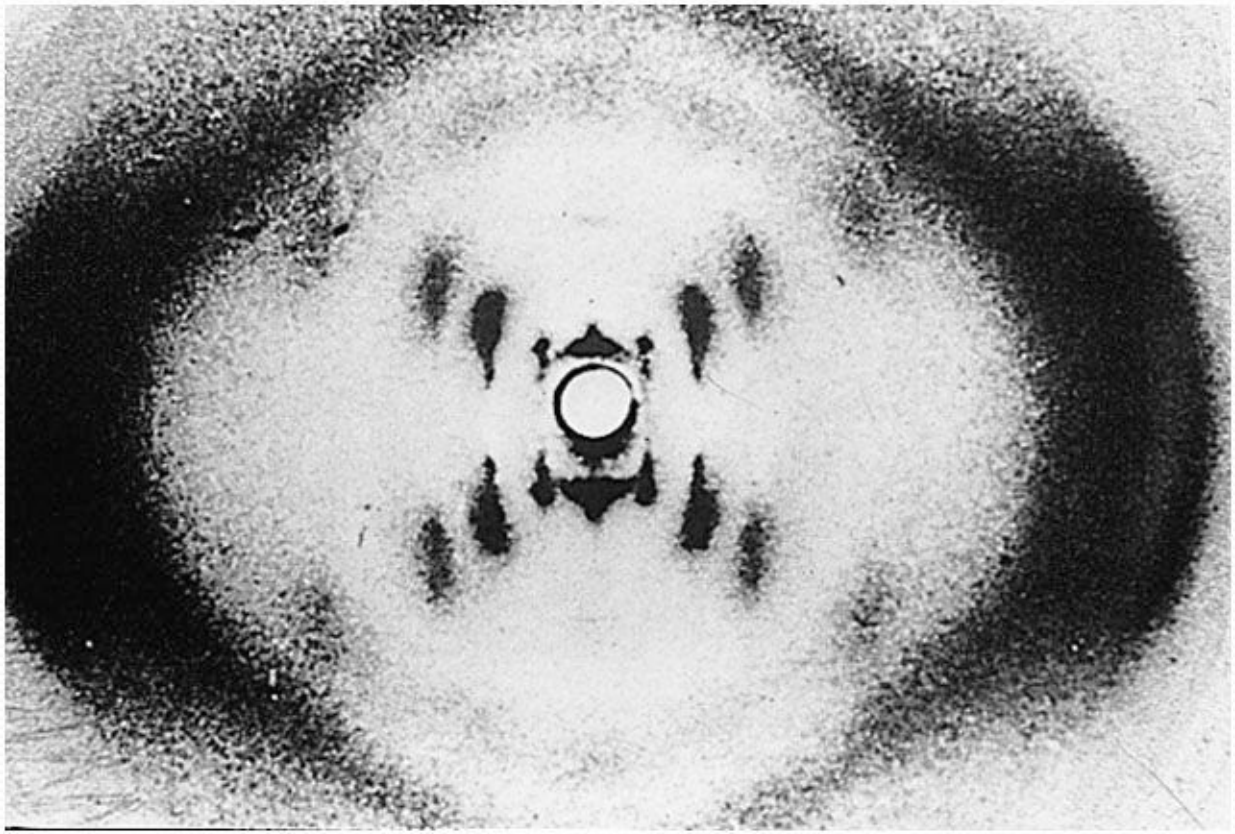
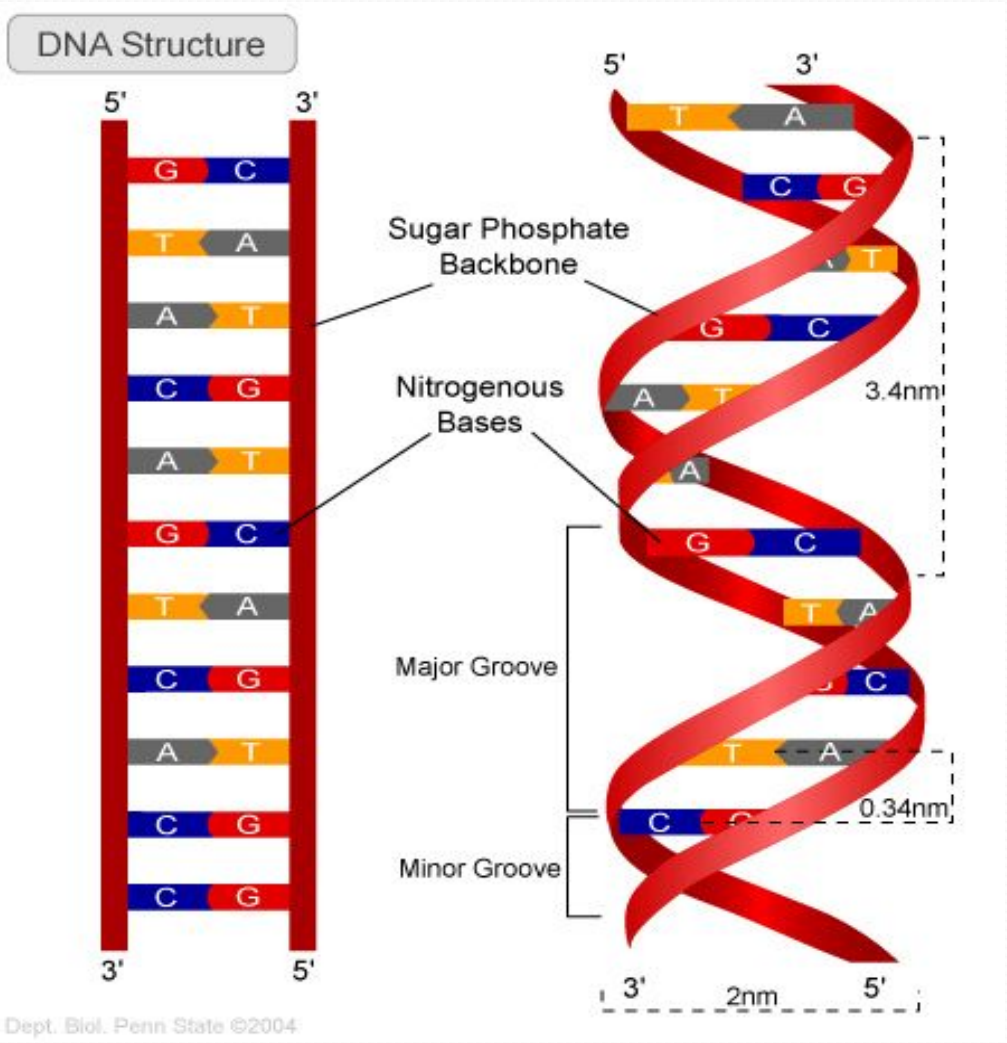


Findings from Rosalind Franklin

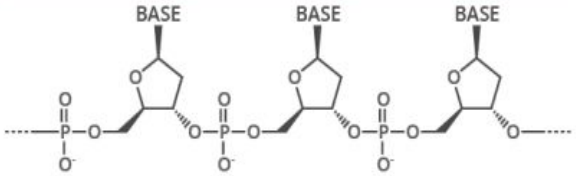
- DNA's helical structure was composed of two strands
- - establish that DNA's diameter was similar throughout
- - calculated that 1 turn was 34 A, distance between base pairs as 3.4A, and 10 nucleotides per helical turn
- - showed that sugar phosphate backbones were located outside of the structure
-

Watson –Crick Model Of DNA



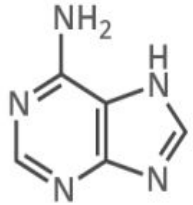
THE CHEMICAL STRUCTURE OF DNA

THE SUGAR PHOSPHATE 'BACKBONE'

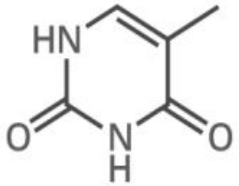


DNA is a polymer made up of units called nucleotides. The nucleotides are made of three different components: a sugar group, a phosphate group, and a base. There are four different bases: adenine, thymine, guanine and cytosine.

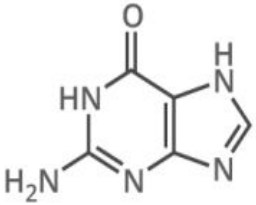
A ADENINE



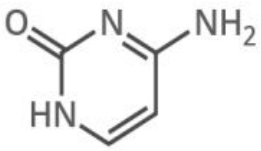
T THYMINE



G GUANINE

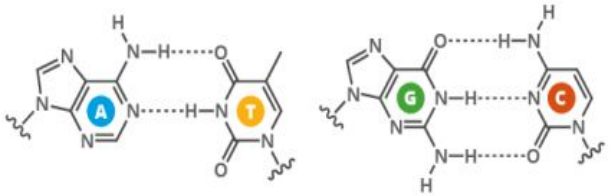


C CYTOSINE



WHAT HOLDS DNA STRANDS TOGETHER?

DNA strands are held together by hydrogen bonds between bases on adjacent strands. Adenine (A) always pairs with thymine (T), while guanine (G) always pairs with cytosine (C). Adenine pairs with uracil (U) in RNA.



FROM DNA TO PROTEINS

The bases on a single strand of DNA act as a code. The letters form three letter codons, which code for amino acids - the building blocks of proteins.

An enzyme, RNA polymerase, transcribes DNA into mRNA (messenger ribonucleic acid). It splits apart the two strands that form the double helix, then reads a strand and copies the sequence of nucleotides. The only difference between the RNA and the original DNA is that in the place of thymine (T), another base with a similar structure is used: uracil (U).

In multicellular organisms, the mRNA carries genetic code out of the cell nucleus, to the cytoplasm. Here, protein synthesis takes place. 'Translation' is the process of turning the mRNA's 'code' into proteins. Molecules called ribosomes carry out this process, building up proteins from the amino acids coded for.

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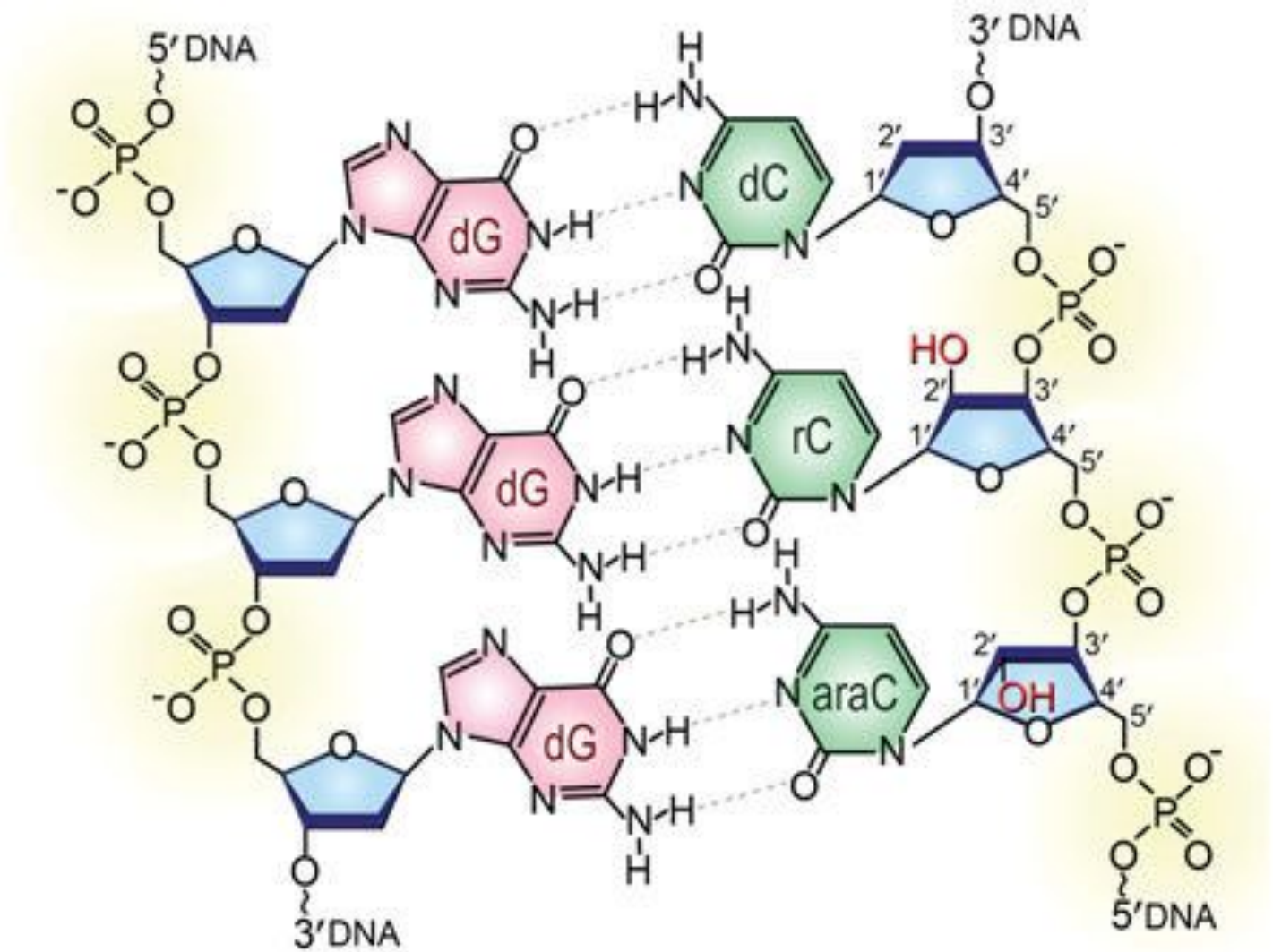
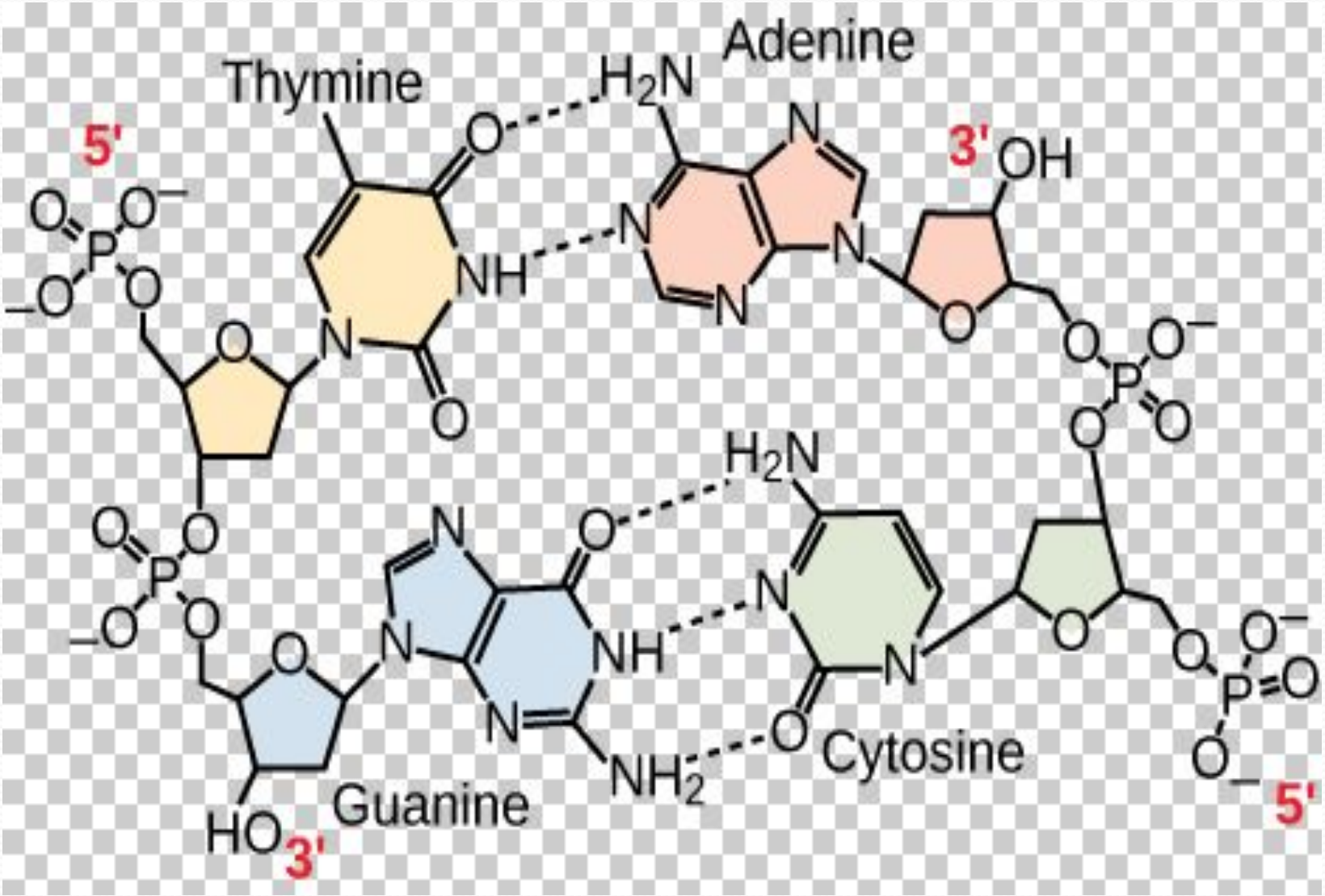
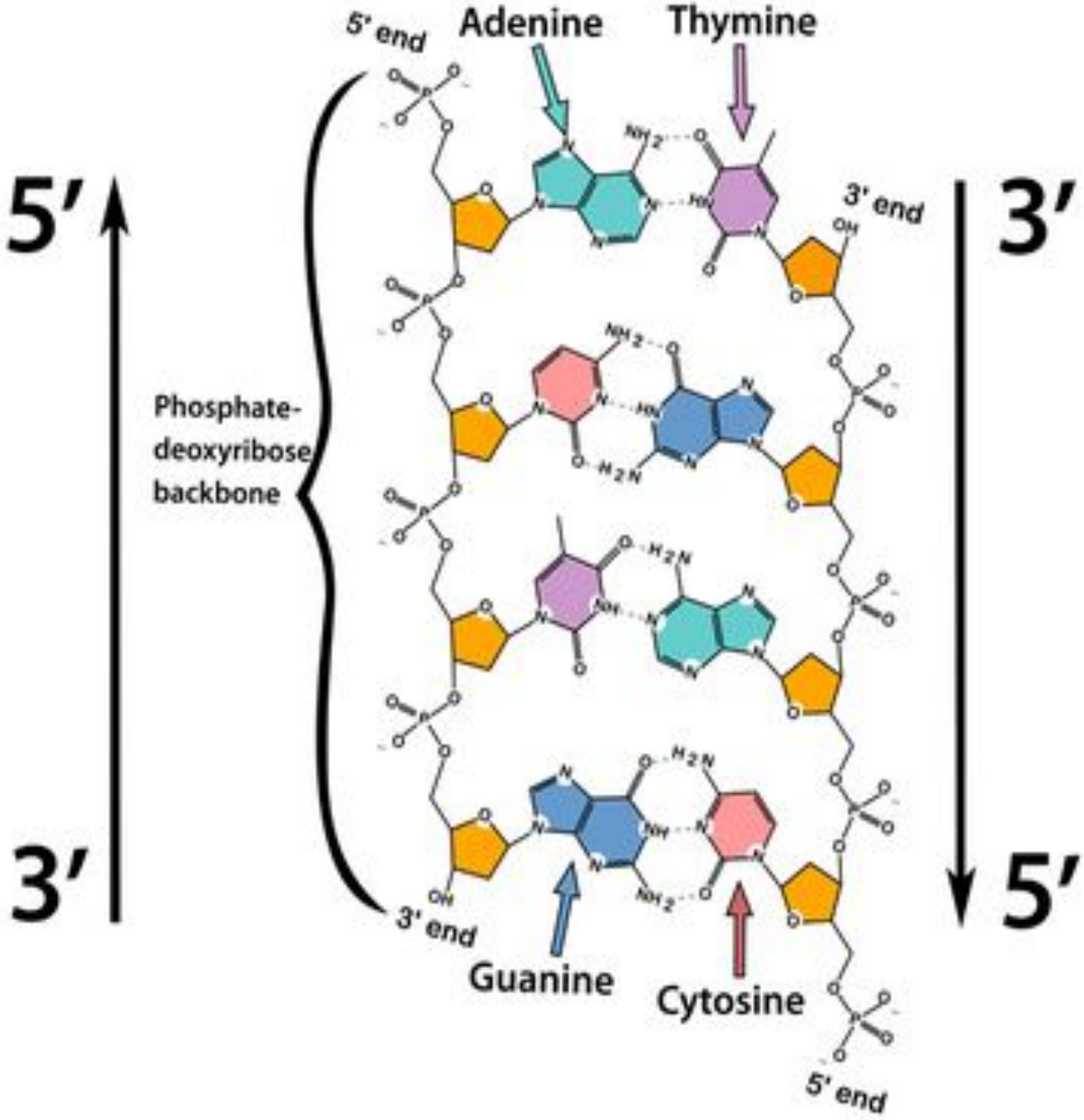
Sugar-phoshatebackbone of Nucleotide



Antiparellel structure



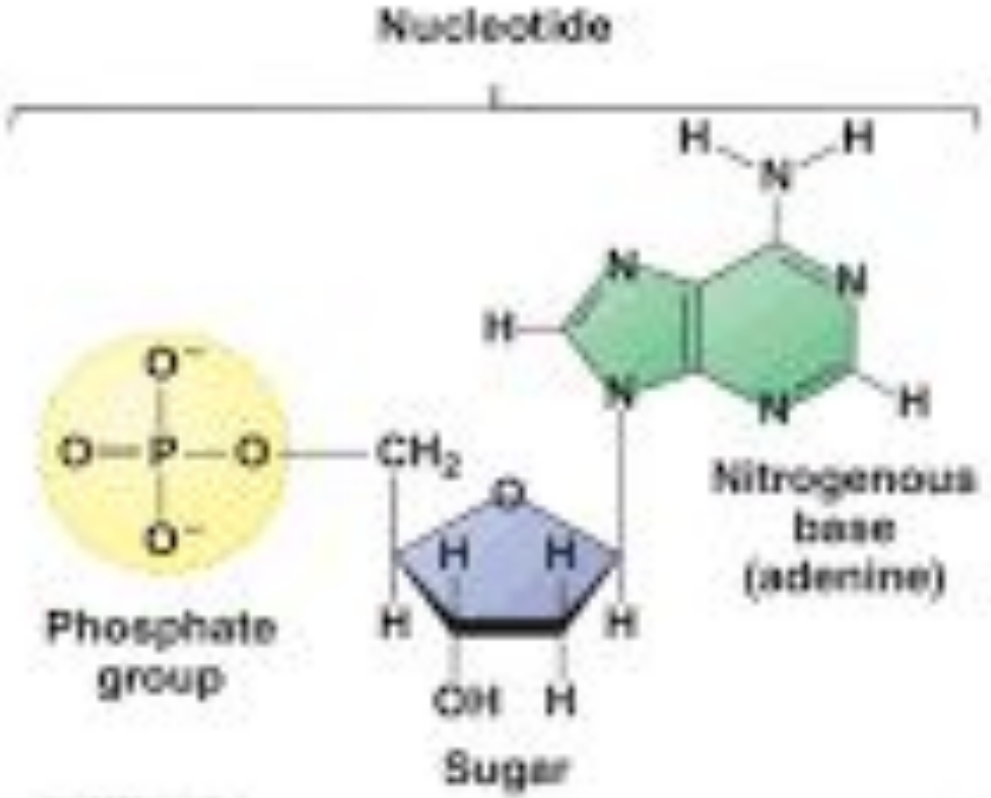

5' end
Adenine
Thymine
3' end
5′
3′
Phosphate-
deoxyribose
backbone
3′
5′
3' end
Guanine
Cytosine
5' end

DNA and RNA chemical unit

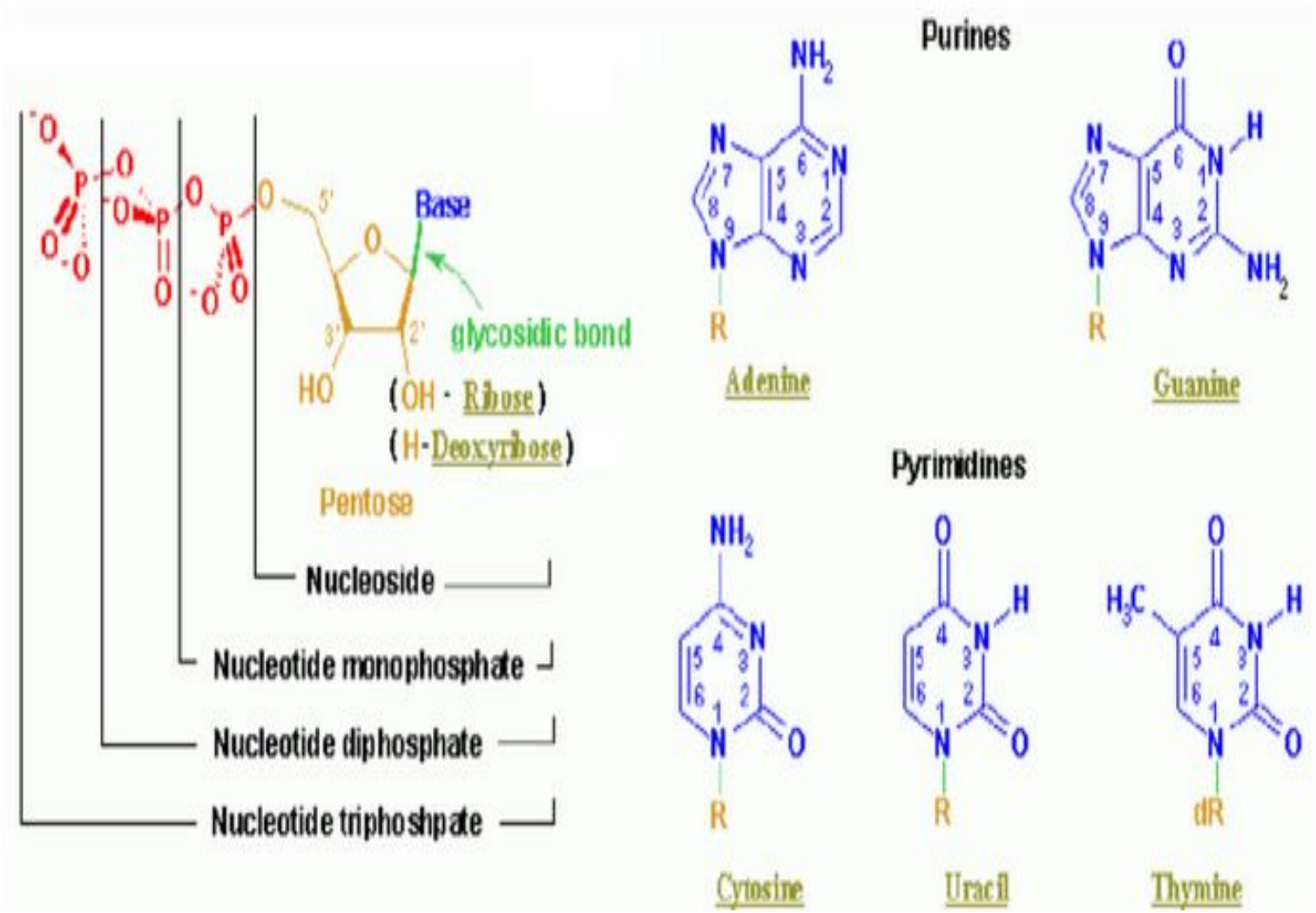
- The chemical unit that makes nucleic acids (DNA and RNA) is called **Nucleotide.**

- A **nucleotide** is composed of:

1. Sugar
2. Phosphate group
3. Nitrogenous base



Chemical structure of nitrogenous Bases



Complementary Base Pairing

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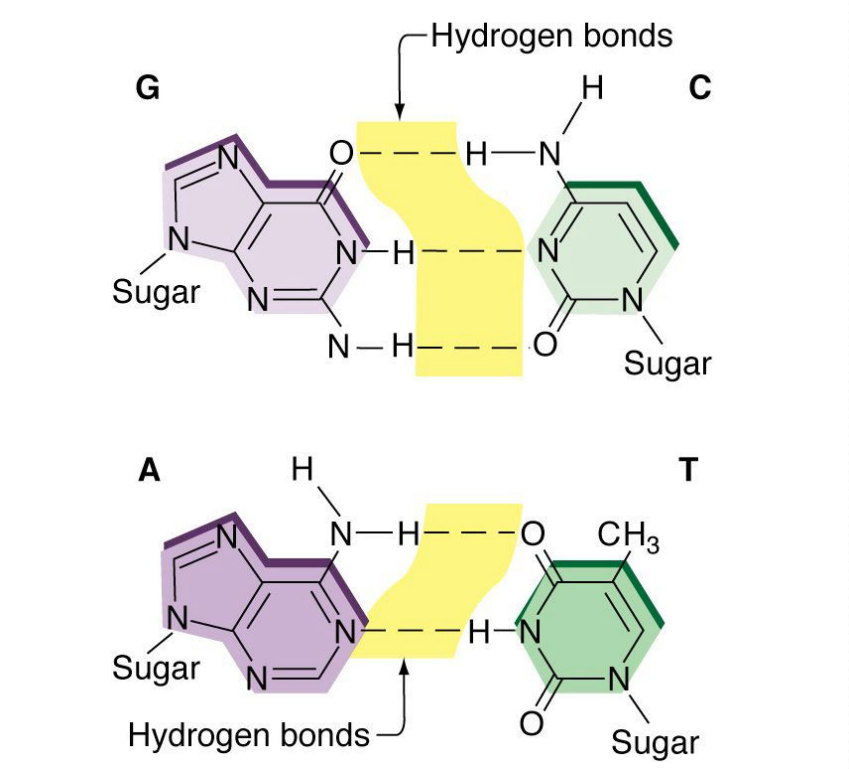


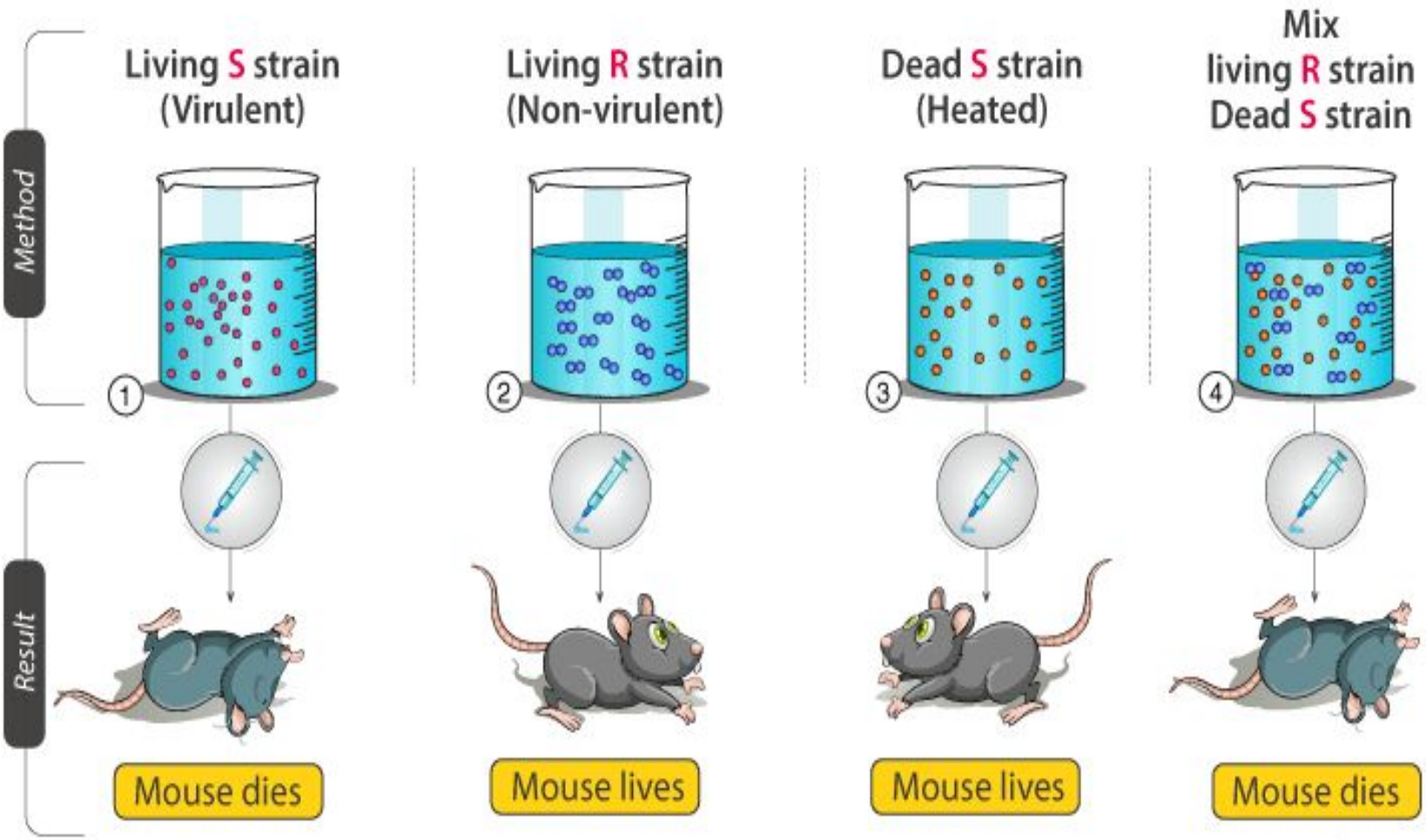
- – three hydrogen bonds
- between C and G;
- –two hydrogen bonds
- between A and T.

Experimental Proof To Show DNA as the Genetic Material

- 1928 – Frederick Griffith – experiments with smooth (S), virulent strain *Streptococcus pneumoniae, and rough (R), nonvirulent strain*– Bacterial transformation demonstrates transfer of genetic material
- • 1944 – Oswald Avery, Colin MacLeod, and MacIyn McCarty — determined that DNA is the transformation material.

- Hershey and Chase experiment- 1952 – Alfred Hershey and Martha Chase provide convincing evidence that DNA is genetic material

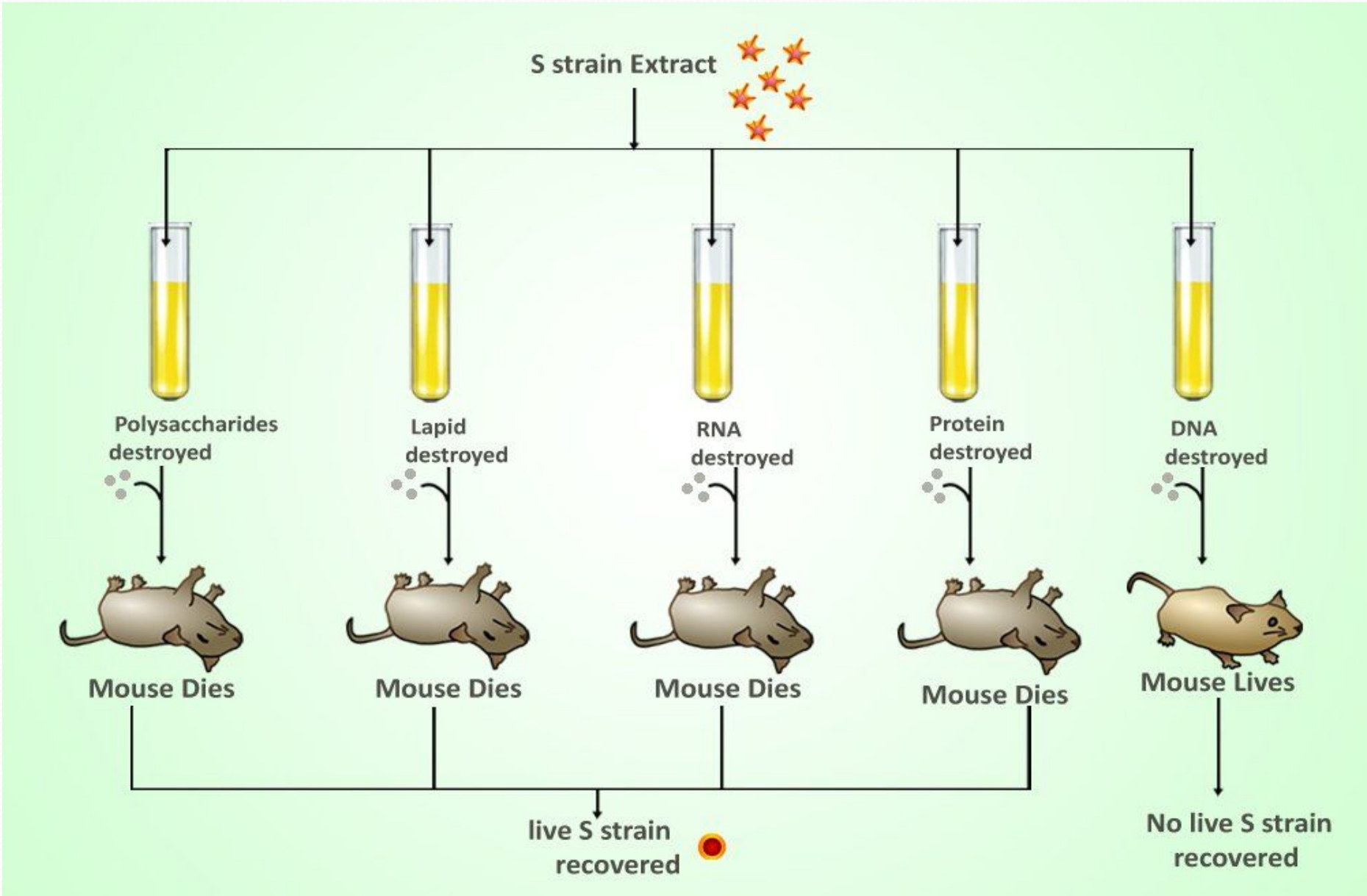
GRIFFITH EXPERIMENT & TRANSFORMING PRINCIPLE



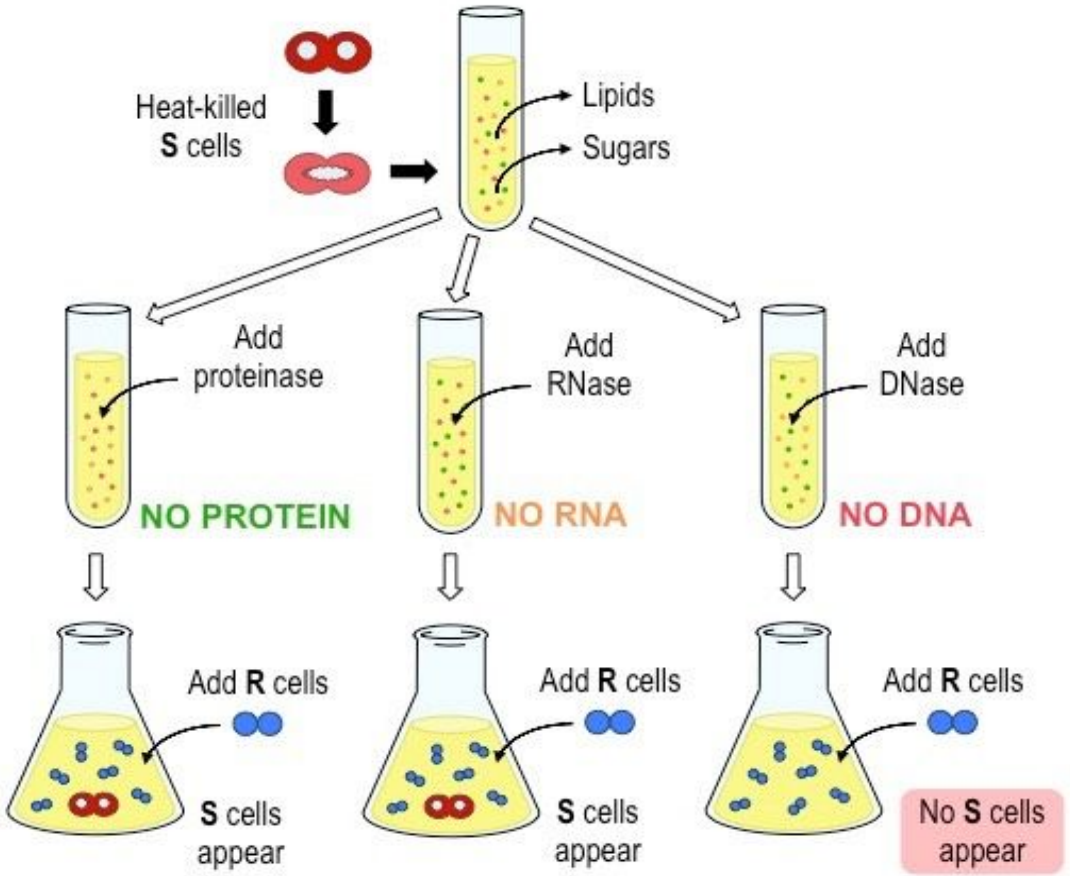
Griffith Experiment

- Griffith observed that live S bacteria could kill mice injected with them.
- When he heat killed the S variants and mixed them with live R variants, and then injected the mixture in the mice, they died.
- Griffith was able to isolate the bacteria from the dead mice, and foundthem to be of the S variety.
- Thus the bacteria had been *Transformed from the rough to the smooth* version.
- *The ability of a substance to change the genetic characteristics of an organism is known as transformation.*
- Scientists set out to isolate this 'transforming principle' since they were convinced it was the carrier of the genetic information

Avery, MacLeod, McCarty Experiment: Identity of the Transforming Principle



Hypothesis: The genetic material of the cell is either protein or nucleic acid (DNA or RNA)



Remove lipids and sugars from a solution of heat-killed **S** cells.

Proteins, RNA and DNA remain

Treat solutions with enzymes to destroy protein, RNA or DNA

Add to culture containing living **R** cells.

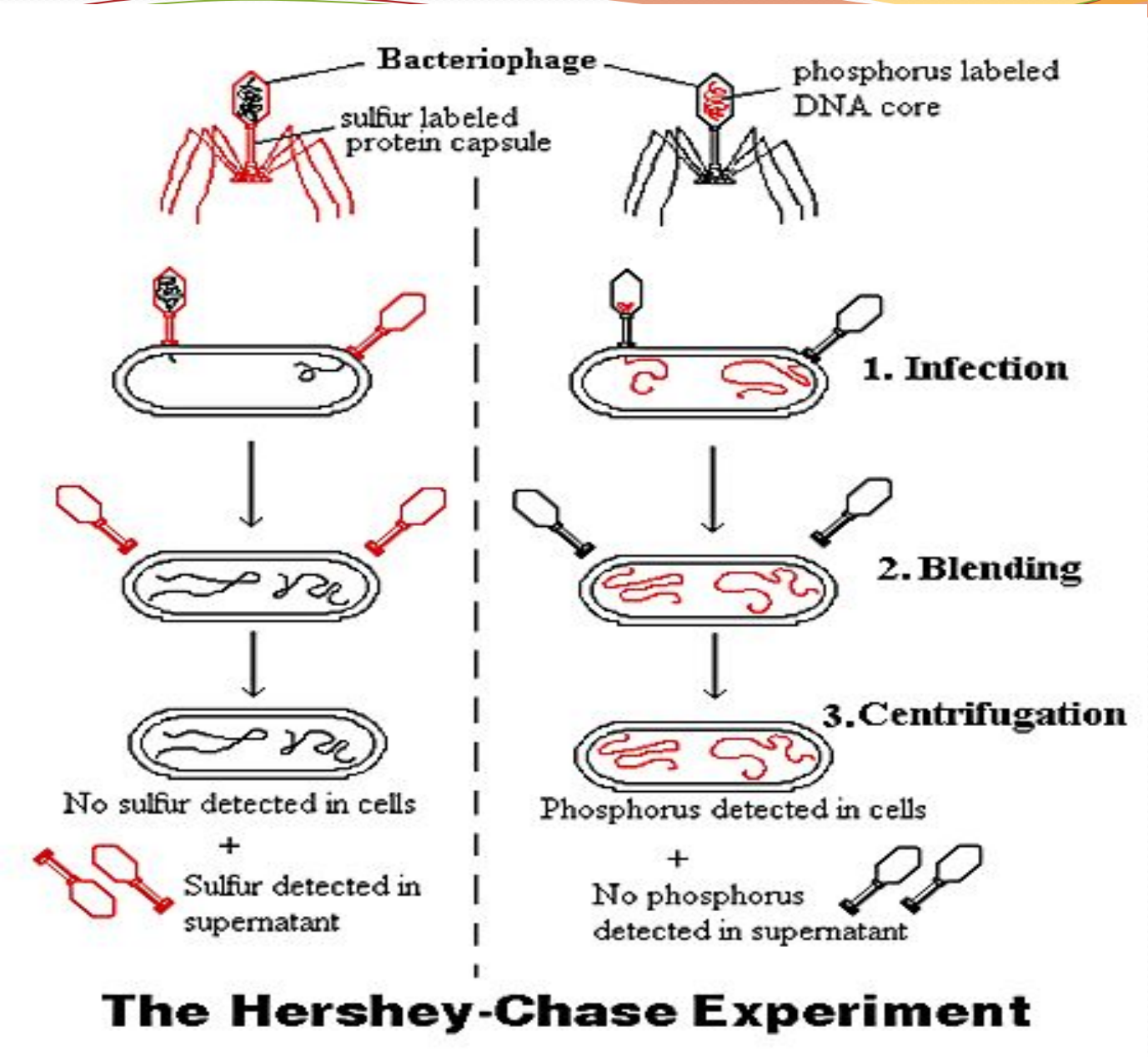
Observe for transformation by testing for the presence of virulent **S** cells

Conclusion: Transformation requires DNA, therefore it is the genetic material of the cell

Hershey and Chase Experiment

- 1952 – Alfred Hershey and Martha Chase provide convincing evidence that DNA is genetic material
- Did experiment using T2 bacteriophage and bacteria.
- Radioactive labels 32P for DNA and 35S for protein were used.

- Hershey and Chase experiment
- Performed in 1952, using bacteriophage, a type of virus that have a very simple structure: – an outer core and an inner component.
- The phage are made up of equal parts of protein and DNA.
- It was known that the phage infect by anchoring the outer shell to the cell surface and then deposit the inner components to the cell, infecting it.
- Scientists were interested in finding out whether it was the protein component or the DNA component that got deposited inside the infected cell.
- By incorporating radiolabel either in the protein or the DNA of the infecting phage, – they determined that the DNA was indeed introduced into the infected bacteria, causing proliferation of new phage.


Bacteriophage
sulfur labeled protein capsule
phosphorus labeled DNA core
1. Infection
2. Blending
3. Centrifugation
No sulfur detected in cells
+
Sulfur detected in supernatant
Phosphorus detected in cells
+
No phosphorus detected in supernatant
The Hershey-Chase Experiment

Thankyou