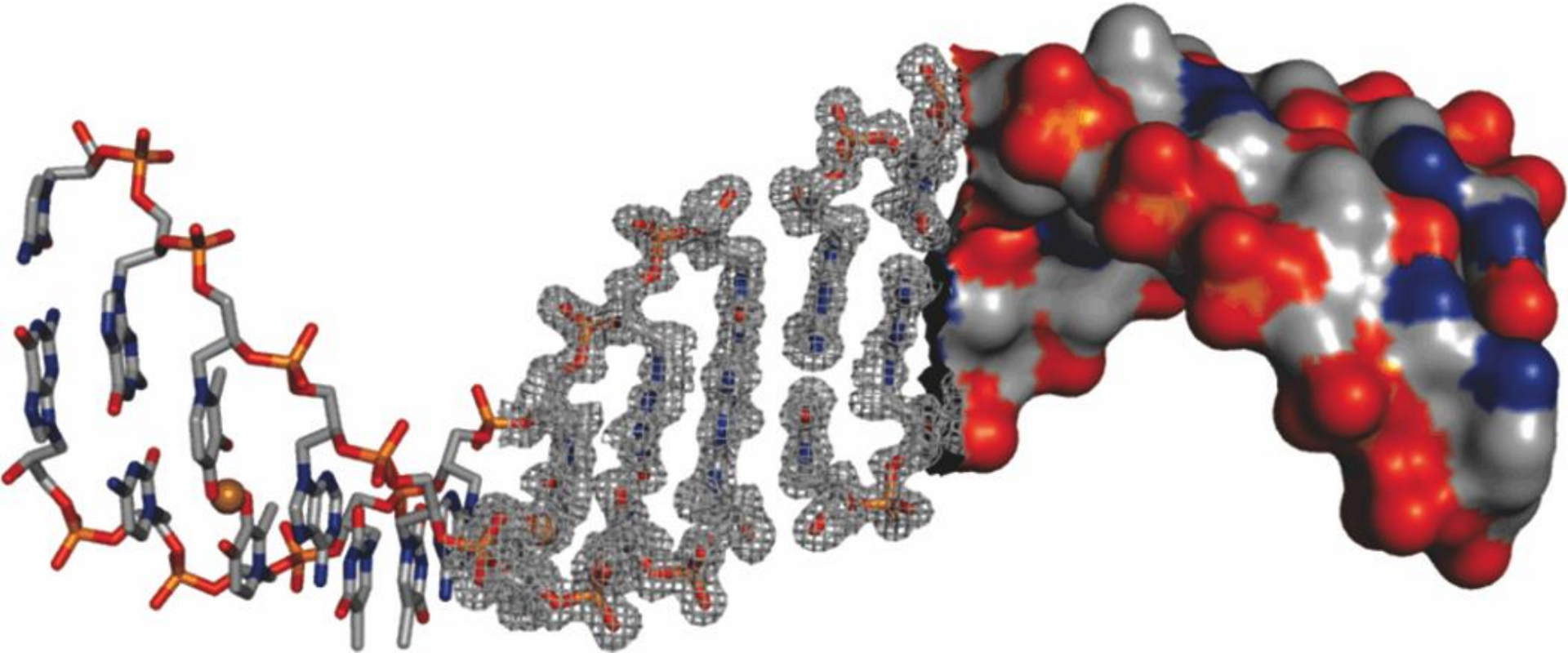
NUCLEIC ACIDS!

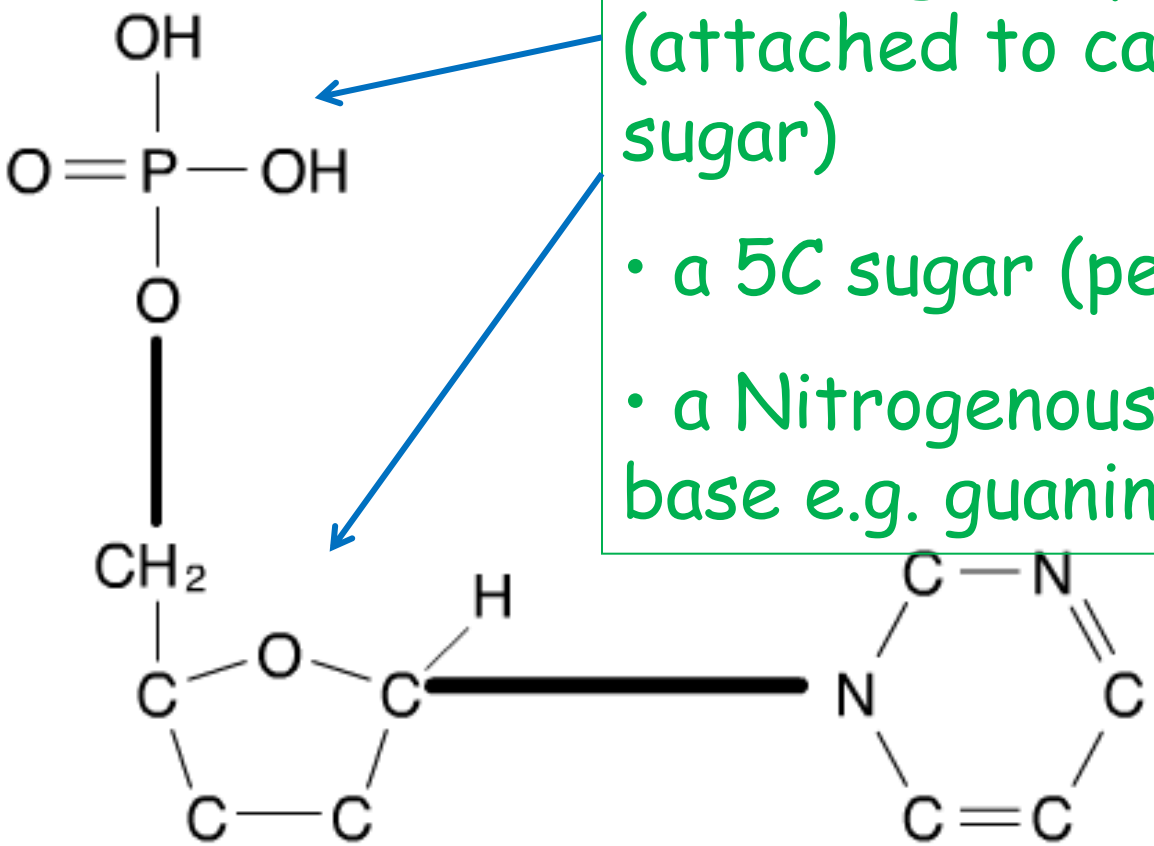
Nucleic acids are found in all living cells and viruses and the two main types are DNA and RNA. They are macromolecules made of chains of nucleotides bonded together. They carry genetic information that codes for the creation of proteins (DNA also codes for the creation of RNA). Genetic information is passed from one generation to the next via the DNA.



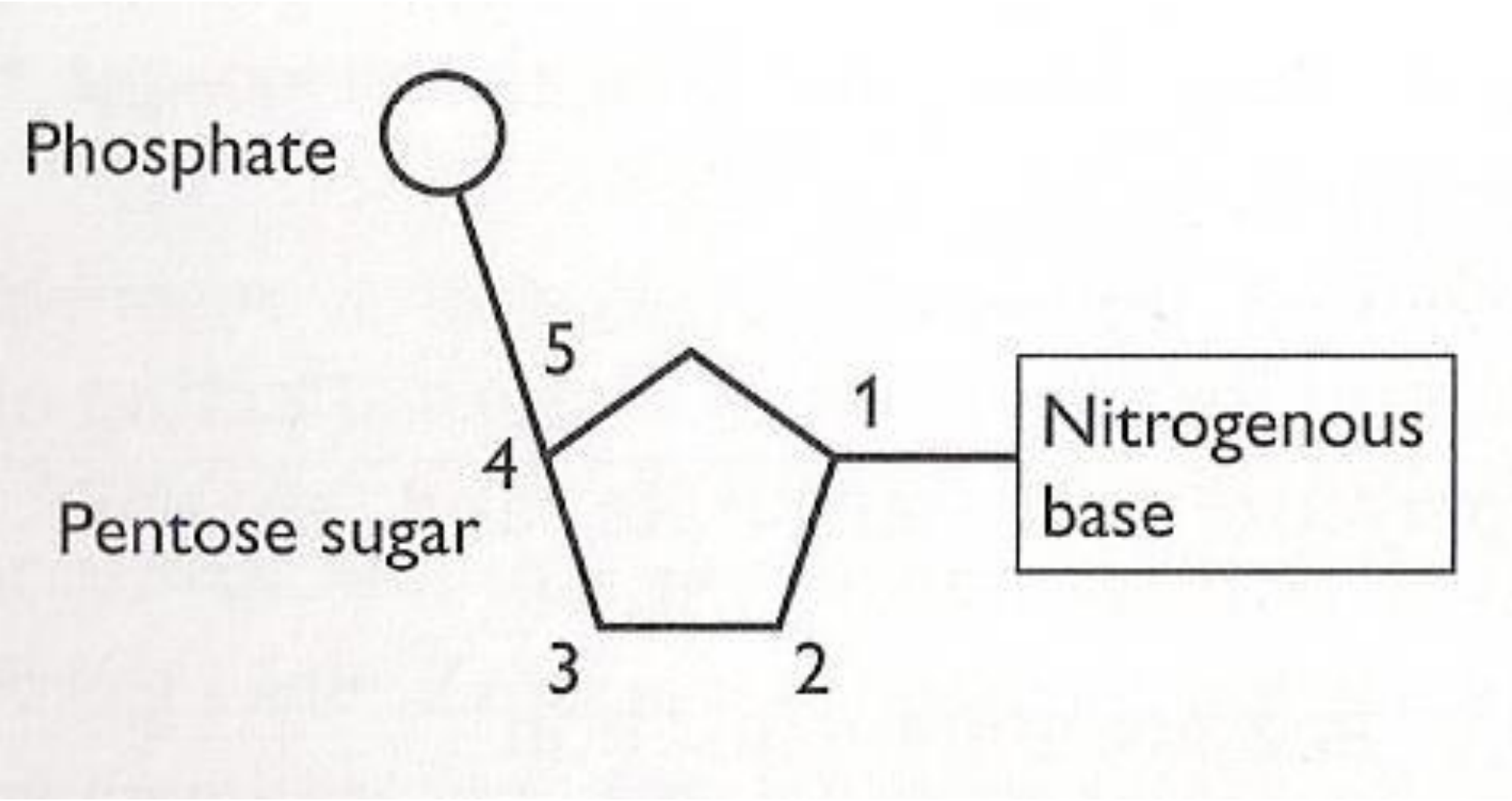
A **nucleic acid** is composed of a long string of nucleotides

A nucleotide consists of:

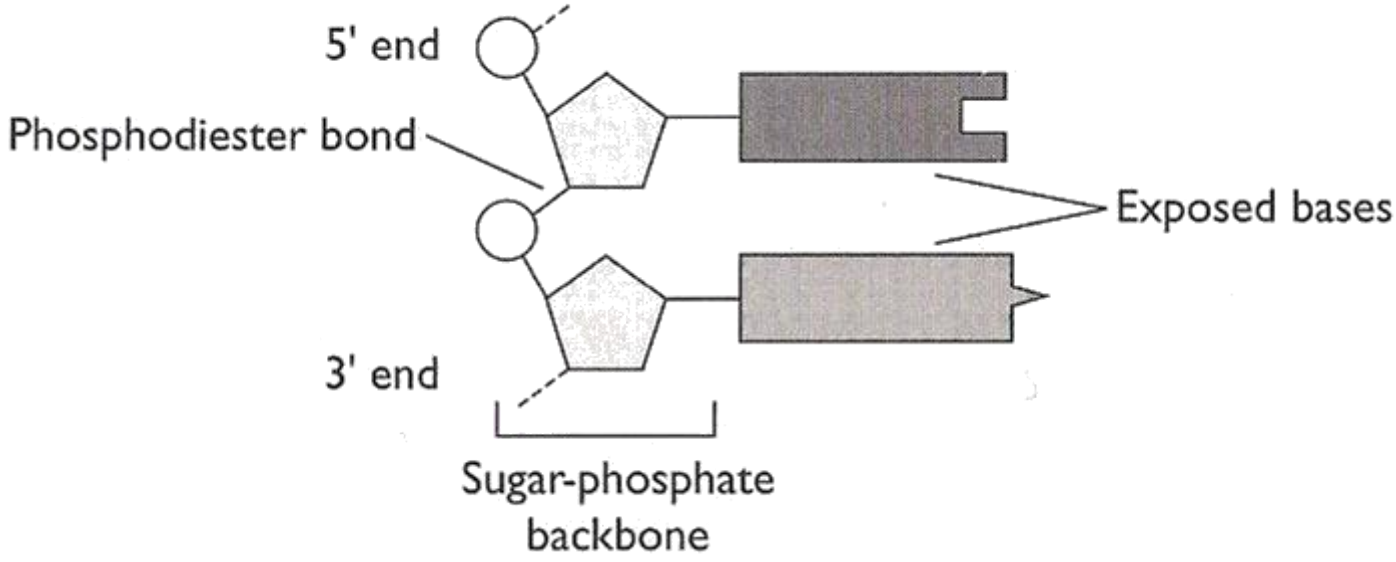
- an inorganic phosphate group (attached to carbon 5 of the sugar)
- a 5C sugar (pentose)
- a Nitrogenous (N containing) base e.g. guanine



One nucleotide (sub unit of nucleic acids)



- Nucleotides join together by condensation reactions to form a nucleic acid e.g. DNA or RNA
- A strong covalent **phosphodiester** bond forms between the phosphate group of 1 nucleotide and the carbon 3 of the pentose of another (forms a **sugar-phosphate backbone** to the DNA strand)
- The polynucleotide strand that is formed has a free 5' end and a free 3' end (referring to the carbon atoms)
- The nucleic acid can be hydrolised to release the nucleotides

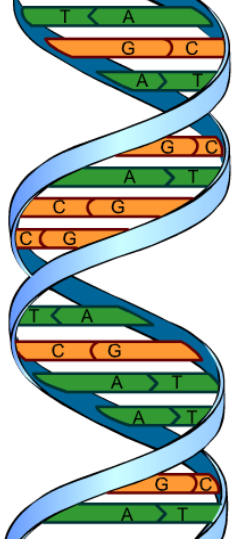


DNA – Deoxyribonucleic acid

- DNA nucleotides are made up of:
  - 1 phosphate group
  - 5C sugar Deoxyribose
  - 1 of 4 organic bases:

A – **Adenine**
T – **Thymine**
G – **Guanine**
C - **Cytosine**

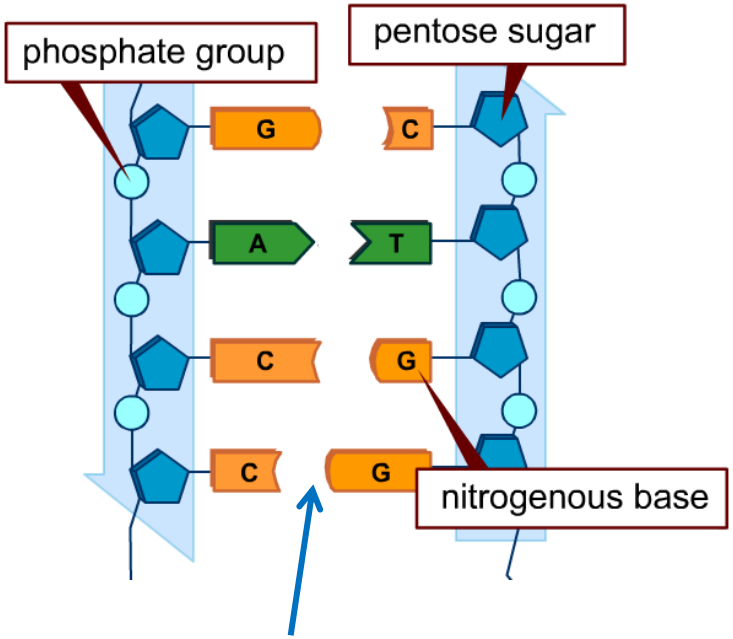
- The DNA molecule is a **double helix**



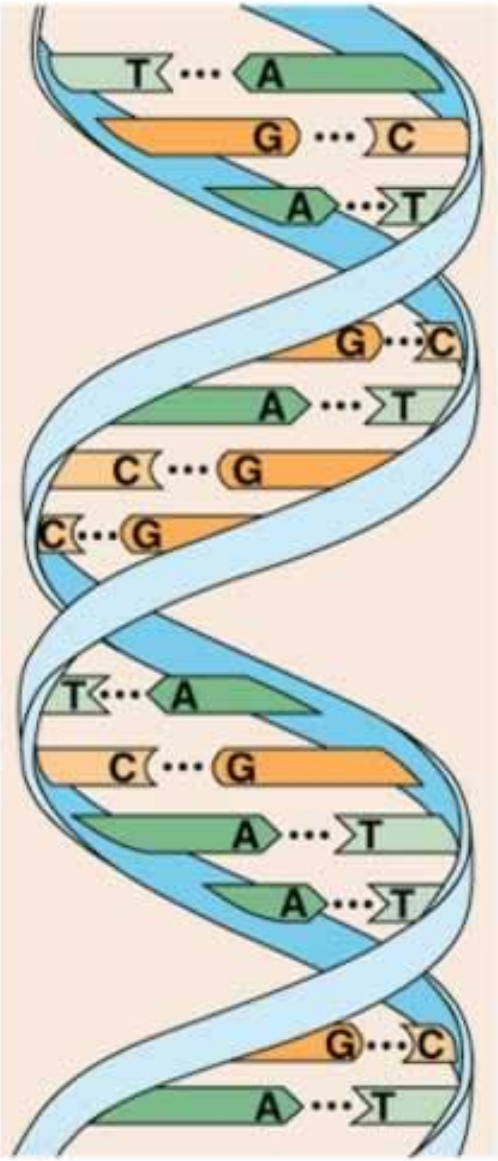
- It is made up of 2 strands joined together by **H-bonds between the bases. This increases the molecules stability**

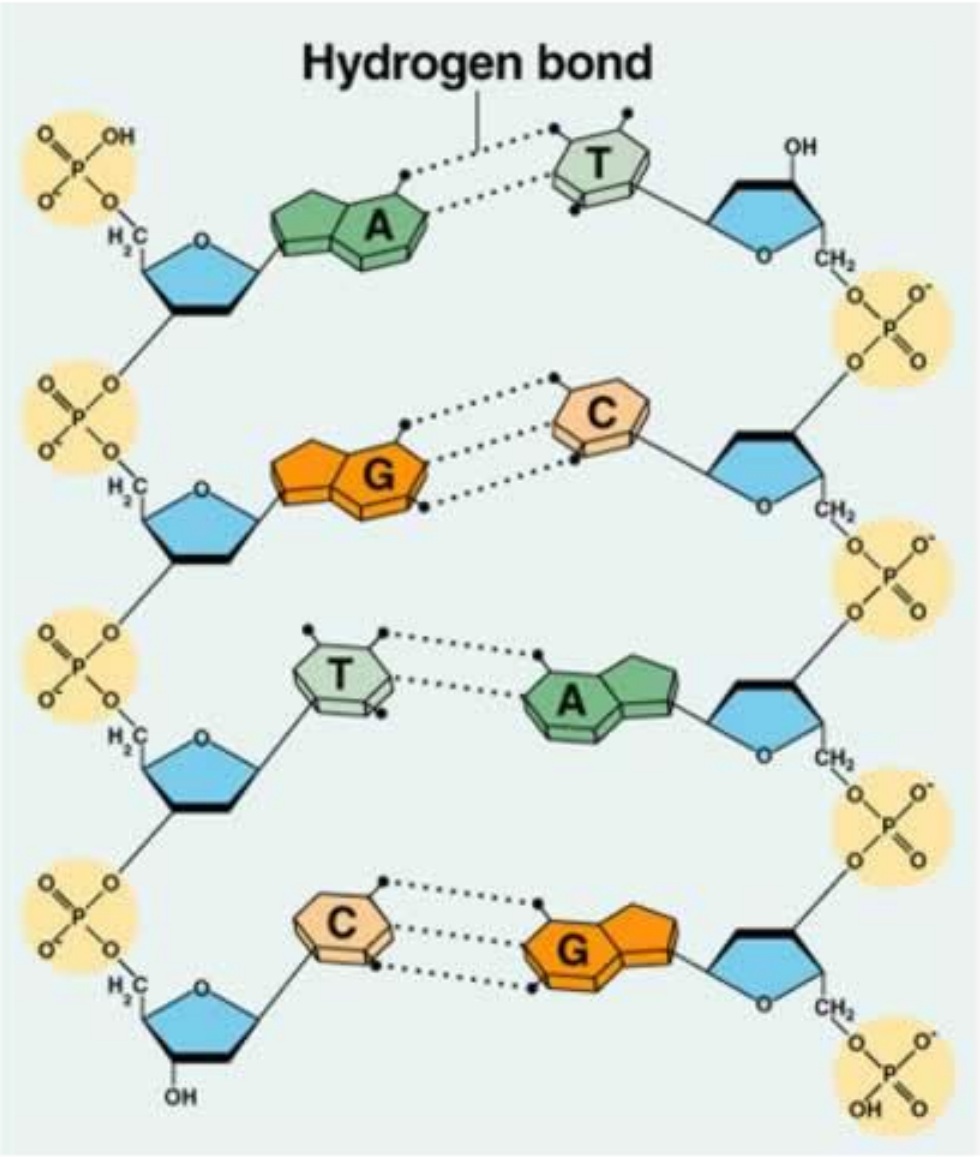
- The bases form specific complementary pairs i.e. Always A with T and C with G

- The 2 strands are "Anti-parallel" i.e. They run in opposite directions



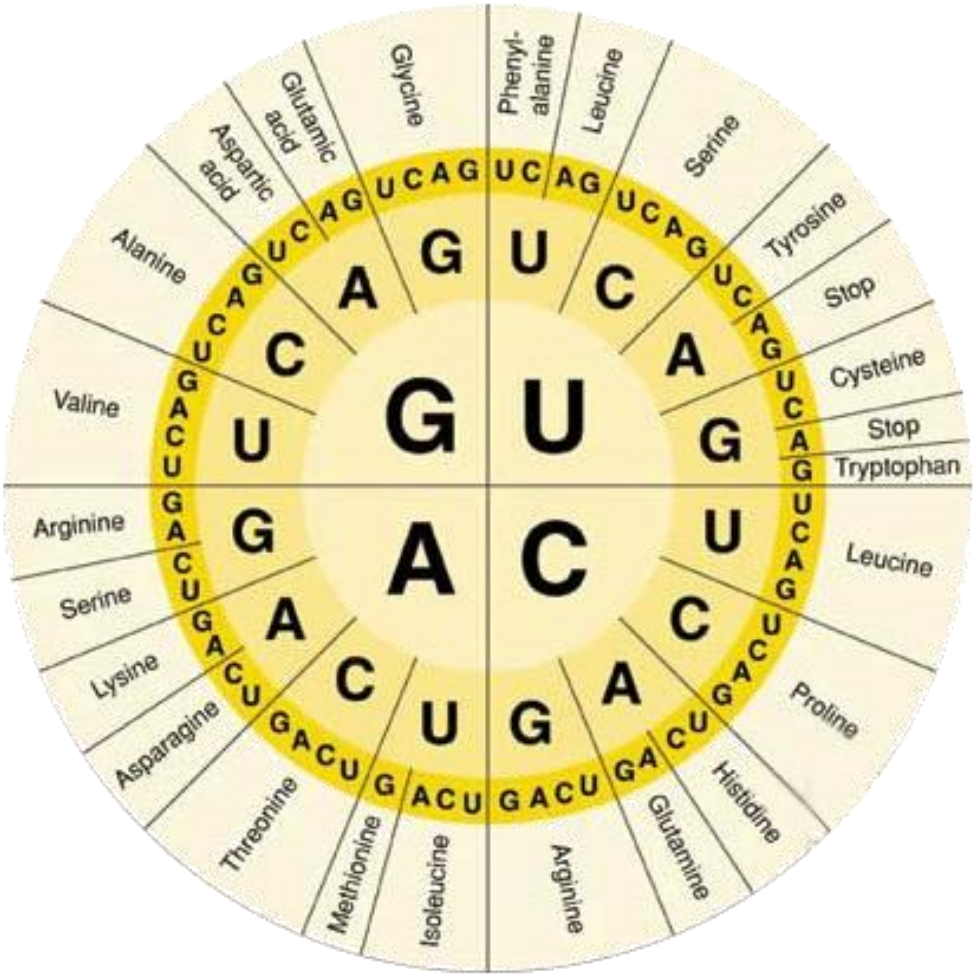
(3 hydrogen bonds between C and G; 2 between A and T)



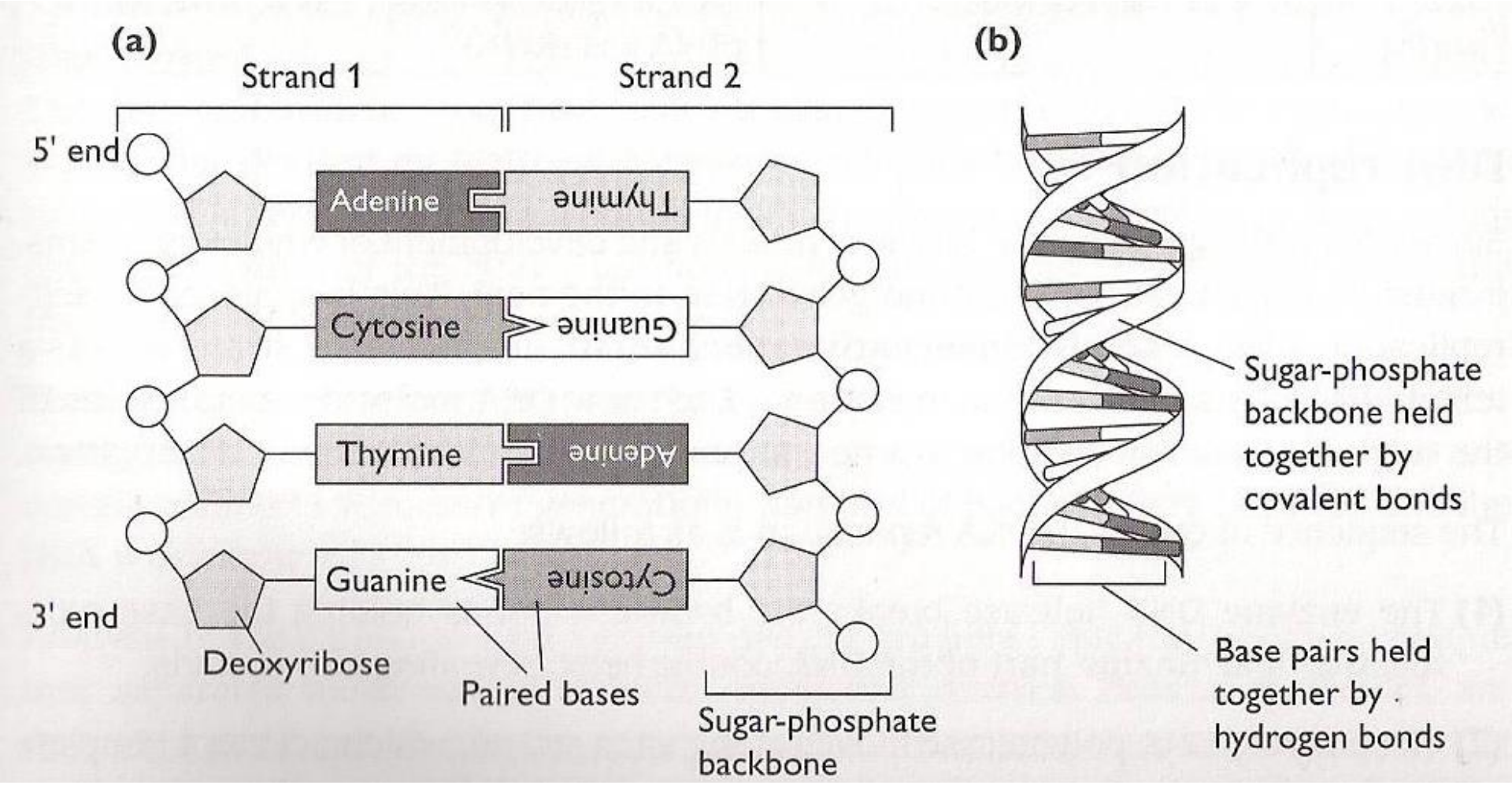


- The sequence of organic bases makes up the genetic code (e.g. C-G-T-G-G-T-A-C etc)
- This code is what determines the sequence of amino acids in a polypeptide chain
- Lengths of DNA that carry the genetic code for proteins are called genes

- A triplet of 3 bases is called a codon. This codes for one amino acid. Sets of consecutive codons in a gene will thus code for a polypeptide (protein)



Bonds holding the double helix together



RNA – Ribonucleic acid

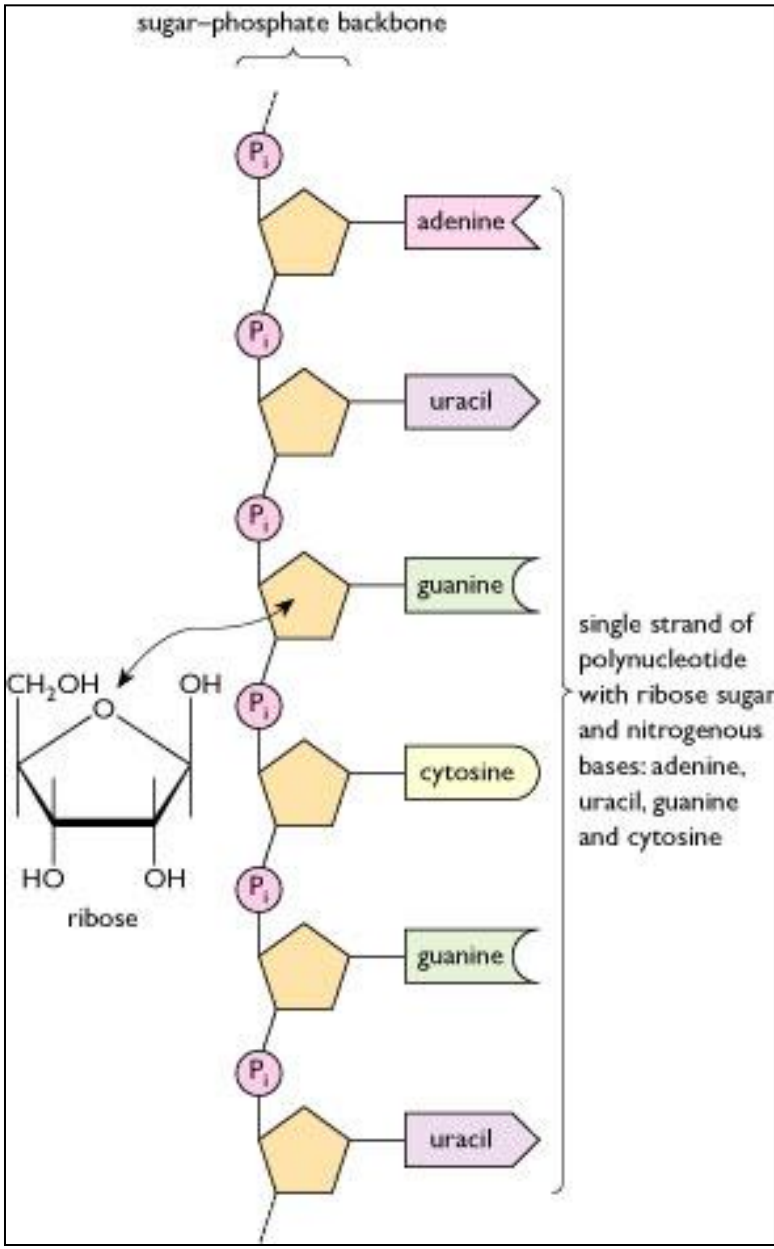
- RNA nucleotides are made up of:
  - 1 phosphate group
  - 5C sugar Ribose
  - 1 of 4 nitrogenous bases (note the addition of "U" in place of "T"):

    U - **Uracil**

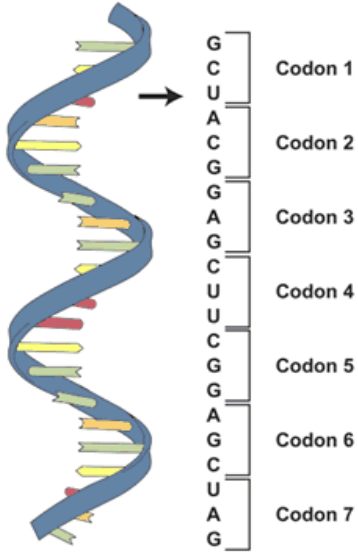
    A - **Adenine**

    G – **Guanine**

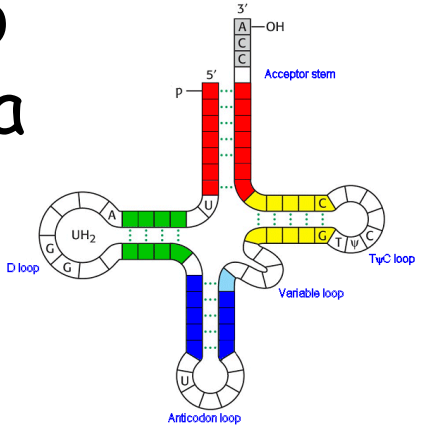
    C - **Cytosine**



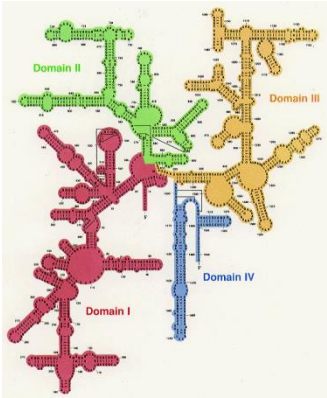
There are three main types of RNA:



- **Messenger RNA (mRNA) –** carries the code for the synthesis of a protein in the cytoplasm from the DNA in the nucleus



- **Transfer RNA (tRNA) –** carries the amino acid to the ribosome to be linked to form a polypeptide (protein synthesis). tRNA is folded into clover leaf shape with H bonds between the folds

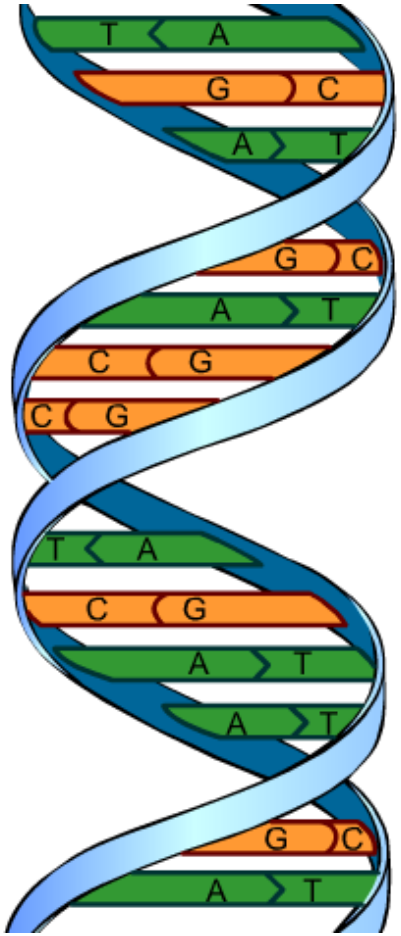


- **Ribosomal RNA (rRNA) –** forms part of the structure of a ribosome (cell organelle that performs protein sysnthesis)

Comparison of DNA and RNA...

Feature	DNA	RNA
Subunits:	Deoxyribonucleotides (contains deoxyribose sugar and thymine)	Ribonucleotides (contains ribose and uracil)
Length:	Very long	Relatively short
Types:	One (though nucleotide sequences differ)	Three types: mRNA, tRNA, rRNA
Strands:	Double stranded	Single strands (although tRNA and rRNA have bonded folds)
Base pairing:	A with T, G with C	No base pairing (except the joining folds of tRNA and rRNA)

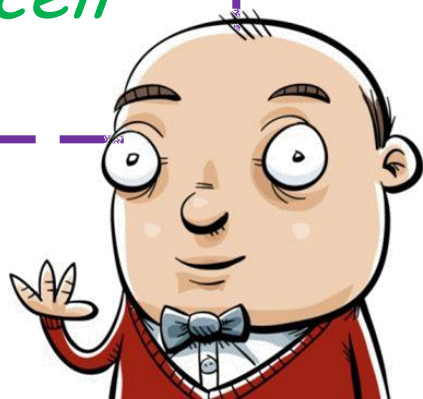
DNA REPLICATION



DNA MUST REPLICATE (COPY ITSELF) BEFORE CELL DIVISION SO AS TO PASS ON GENETIC INFORMATION FROM ONE GENERATION TO THE NEXT

Francis Crick James Watson Maurice Wilkins Rosalind Franklin

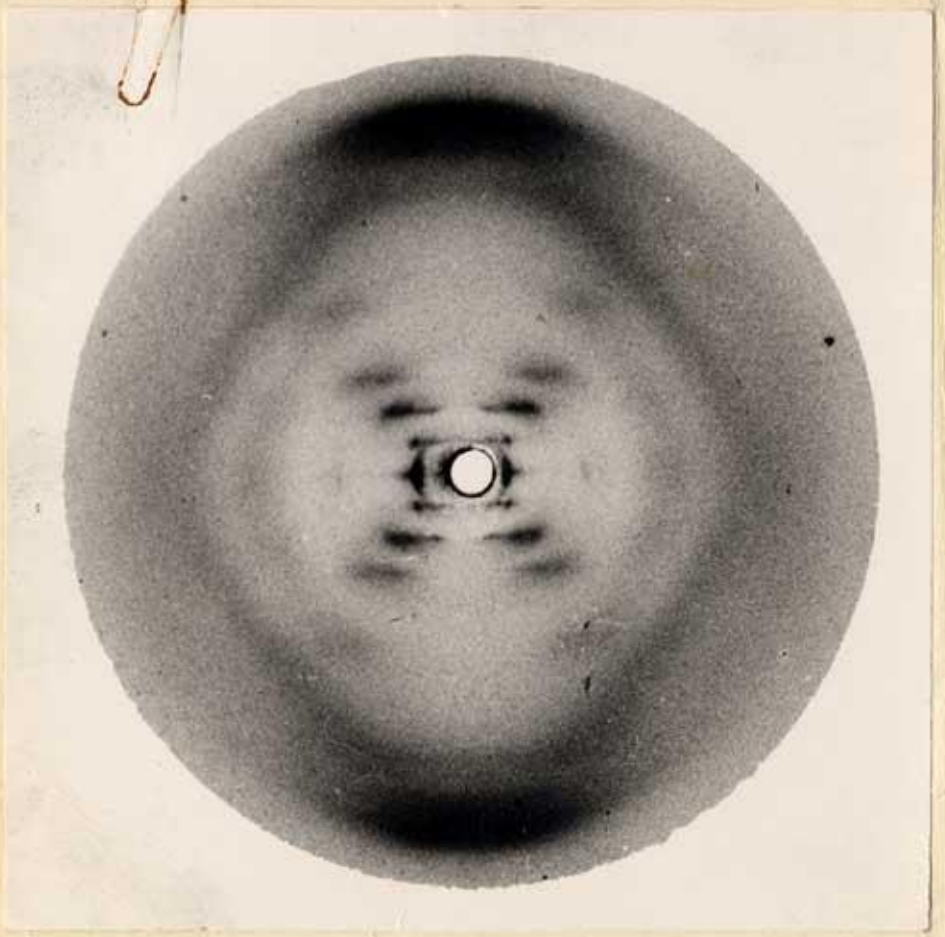
Did you know?
4 people played key roles in the discovery of the shape of the DNA molecule, and how it replicated (copied itself before cell division)

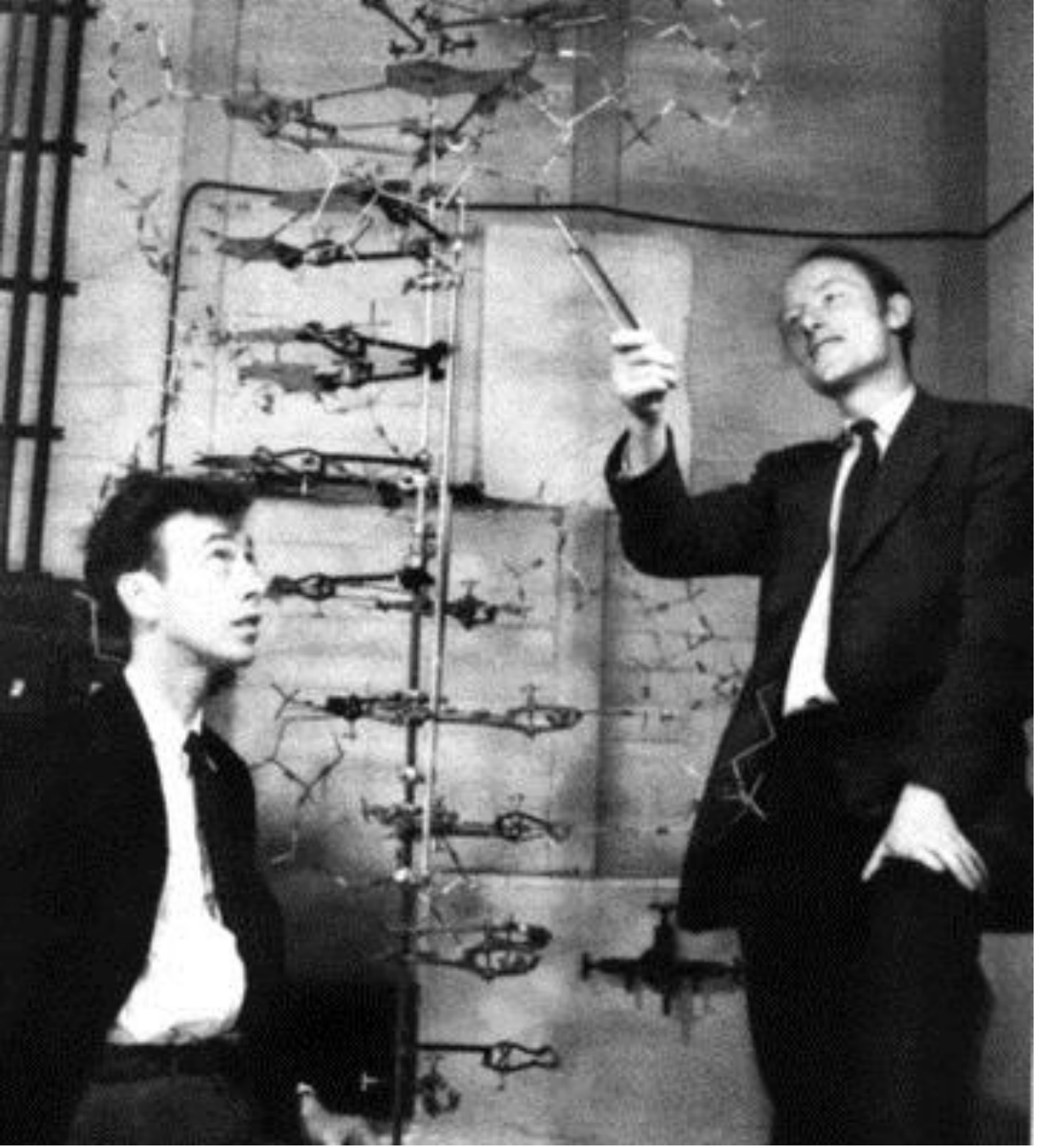


1953: Rosalind Franklin and Maurice Wilkins took X-ray diffractions of DNA crystals (showed that the phosphate groups were arranged to the outside)

Rosalind Franklin

Maurice Wilkins





1953: Watson and Crick create 3D model of the DNA double helix structure (2 polynucleotide chains twisted around each other in a double helix)

Did you know?
They also predicted the correct method of DNA replication

DNA replication is "semi-conservative"

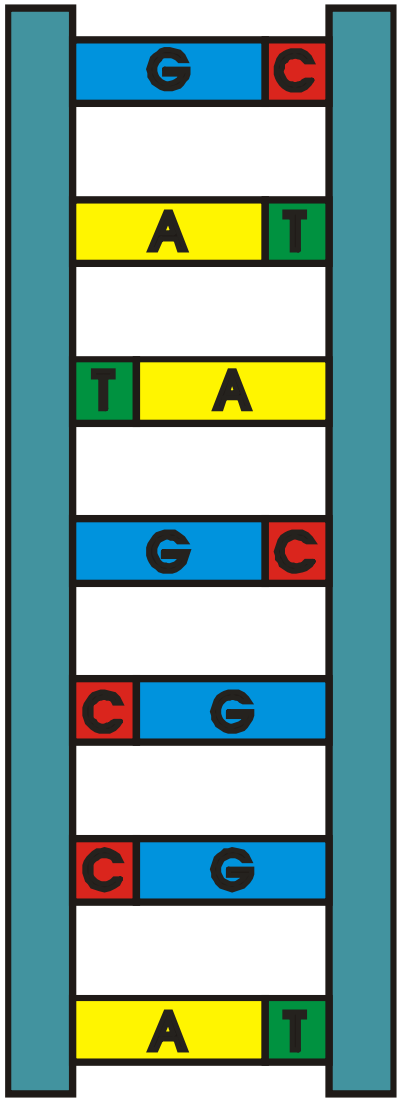
Much like the last UK government. Ha ha.

i.e. one of each original strand has been "conserved" and is included in each of the two new double helices (along with a newly synthesised strand)

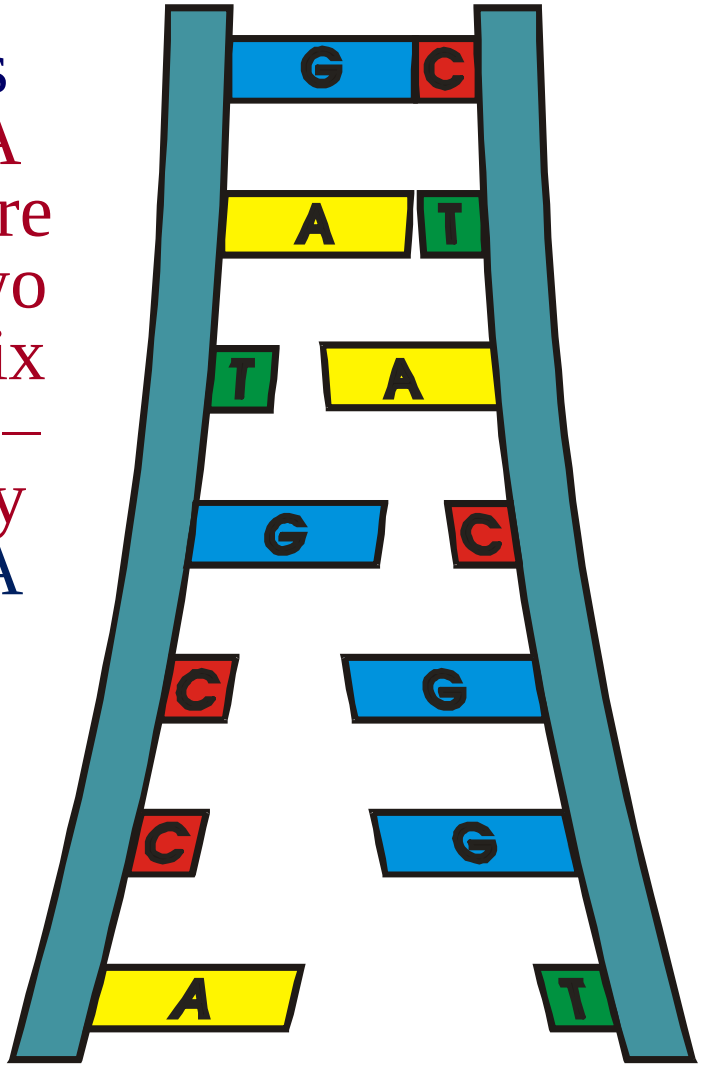
The replication of DNA *- The replication (copying) of DNA occurs in every cell* ***before cell division*** *takes place. 2 complete new copies are created:*

1. The enzyme DNA Helicase breaks the hydrogen bonds holding the base pairs together at a part of the double helix and the strands separate/DNA molecule "unzips"
2. DNA bases are exposed and DNA polymerase moves along the strands, which act as templates for a new strand to be synthesised
3. The DNA polymerase catalyses the joining of free deoxyribonucleotides in the nucleoplasm to each of the exposed original/template strands according to base pairing rules, so that new complementary strands form
4. This process is repeated along the whole DNA molecule until all DNA is replicated. (Phosphodiester bonds are formed along the sugar and phosphate backbone as each new nucleotide is added by the DNA polymerase)

The Mechanism of DNA replication

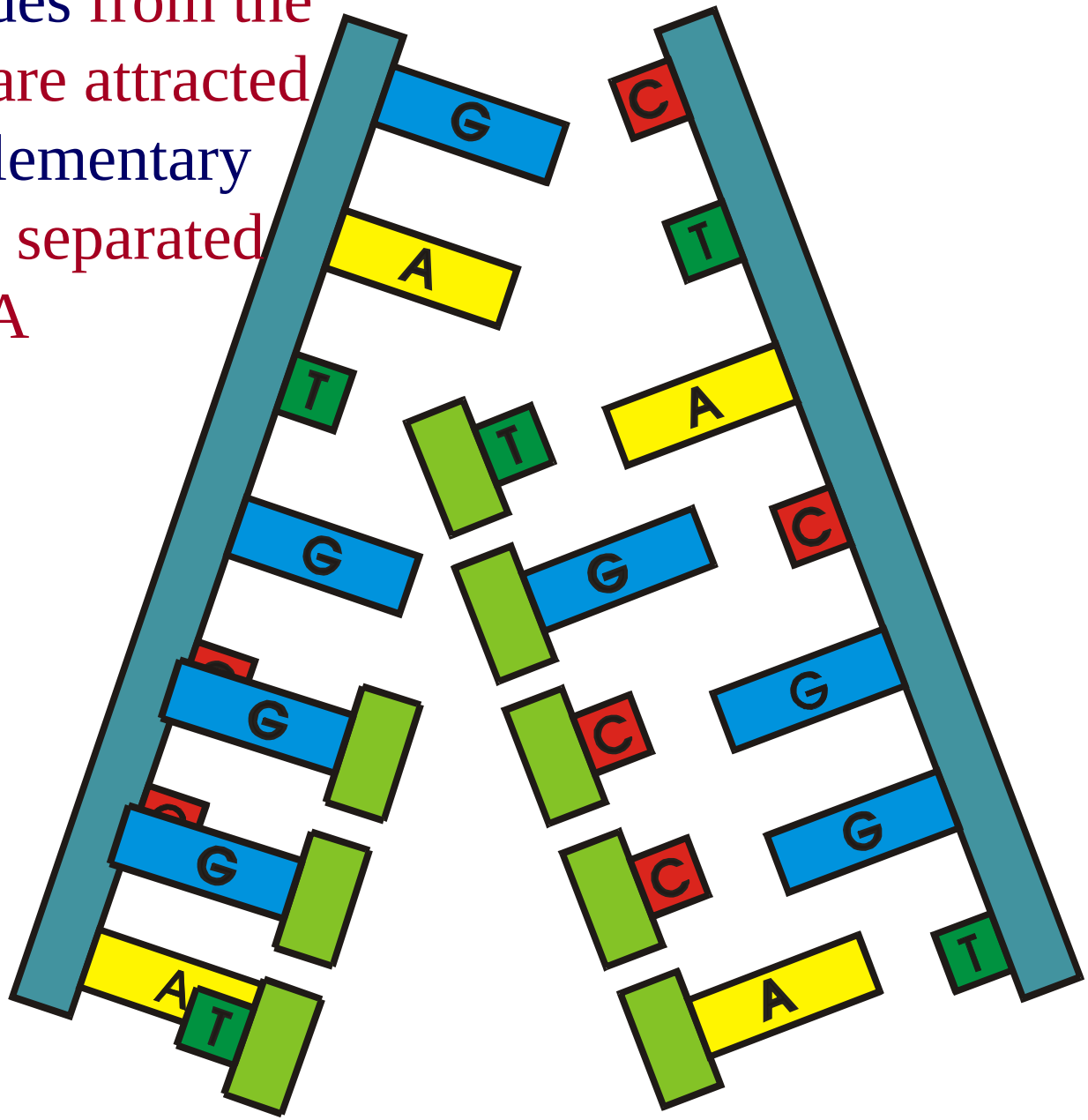


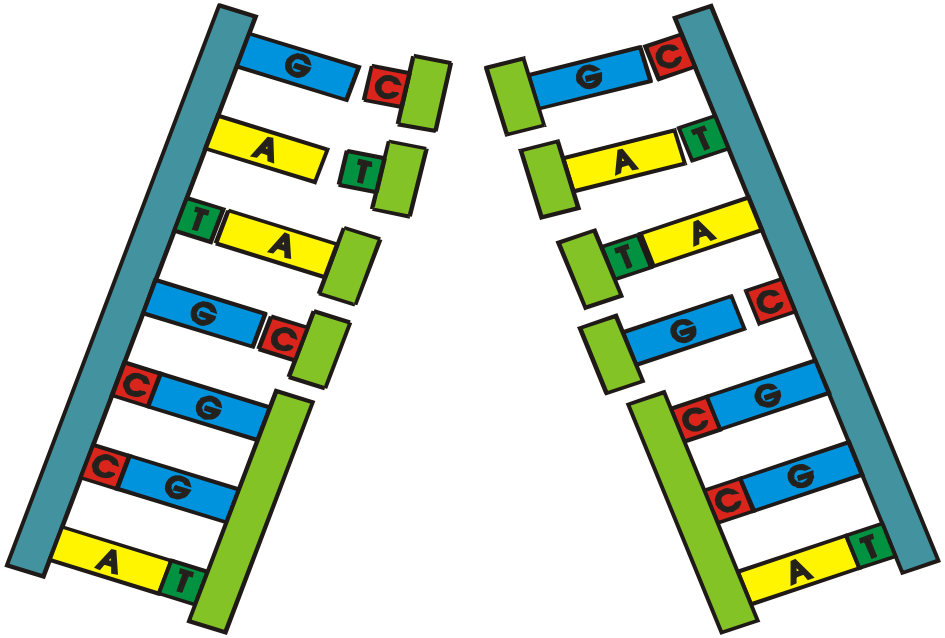
Hydrogen bonds holding the DNA strands together are broken and the two strands of the helix begin to separate – this is initiated by the enzyme DNA helicase



A portion of DNA representing base pairs held together by hydrogen bonds

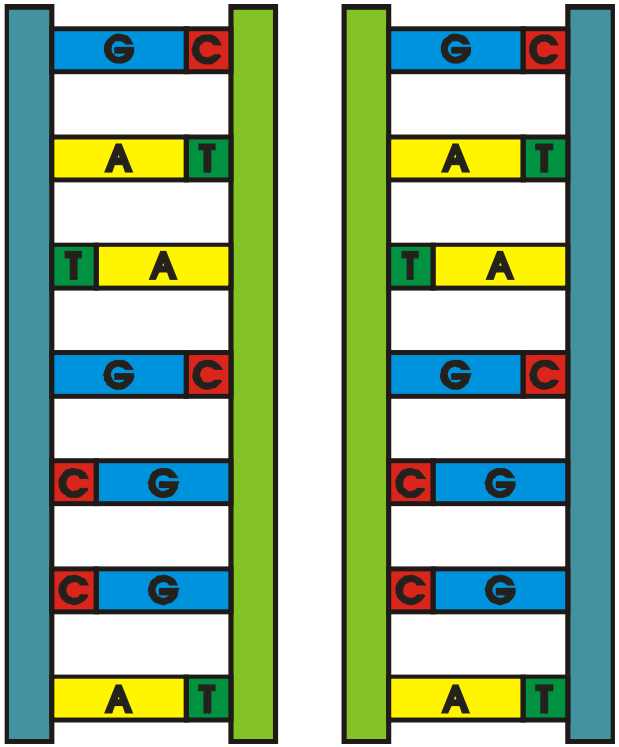
Free nucleotides from the nucleoplasm are attracted to their complementary bases on each separated strand of DNA





DNA polymerase binds the nucleotides together

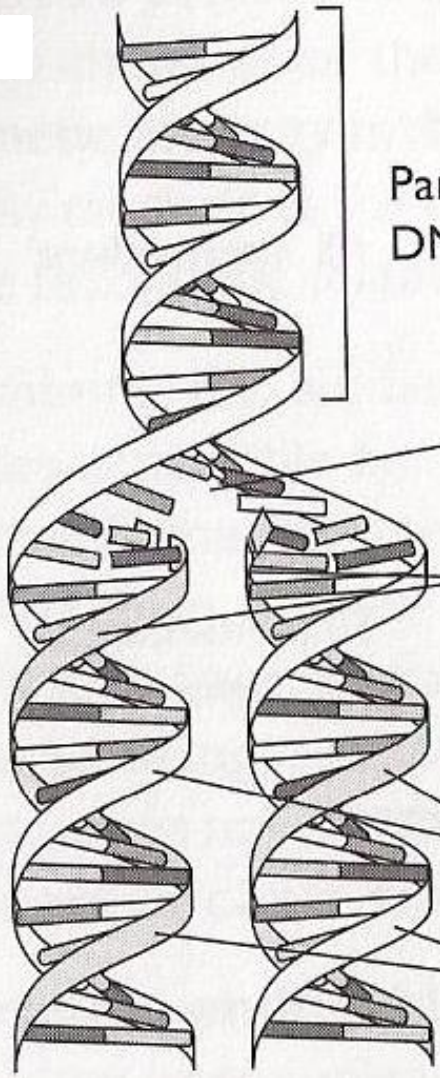
Two identical DNA molecules are formed



Each new DNA molecule consists of one strand from the original DNA double helix and one newly synthesised strand

This mechanism is called SEMI-CONSERVATIVE REPLICATION

DNA performs **semi-conservative replication**



Part of the original DNA molecule

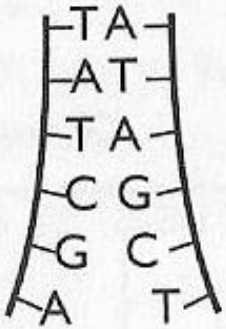
DNA helicase breaks hydrogen bonds and separates the two strands

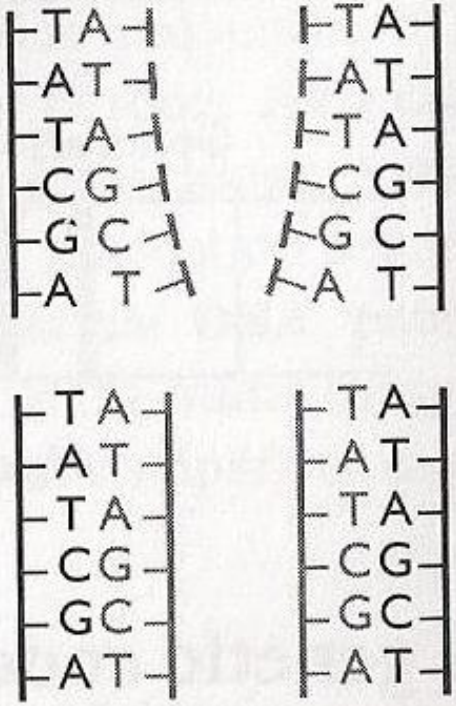
DNA polymerase builds new strands complementary to the existing ones using free DNA nucleotides

These two strands identical

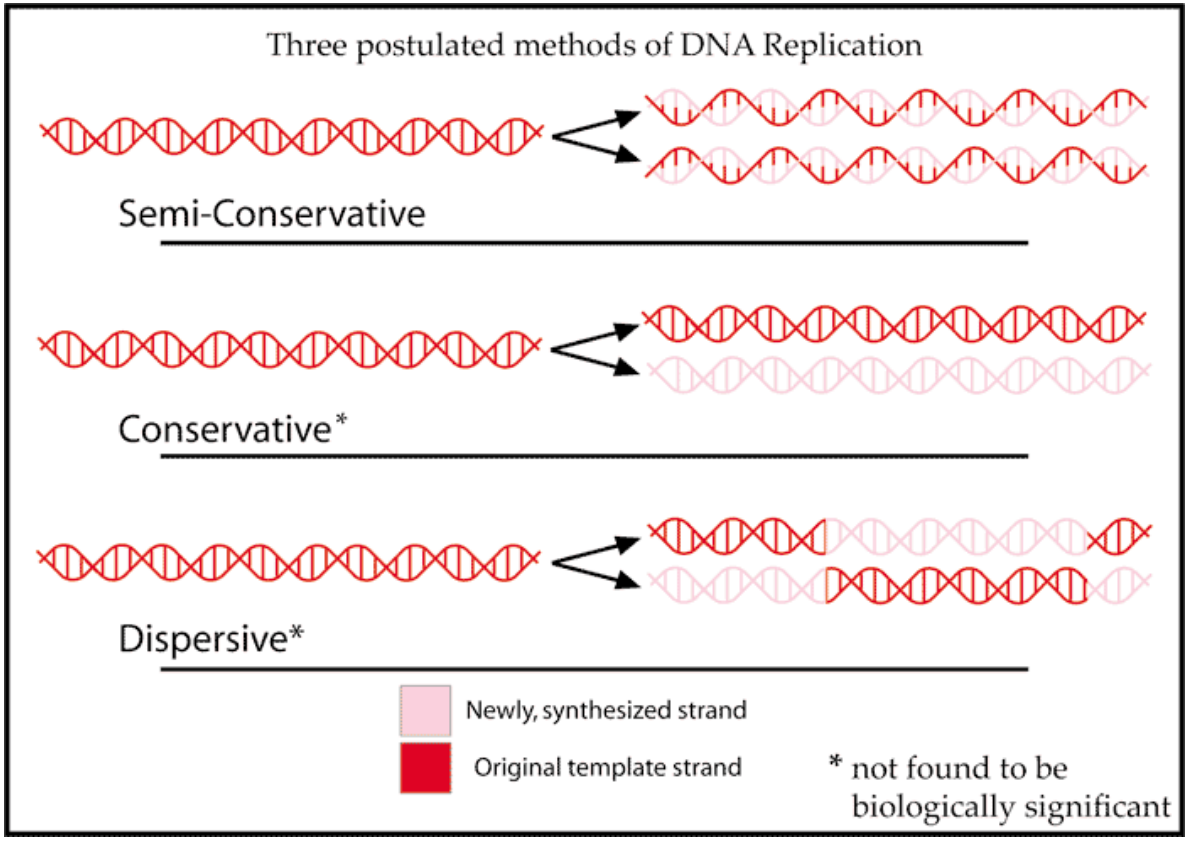
These two strands identical

The two new molecules are identical





Watson and Crick had proposed the semi conservative hypothesis i.e. the two strands of a DNA molecule separate during replication with each strand then acting as a template for the synthesis of a new strand.

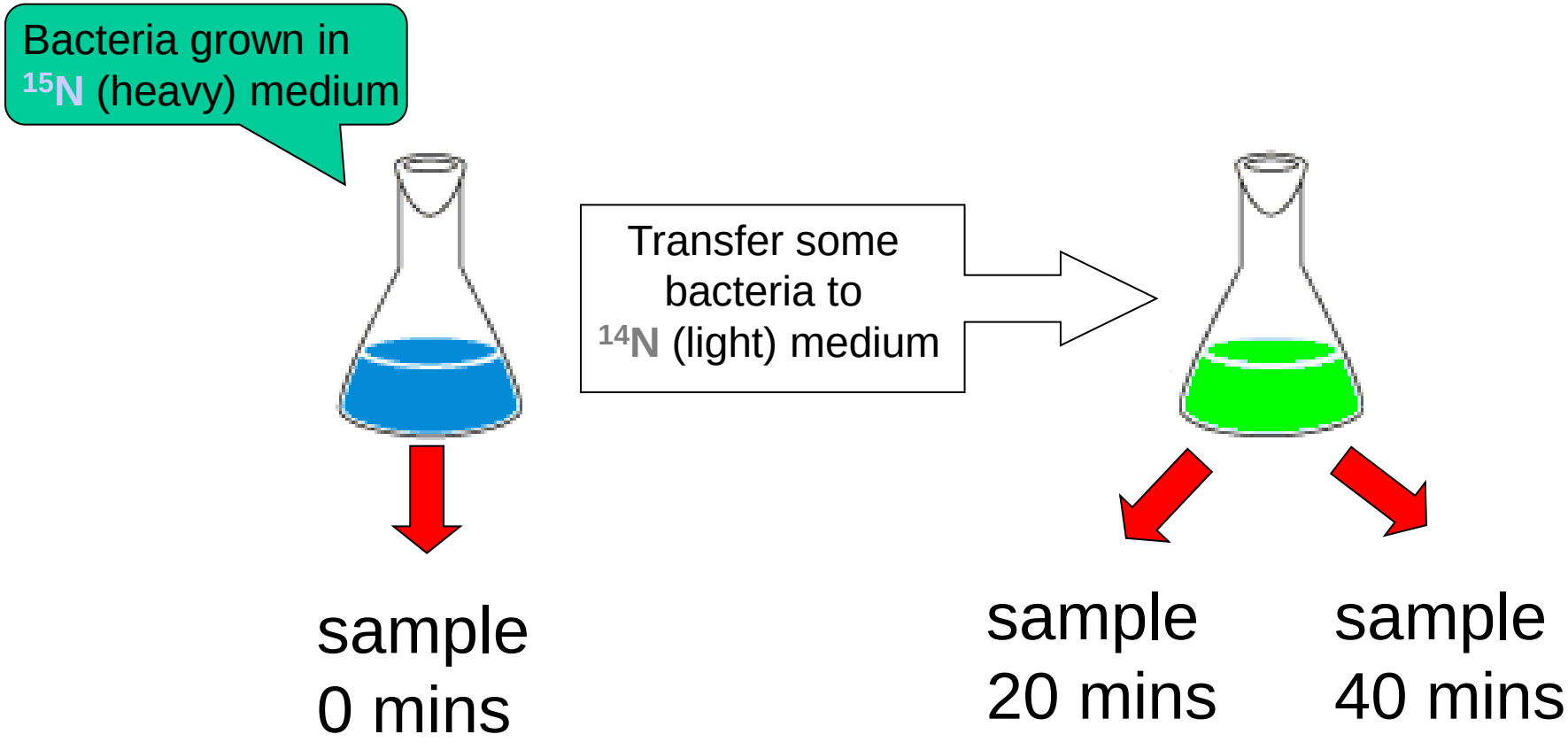


But, they hadn't proved it…

Evidence to support semi-conservative replication:

In 1958 Meselsohn and Stahl conducted a series of experiments that gave strong support to the theory of **semi-conservative replication**

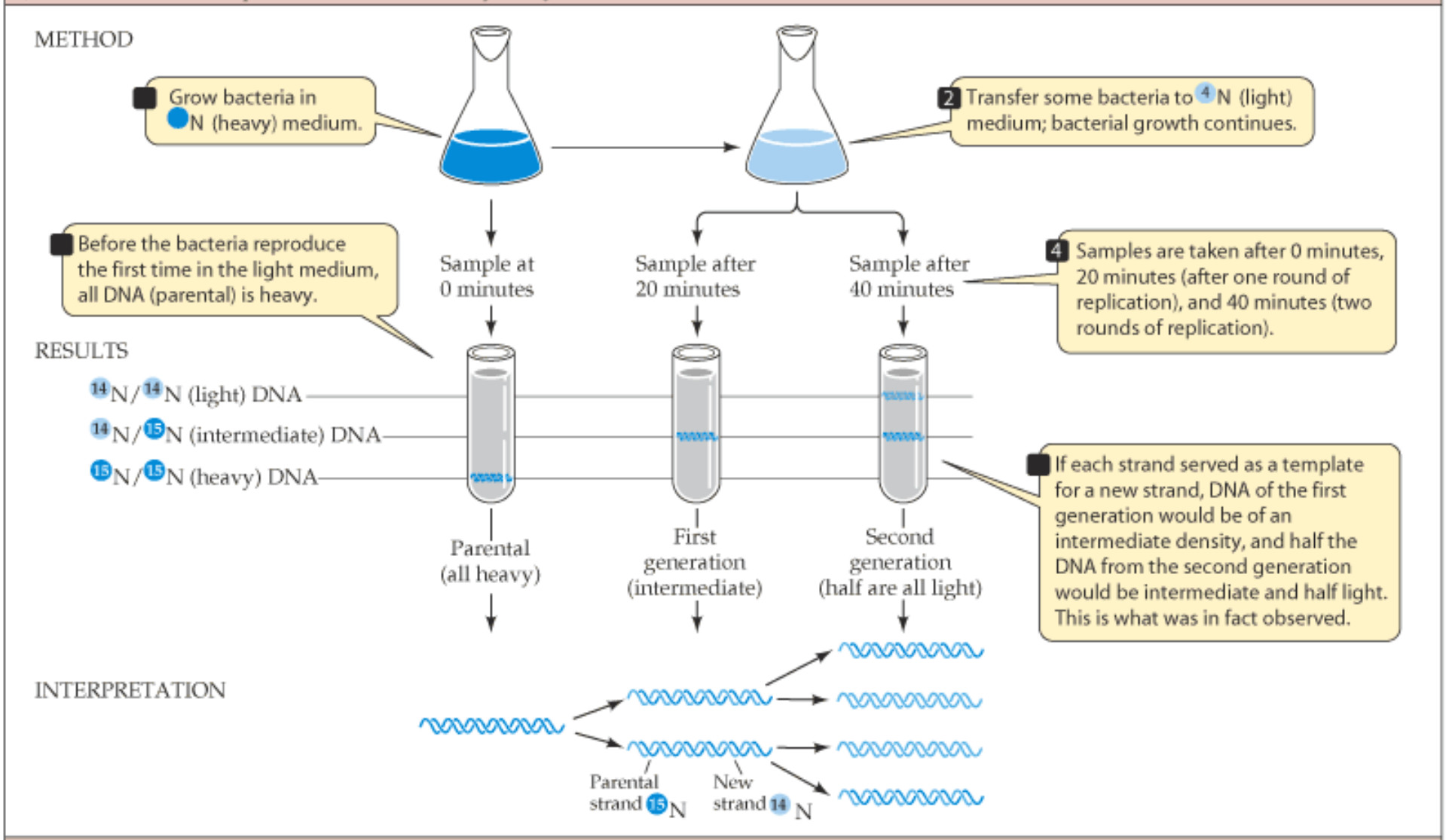
They supplied *E. coli* bacteria with nucleotides containing **radioisotopes of nitrogen** (heavy/^{15}N and light/^{14}N) and then observed the replication of the DNA by sampling the new generations of bacteria produced


Bacteria grown in
^{15}N (heavy) medium
Transfer some
bacteria to
^{14}N (light) medium
sample
0 mins
sample
20 mins
sample
40 mins

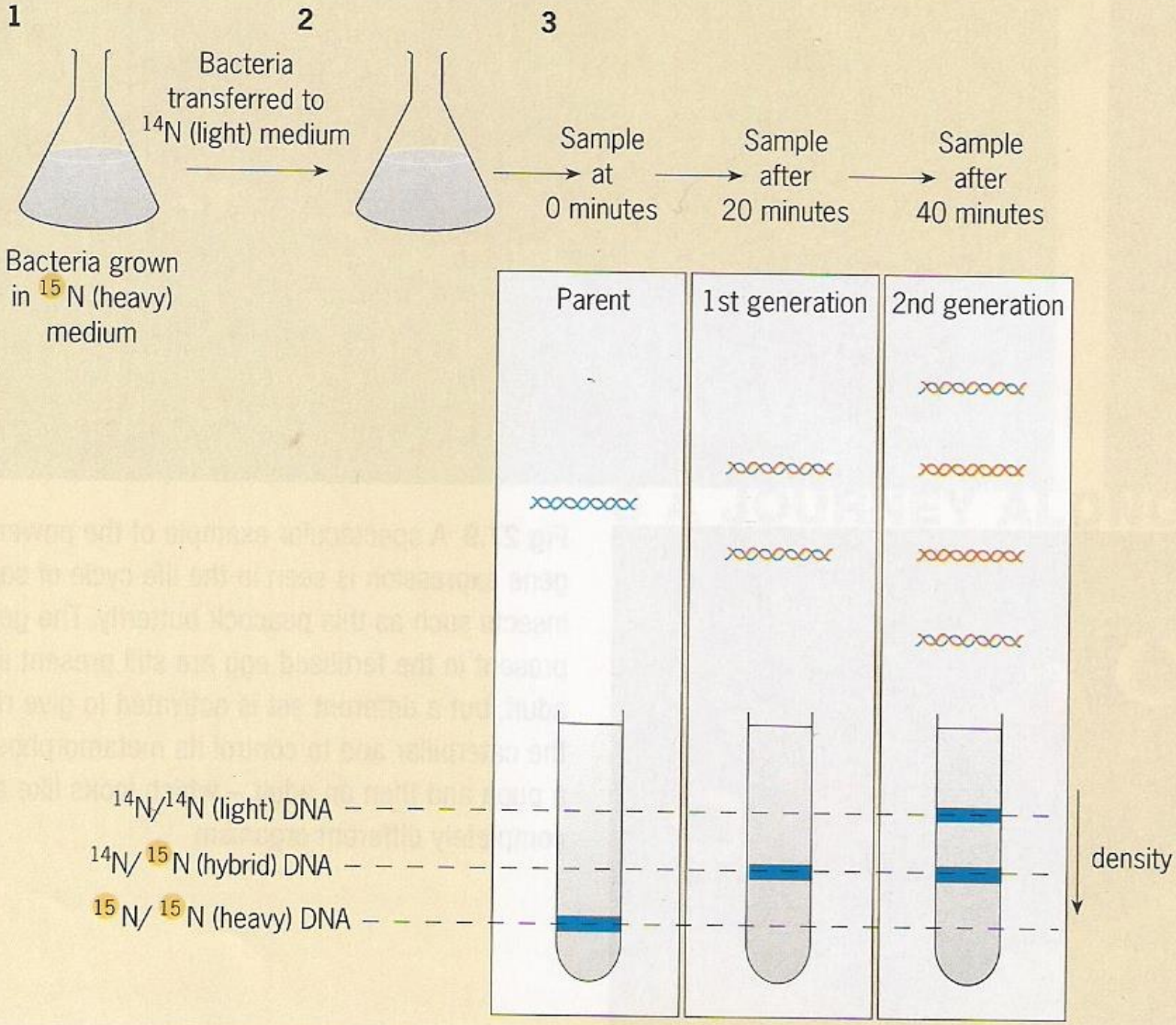

^{14}N/ ^{14}N
^{15}N/ ^{14}N
^{15}N/ ^{15}N

EXPERIMENT

Question: Does DNA replicate semiconservatively, or by some other mechanism?



Conclusion: DNA replication is semiconservative

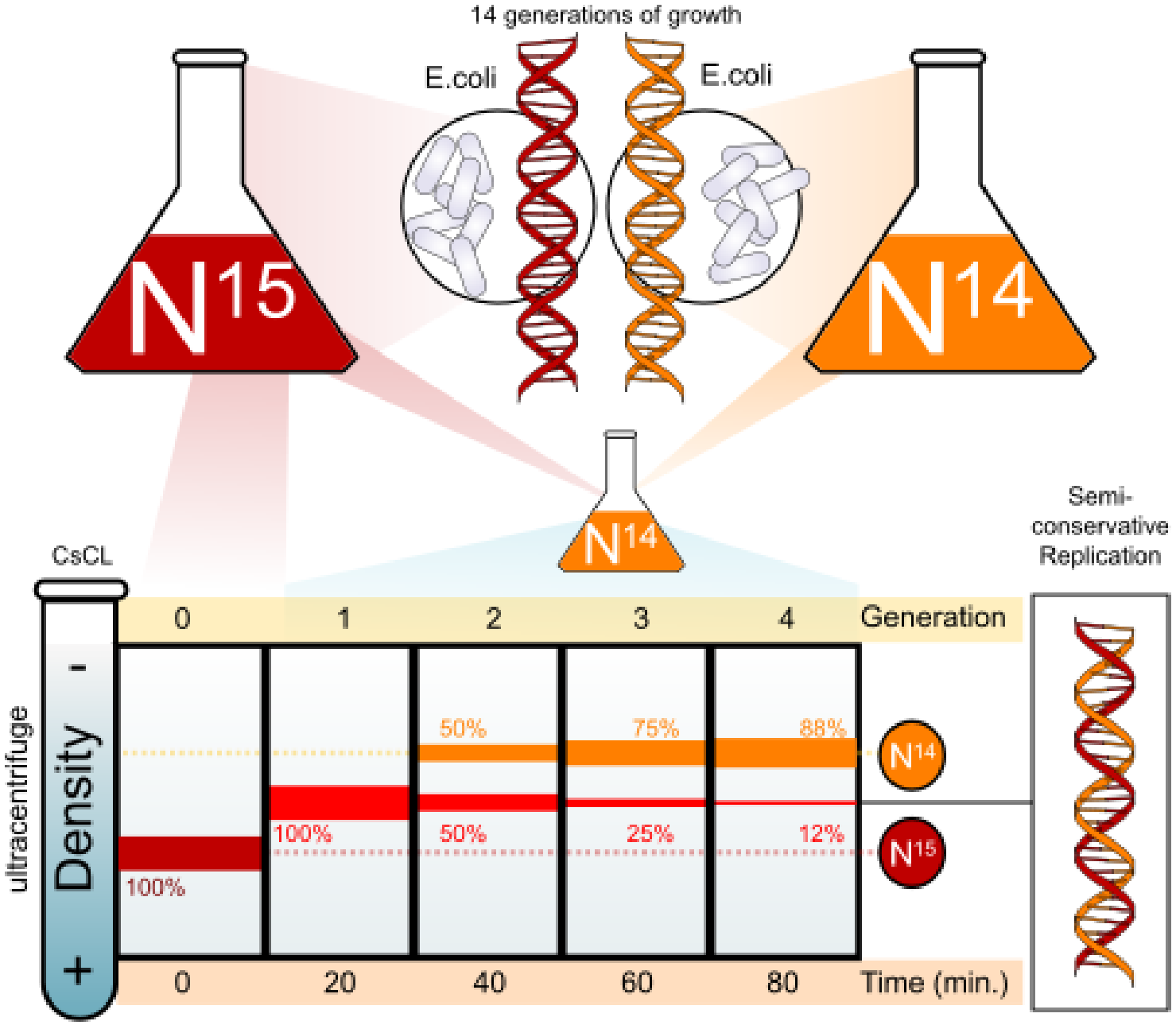

1
2
3
Bacteria transferred to ^{14}N (light) medium
Sample at 0 minutes
Sample after 20 minutes
Sample after 40 minutes
Bacteria grown in ^{15}N (heavy) medium
Parent
1st generation
2nd generation
$^{14}N/^{14}N$ (light) DNA
$^{14}N/^{15}N$ (hybrid) DNA
$^{15}N/^{15}N$ (heavy) DNA
density

Results of Meselsohn and Stahl 's experiment:

1. *E. coli* are grown in a medium (growth environment) containing the heavy nitrogen radioisotope ^{15}N. Soon nearly all of the bacteria contain this isotope in the bases of their DNA (which is now denser than normal). A control culture of bacteria with only normal ^{14}N is also grown
2. The ^{15}N bacteria get transferred to a ^{14}N medium and samples taken at 0, 20 and 40 minutes. DNA is extracted, placed in caesium chloride and centrifuged. This separates the DNA according to density and allowed M and S to see distinguish between heavy and light DNA

3. Results confirm that at 0 minutes, all the DNA contained heavy ^{15}N but after 20 minutes the DNA had replicated and produced 2 strands of $^{15}N/^{14}N$ hybrid DNA. After 40 minutes the 2nd generation consisted of half $^{15}N/^{14}N$ and half all new $^{14}N/^{14}N$ strands

A centrifuge →


14 generations of growth
E.coli
E.coli
N15
N14
N14
Semi-conservative Replication
CsCL
ultracentrifuge
Density
-
+
0
1
2
3
4
Generation
50%
75%
88%
100%
50%
25%
12%
100%
N14
N15
0
20
40
60
80
Time (min.)

Research and learn the experiment method and the results

http://en.wikipedia.org/wiki/Meselson%E2%80%93Stahl_experiment#cite_note-0