Nucleotides

A Level

Part A Nucleotide structure

Nucleotides are the monomers of [ ] (DNA and RNA). A nucleotide is made of a [ ] sugar bound to a [ ] (at the [ ] carbon) and to [ ] (at the [ ] carbon).

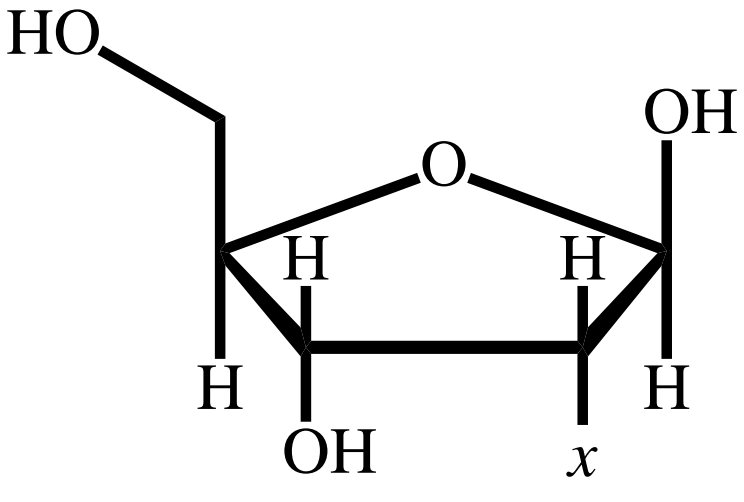
Items:

proteins **nucleic acids** **pentose** **hexose** **carbonate** **phosphate** **a nitrogenous base**

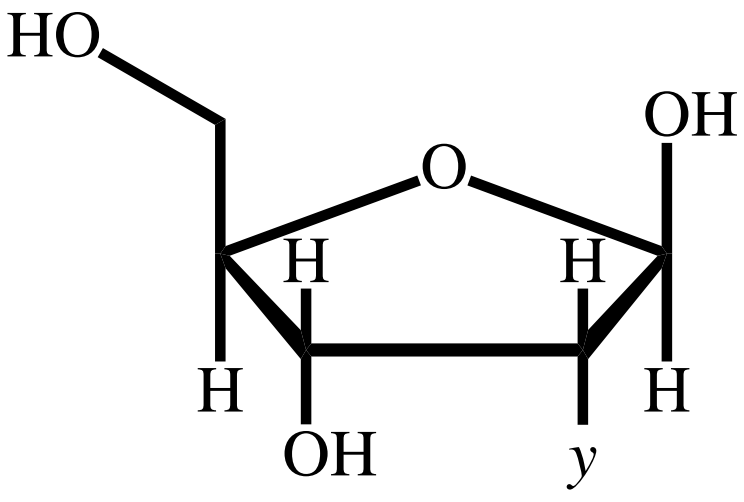
a phosphorous base $1'$ $2'$ $3'$ $4'$ $5'$

Part B Sugars

There are two types of pentose sugar that are used to make nucleotides: ribose and deoxyribose. Ribose is used to make ribonucleotides, which are the monomers of RNA. Deoxyribose is used to make deoxyribonucleotides, which are the monomers of DNA.



ribose



deoxyribose

Figure 1: The chemical structures of ribose and deoxyribose. The structures are identical except for x and y.

What is x in Figure 1? Write your answer in atomic symbols.

What is y in Figure 1? Write your answer in atomic symbols.

Part C Nucleotides, nucleosides, and nucleobases

A nucleoside is made of a pentose sugar bound to [ ]. In other words, a nucleoside is a nucleotide without [ ].

Nitrogenous bases can also be called nucleobases. Nucleosides are named based on the nucleobase they contain e.g. [ ] is the ribonucleoside that contains [ ]. As well as being part of RNA, this nucleoside can also form [ ] (ATP) by binding to three phosphates.

Items:

adenosine | **a nitrogenous base** | **adenosine triphosphate** | **adenine** | **a phosphate**

Part D Carbon numbers

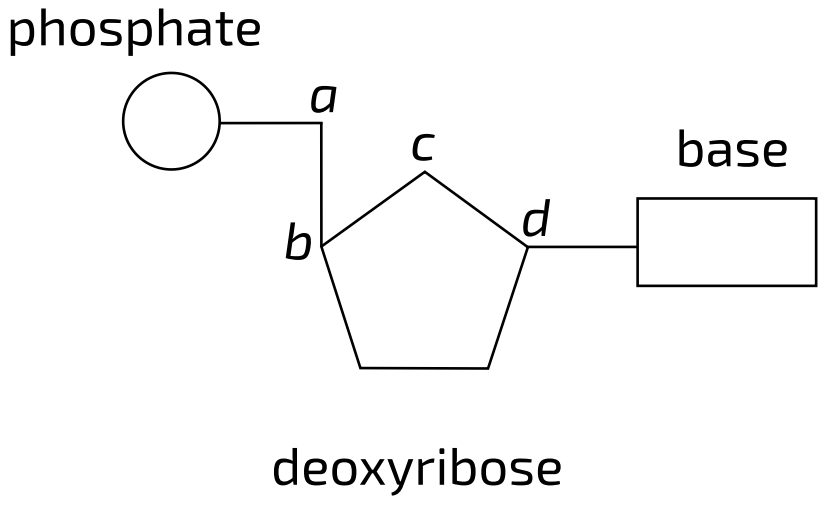


Figure 2: A simplified diagram of a nucleotide. Atoms within the deoxyribose are labelled *a* to *d*.

Match the atoms to the letters in Figure 2.

Letter	Atom
a	
b	
c	
d	

Items:

1′C | 2′C | 3′C | 4′C | 5′C | 6′C | O

Created for isaacphysics.org by Lewis Thomson

Nitrogenous Bases

A Level

Part A DNA bases

Which nitrogenous bases are part of deoxyribonucleotides?

- [ ] cytidine
- [ ] thymidine
- [ ] adenosine
- [ ] guanosine
- [ ] adenine
- [ ] uracil
- [ ] thymine
- [ ] guanine
- [ ] cytosine

Part B RNA bases

Which nitrogenous bases are part of ribonucleotides?

- [ ] thymidine
- [ ] cytosine
- [ ] guanine
- [ ] cytidine
- [ ] uracil
- [ ] adenosine
- [ ] guanosine
- [ ] thymine
- [ ] adenine

Part C Purines

Purine bases have a [ ]-ring structure.

Items:

single **double** **triple**

Which bases are purine bases?

- [ ] adenine
- [ ] cytosine
- [ ] guanine
- [ ] thymine
- [ ] uracil

Part D Pyrimidines

Pyrimidine bases have a [ ]-ring structure.

Items:

single **double** **triple**

Which bases are pyrimidine bases?

- [ ] guanine
- [ ] adenine
- [ ] uracil
- [ ] cytosine
- [ ] thymine

Created for isaacphysics.org by Lewis Thomson

Gameboard:

STEM SMART Biology Week 6

Base Pairing

A Level

Part A Complementary base pairing

Each base has a complementary base that it binds to (via hydrogen bonds) on the opposite strand.

Purines bind to [ ] and pyrimidines bind to [ ].

Adenine binds either to [ ] (DNA) or to [ ] (RNA) via [ ] hydrogen bonds.

Guanine binds to [ ] via [ ] hydrogen bonds.

Items:

three **cytosine** **adenine** **purines** **guanine** **uracil** **four** **thymine** **pyrimidines** **two**

Part B Base identification

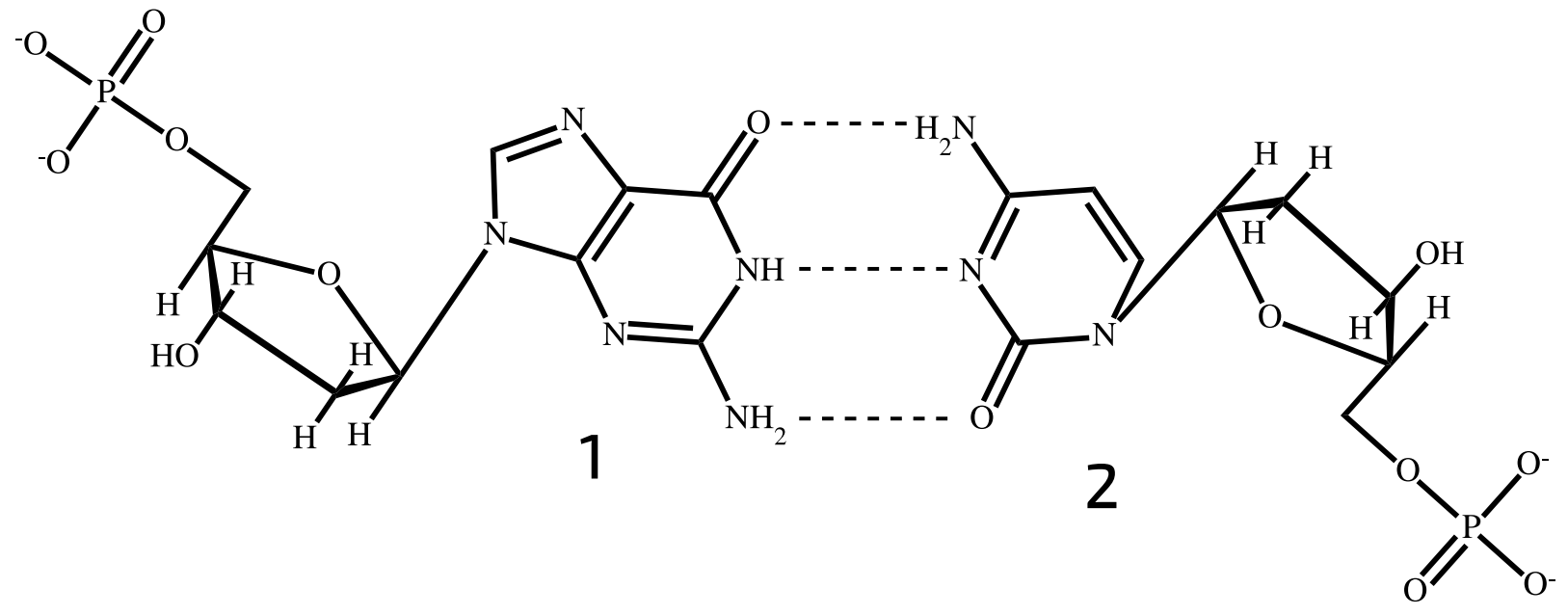


Figure 1: DNA base pairing. Two pairs of nucleotides are shown, each one with a different nitrogenous base (labelled 1-4).

Match the nitrogenous base to the number in Figure 1.

1:

2:

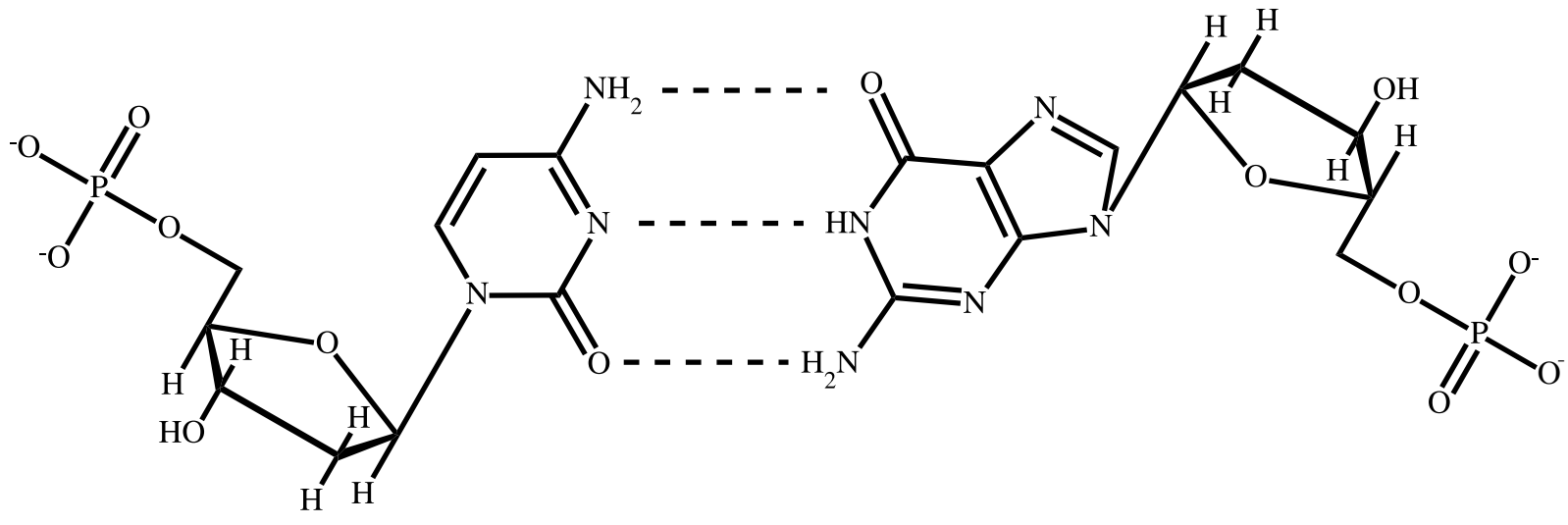
3:

4:

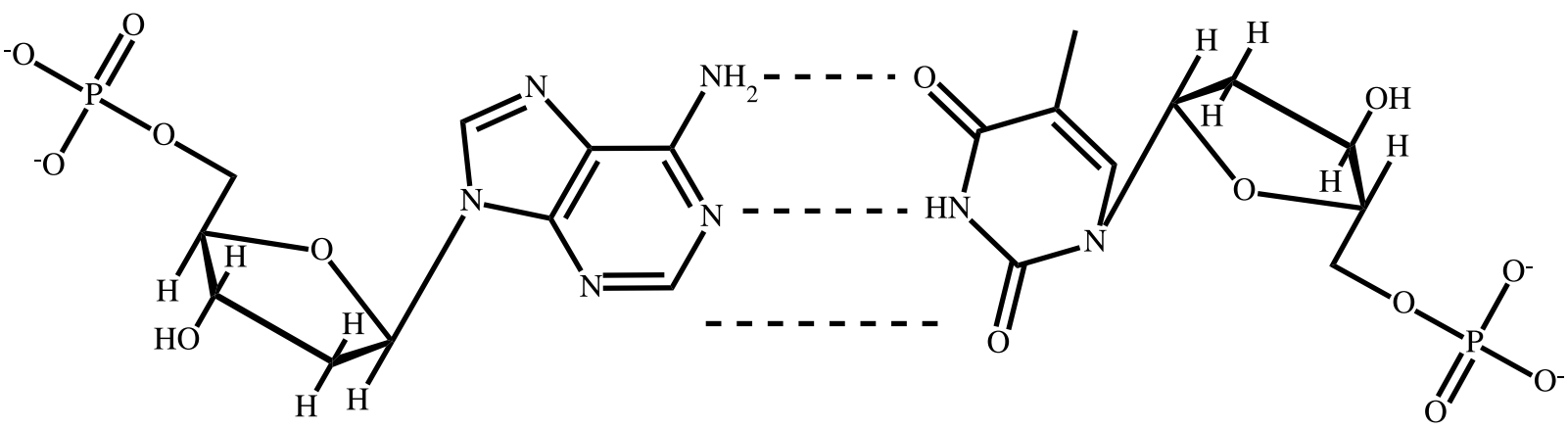
Items:

cytosine **guanine** **adenine** **thymine**

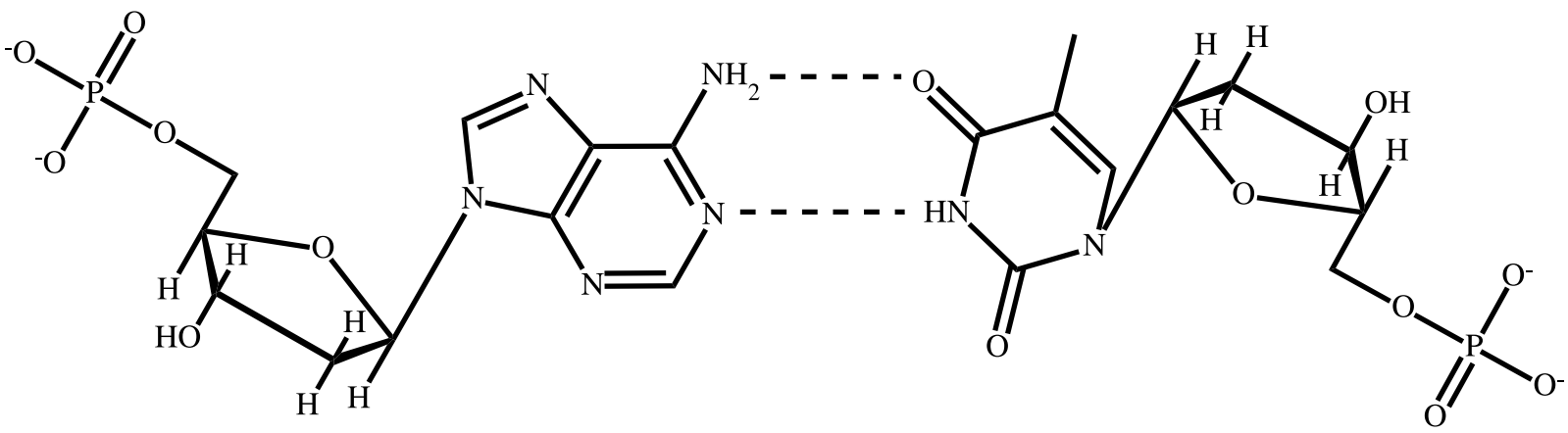
Part C Bonding diagrams



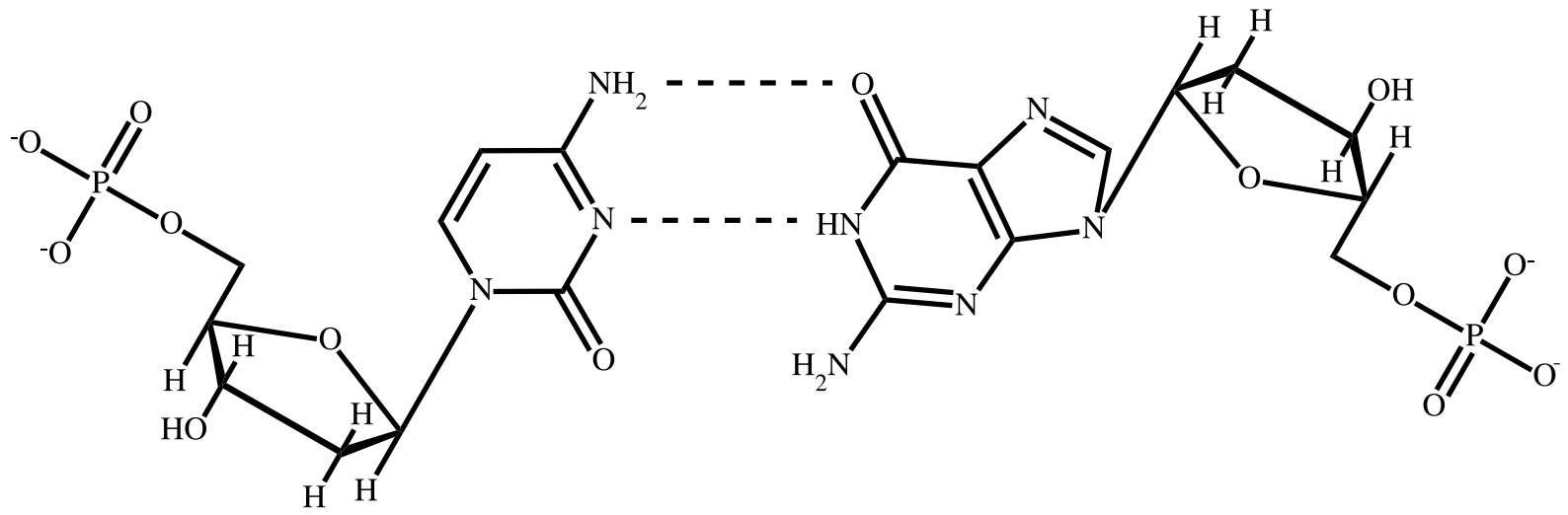
A



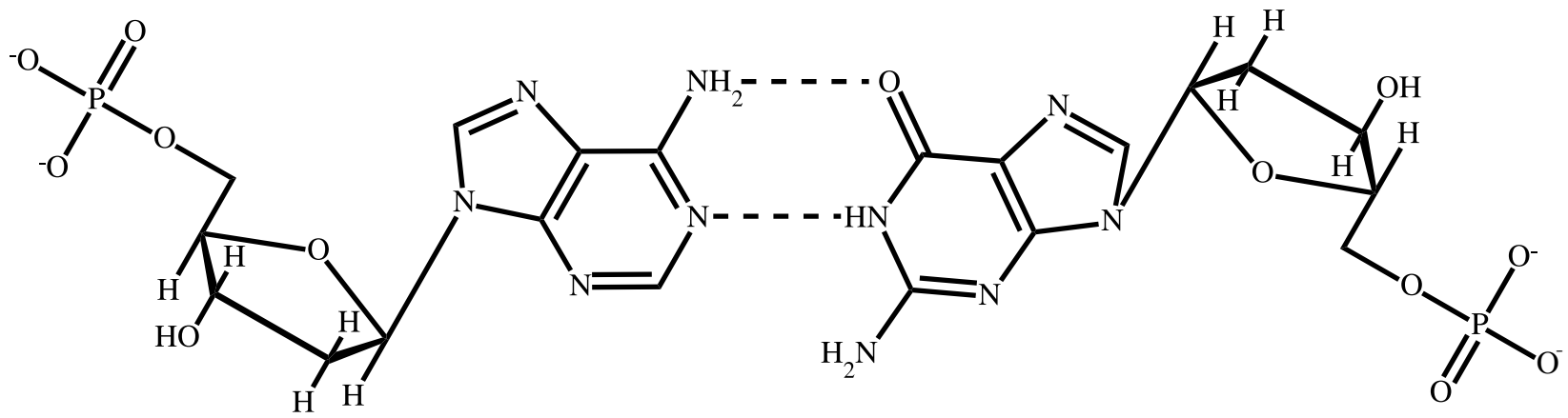
B



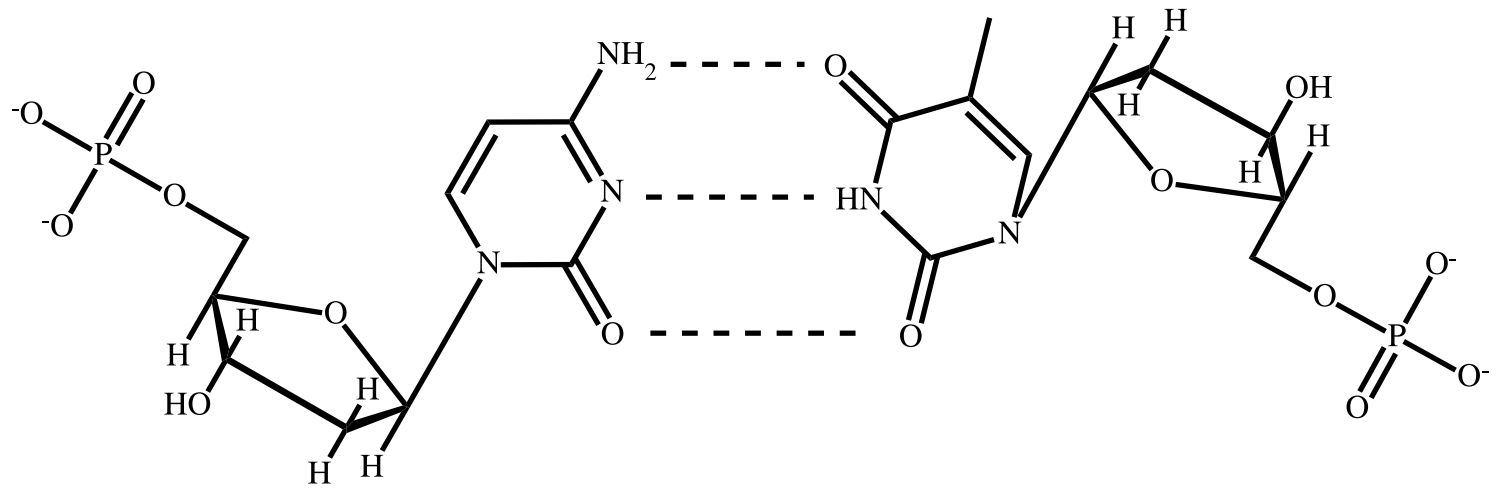
C



D



E



F

Which images above show correct base pair bonding?

- [ ] A
- [ ] B
- [ ] C
- [ ] D
- [ ] E
- [ ] F

Nucleic Acids

A Level

Part A Nucleic acid structure

Nucleic acids are strands of nucleotides. The nucleotides within a strand are bound to each other by [ ] bonds, which form during [ ] reactions. The $5'C$ of one pentose sugar is bound to a phosphate, which is bound to the [ ] C of the next pentose sugar in the strand. This series of sugars and phosphates along the nucleic acid is called the sugar-phosphate backbone and is directional (having a $5'$ end and a [ ] end).

Items:

hydrogen **phosphodiester** **condensation** **hydrolysis** $1'$ $2'$ $3'$ $4'$

Part B DNA vs RNA

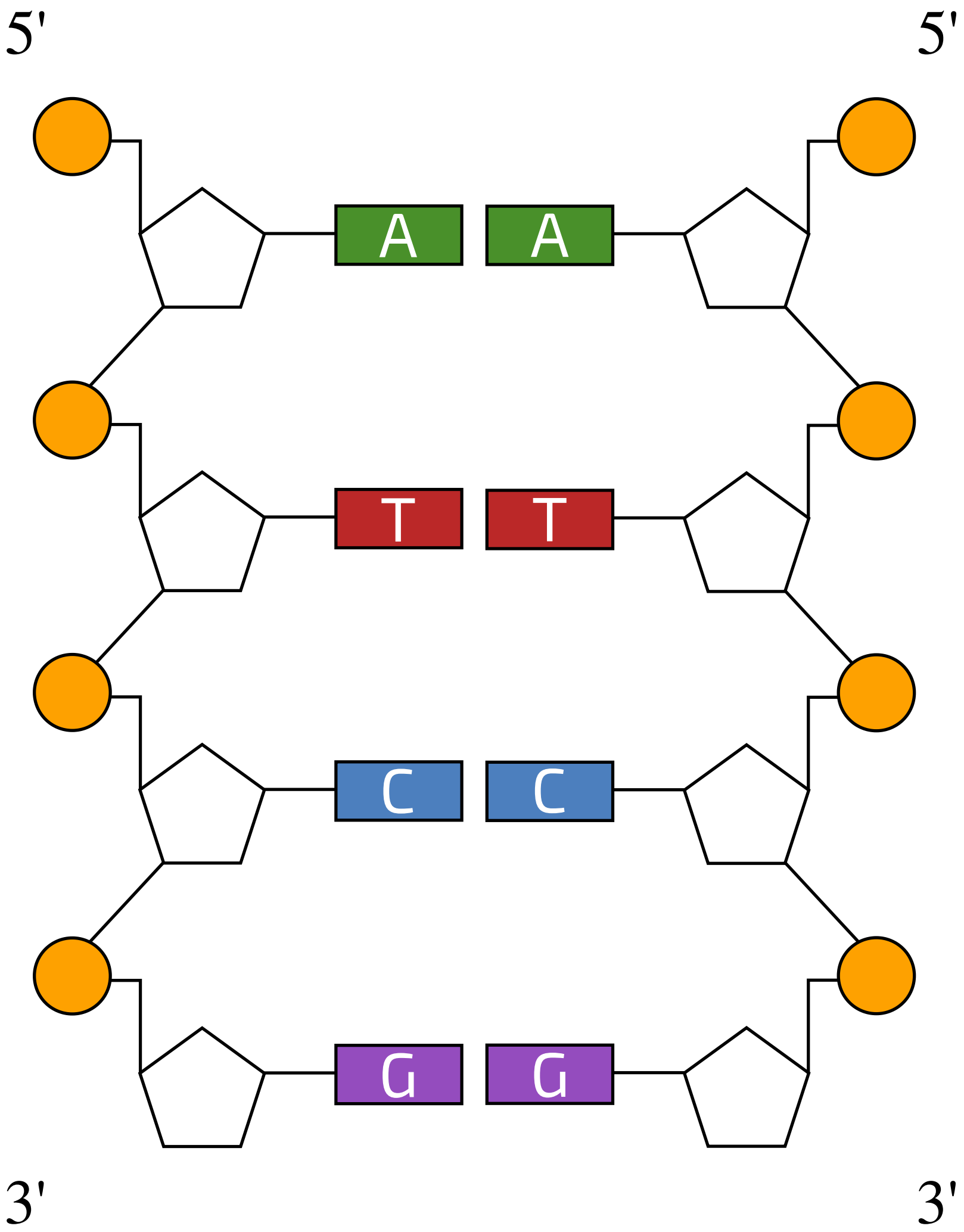
DNA is composed of two strands of [ ] which run in [ ] and are bound by [ ] bonds between complementary bases.

RNA is usually a single strand of [ ], however in some viruses it is double-stranded.

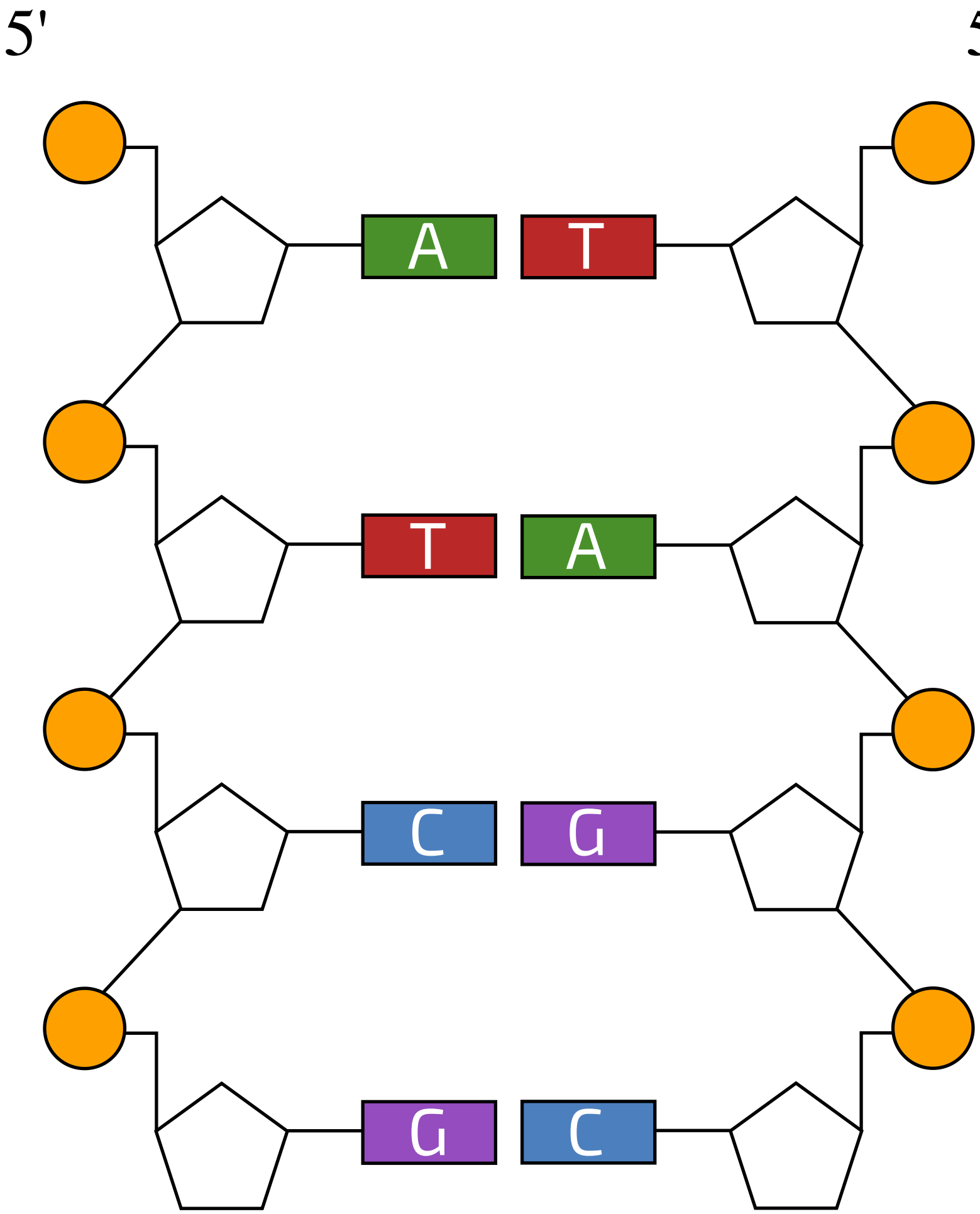
Items:

phosphodiester **the same direction** **deoxyribonucleotides** **hydrogen** **opposite directions** **ribonucleotides**

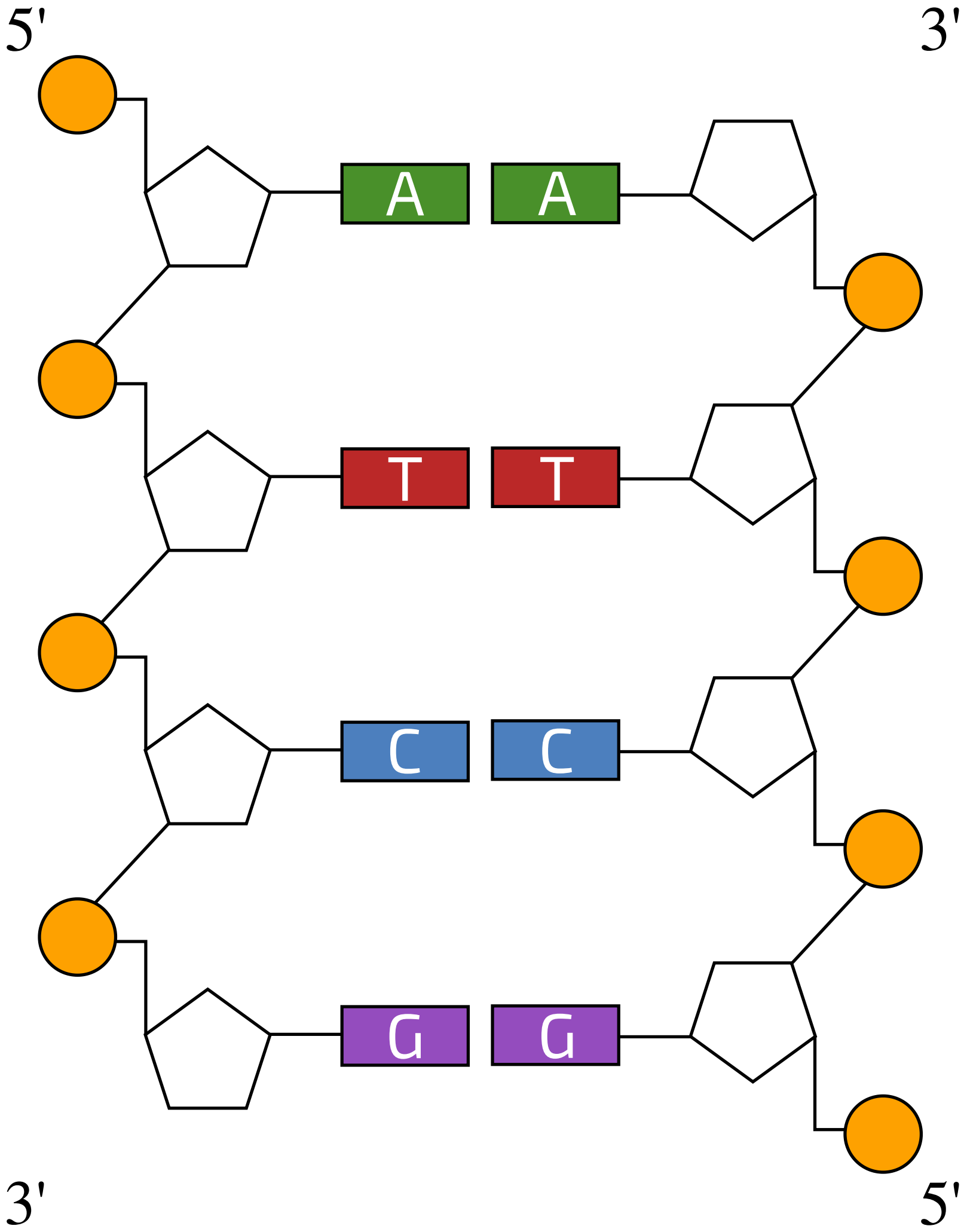
Part C **DNA diagrams**



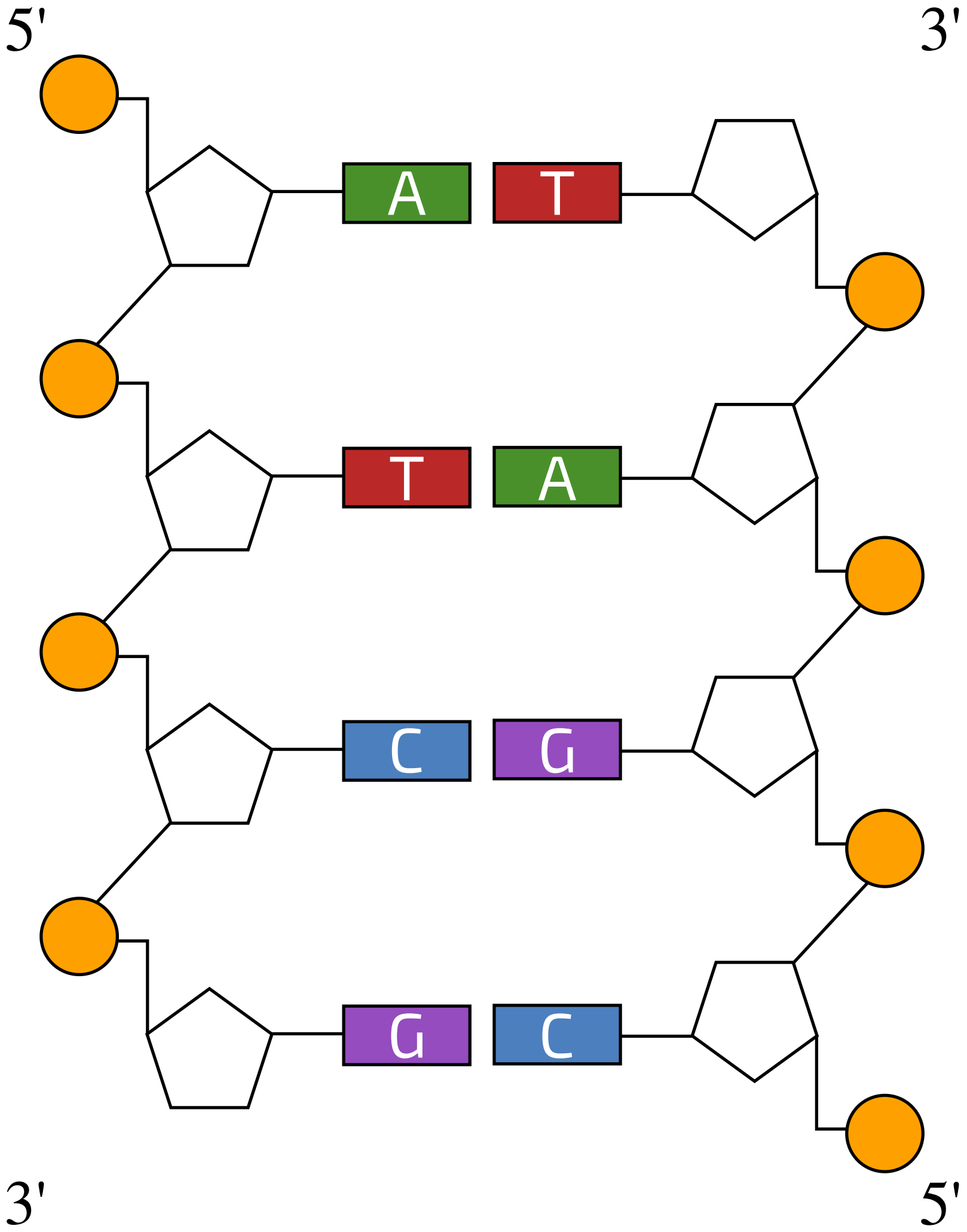
A



B



C



D

Which image above shows the correct structure of a DNA molecule?

- A
- B
- C
- D

Part D Bas(e)ic calculations

A researcher sequences a human gene that is $12\,000$ base pairs long. 27% of the bases are cytosine.

How many thymine bases are there?

The researcher sequences another human gene that is $146\,200$ base pairs long. There are $61\,404$ thymine bases.

What percentage of bases are cytosine?

Created for isaacphysics.org by Lewis Thomson

Gameboard:

STEM SMART Biology Week 6

DNA Replication Enzymes

A Level

Part A Breaking apart

Which enzyme breaks apart the two strands of DNA during DNA replication?

Which type of bond does this enzyme break apart?

Part B Making new strands

Which enzyme catalyses the addition of individual nucleotides along the new strands during DNA replication?

Which type of bond does this enzyme catalyse the formation of?

Part C The lagging strand

Which enzyme catalyses the joining of short DNA fragments along the lagging strand?

Which type of bond does this enzyme catalyse the formation of?

Created for isaacphysics.org by Lewis Thomson

Gameboard:

STEM SMART Biology Week 6

DNA Replication Overview

A Level

C C C

Part A When & why

DNA replication occurs during the [ ] phase of the cell cycle, to ensure that - after the [ ] phase of the cell cycle - both daughter cells have the same amount of DNA as the original cell.

Items:

growth 1 (G1) **mitosis (M)** **growth 2 (G2)** **synthesis (S)**

Part B Strand separation

DNA [ ] enzymes catalyse the breaking of [ ] bonds between the two strands, which causes the double helix to unwind and unzip. This happens gradually as the enzyme moves along the DNA (as opposed to the two strands breaking apart at once). The region of unzipping is called the [ ]. The two strands are then able to act as template strands for new strands to be synthesised from.

Items:

replication fork **ligase** **transcription start site** **phosphodiester** **polymerase** **hydrogen** **helicase**

Part C The two new strands

DNA [ ] can only catalyse the addition of new nucleotides in the [ ] direction (on the new strand).

The [ ] strand is the the new strand for which this direction matches the direction of unzipping, and so new nucleotides are added continuously.

The [ ] strand is the new strand for which this direction goes against the direction of unzipping. On this strand, nucleotides are added in short fragments (called [ ] fragments), which are then later joined together by DNA [ ].

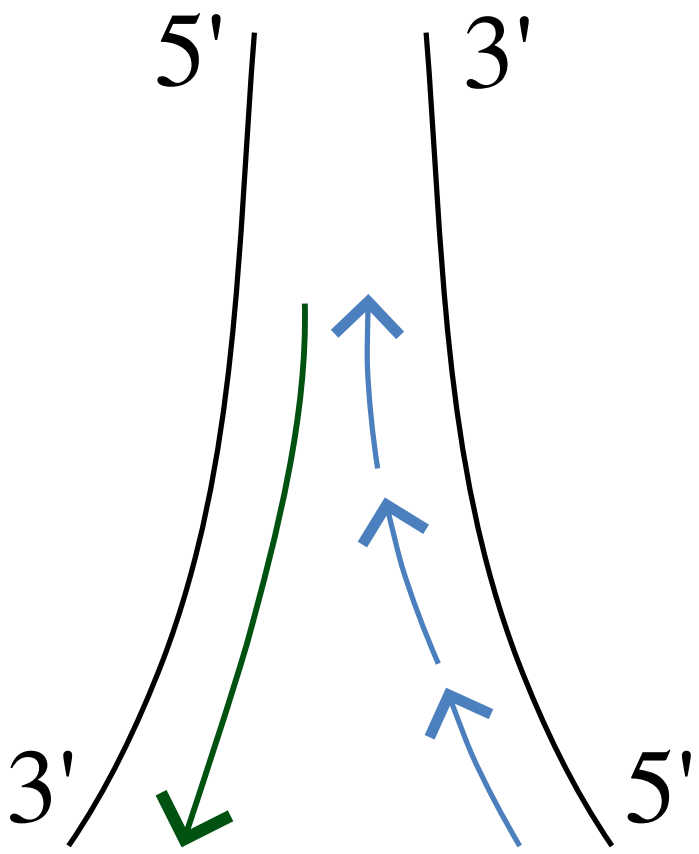
By the end of DNA replication, the two original strands have completely separated from each other and are each bound to a new strand.

Items:

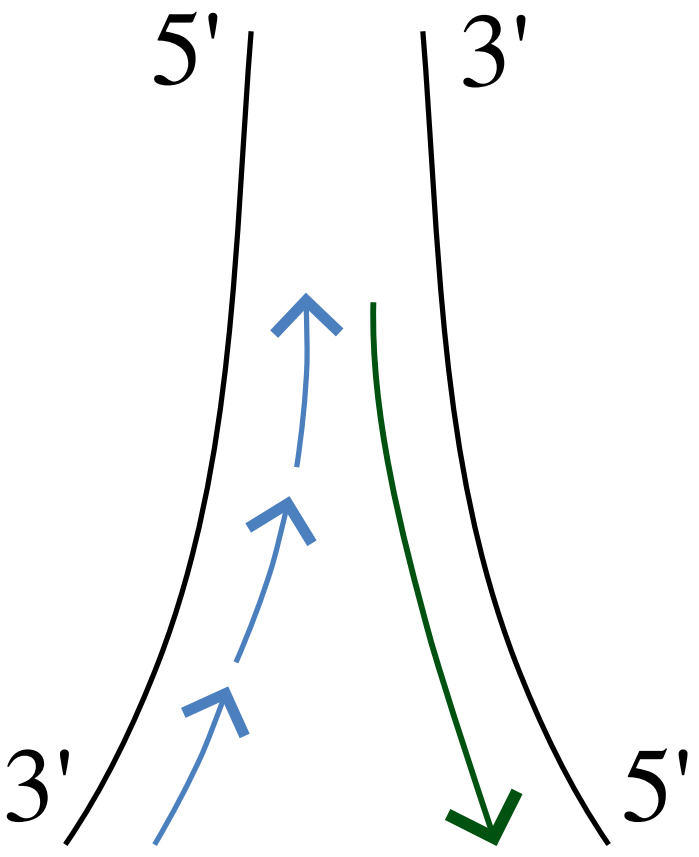
helicase **Okazaki** **polymerase** **$3'$ to $5'$** **leading** **sense** **lagging** **ligase** **$5'$ to $3'$** **antisense**

Part D Replication directions

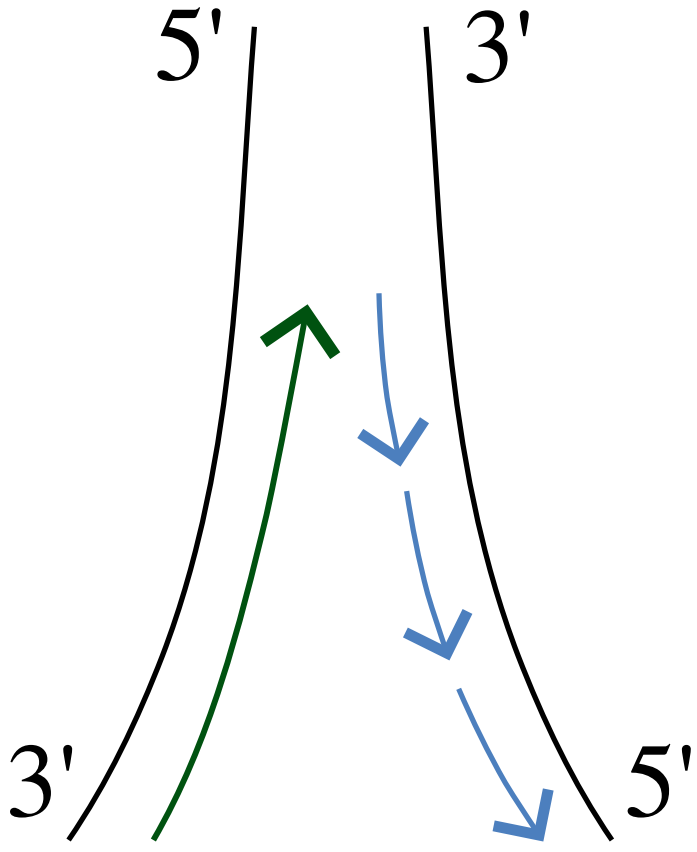
The images below represent DNA replication. The labels ($5'$ and $3'$) refer to the template strands (black). The original DNA molecule is unzipping from bottom to top. The coloured arrows represent possible directions of nucleotide addition by DNA polymerase.



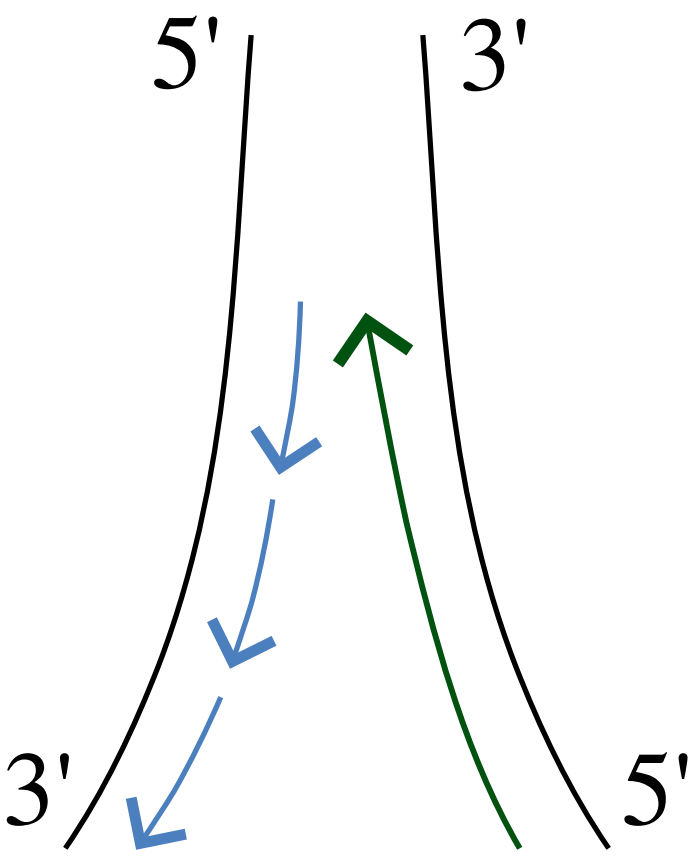
A



B



C



D

Which image above shows the correct directions that nucleotides are added in by DNA polymerase during DNA replication?

- A
- B
- C
- D

Part E Semi-conservative replication

What is meant by the phrase "DNA replication is semi-conservative"?

- DNA polymerase acts on both new strands but in opposite directions.
- When one DNA molecule replicates, one daughter DNA molecule contains both original strands, and the other daughter DNA molecule contains two newly-synthesised strands.
- When one DNA molecule replicates, both daughter DNA molecules contain only newly-synthesised strands and no original strands.
- When one DNA molecule replicates, each daughter DNA molecule contains one original strand and one newly-synthesised strand.
- Proofreading takes place to ensure that the new strand has the correct sequence, but a small number of mutations may happen.
- When one DNA molecule replicates, each daughter DNA molecule contains regions in which both strands belong to the original DNA molecule and regions in which both strands are newly-synthesised.

Created for isaacphysics.org by Lewis Thomson