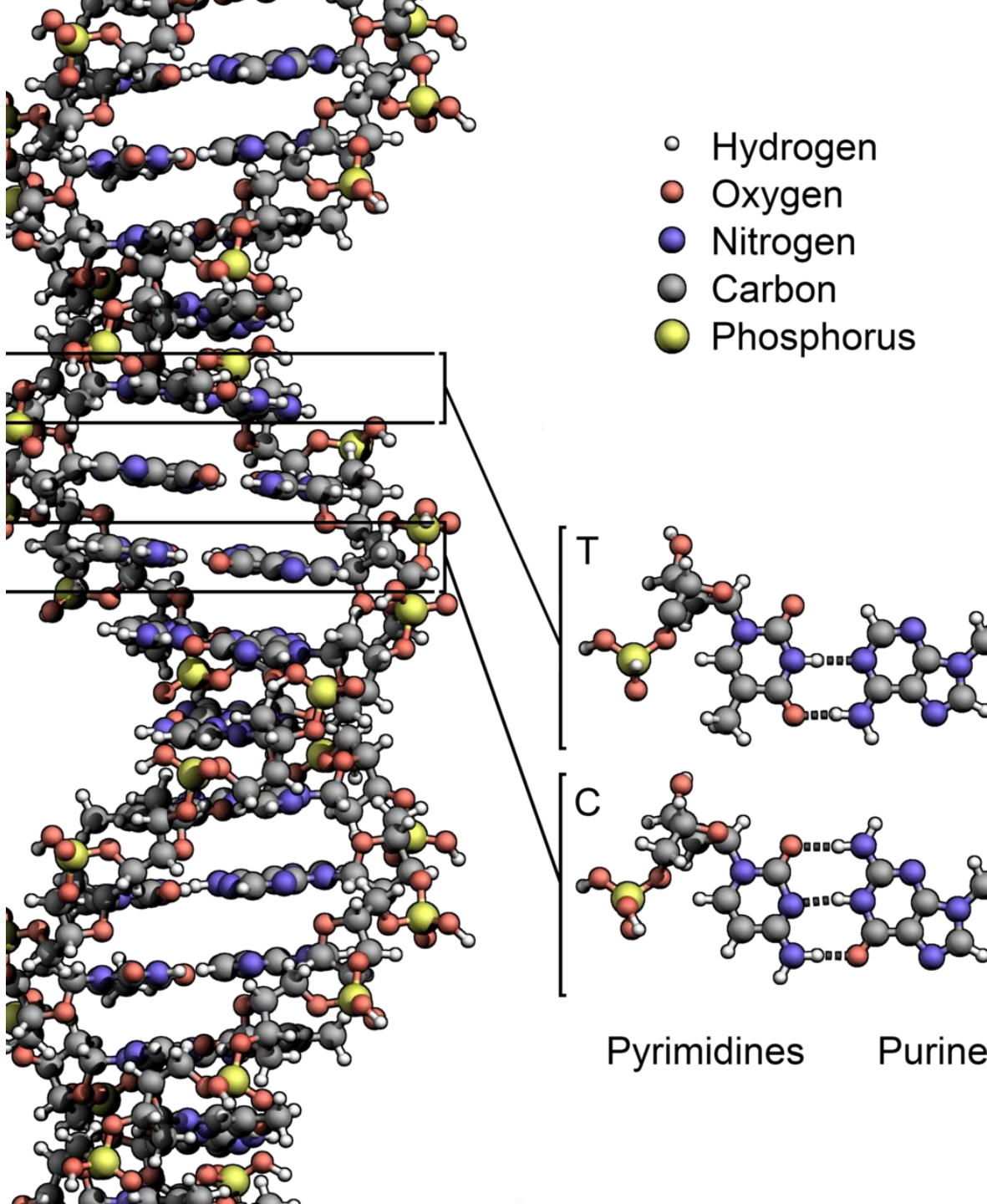
DP Biology – A1.2

Nucleic acids

- How do nucleic acids store information that can be inherited?
- Which features of DNA allow it to be copied accurately?

SL statements A1.2.1–10. Textbook pp. 14–24.
Image: structure of the DNA double helix. Zephyris, CC BY-SA 3.0.



Objectives for each class

Class	Statements	By the end of the class, you can...
1	A1.2.1–5	Draw a nucleotide, and explain how nucleotides form a polymer with a sugar-phosphate backbone
2	A1.2.6–7	Draw a section of DNA, and compare DNA with RNA
3	A1.2.8–10	Explain base pairing, the capacity of DNA to store data, and the code as evidence of common ancestry

Overview of this chapter

Part	Statements	What it covers
Building blocks	A1.2.1–4	Nucleotides, backbone and bases
RNA	A1.2.5	A polymer formed by condensation
DNA	A1.2.6–7	Double helix, and how it differs from RNA
Using the structure	A1.2.8	Base pairing in replication and expression
Bigger ideas	A1.2.9–10	Storing information, common ancestry

DNA is the genetic material of life

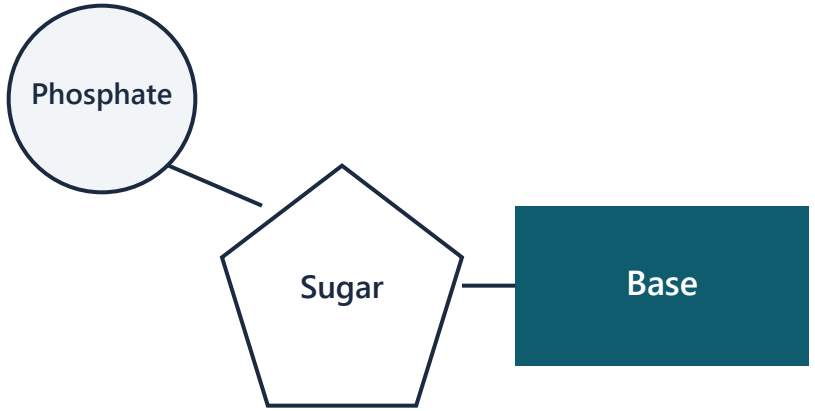
A1.2.1

- All living organisms use **DNA** as their genetic material
- Their cells use it to store the instructions for making proteins
- It is passed from parents to offspring
- Viruses can use DNA or **RNA**, but viruses are not considered to be living

Discussion

A virus with RNA as its genetic material is the exception that seems to break this rule. Why might it not count as an exception? What features of life does a virus lack?

The three parts of a nucleotide



Draw circles, pentagons and rectangles in these relative positions.

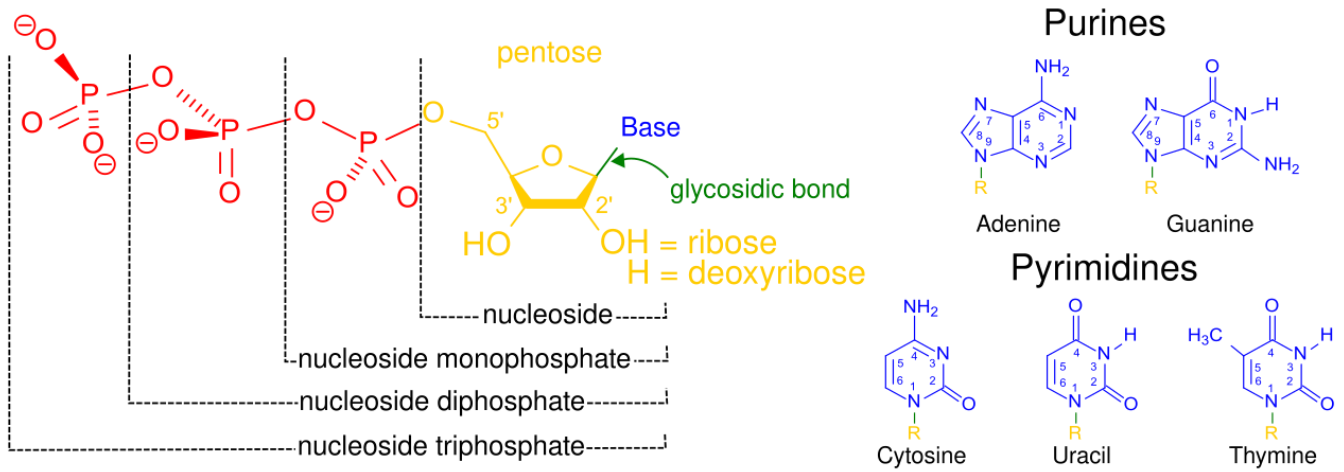
Part	Details
Phosphate	Acidic, with a negative charge
Pentose sugar	5 carbon atoms: ribose or deoxyribose
Nitrogenous base	One of four types in each nucleic acid

Activity

Draw one nucleotide using only these shapes. Make sure that the phosphate and the base are attached at different corners of the pentagon, and label each part.

The sugar-phosphate backbone

A1.2.3



Nucleotides of DNA and RNA. Boris, SVG by Sjef, public domain.

- Nucleotides join by covalent bonds between a sugar and the phosphate of the next nucleotide
- This makes a continuous chain of covalently bonded atoms, called the **backbone**
- The chain is strong, and it does not depend on which bases are present

Key idea

A strong backbone keeps the base sequence intact. The bases stick out from it, and any base can follow any other.

Bases carry the code

A1.2.4

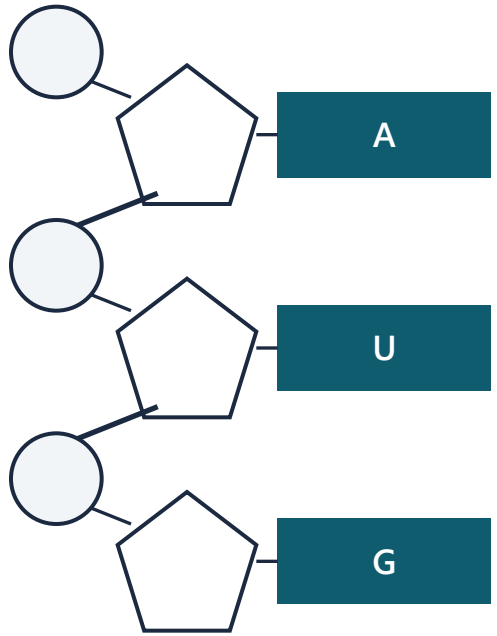
Base	In DNA?	In RNA?
Adenine (A)	Yes	Yes
Cytosine (C)	Yes	Yes
Guanine (G)	Yes	Yes
Thymine (T)	Yes	No
Uracil (U)	No	Yes

Key idea

The backbone is the same all along a strand. Only the base varies, so the sequence of bases is what carries the information, as letters do in a sentence.

RNA is a polymer formed by condensation

- Nucleotides are the **monomers**, and RNA is the **polymer**
- Each join is a **condensation** reaction, which releases water
- RNA is a single strand, with a sugar-phosphate backbone
- The bases project from the side of the strand



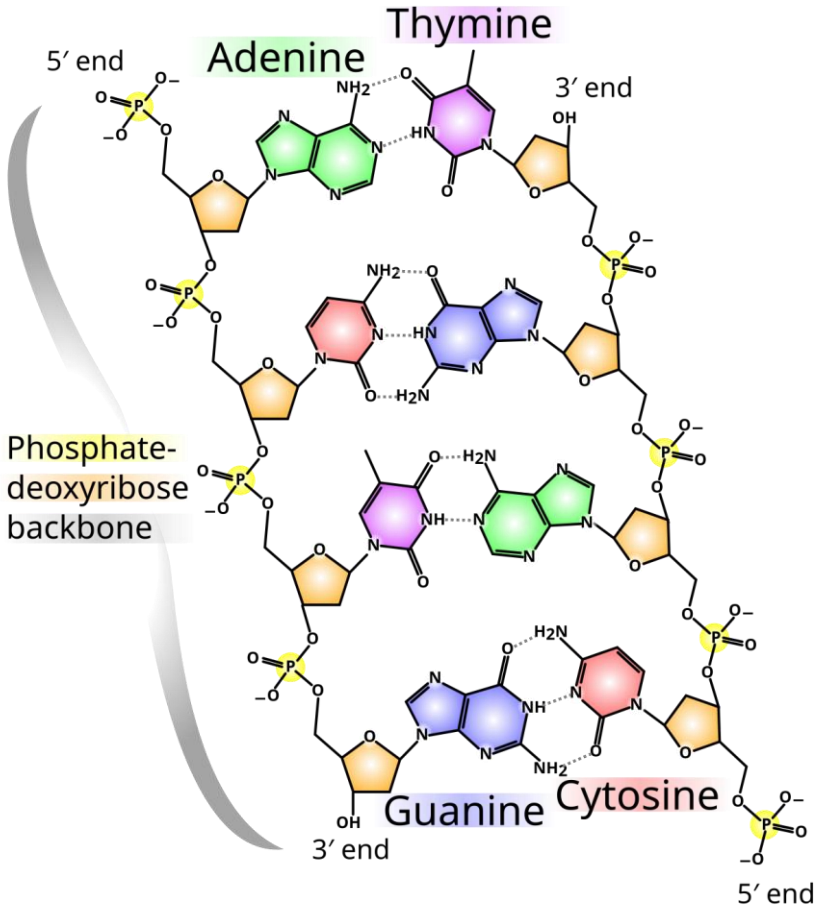
Schematic section of RNA.

Link

This is the same type of reaction that joins amino acids and monosaccharides into their polymers: water is removed for each bond that forms.

DNA: a double helix

A1.2.6



- Two strands wind around each other as a **double helix**
- The strands are **antiparallel**: they run in opposite directions
- **Hydrogen bonds** between bases link the two strands
- Adenine pairs with thymine, and guanine with cytosine

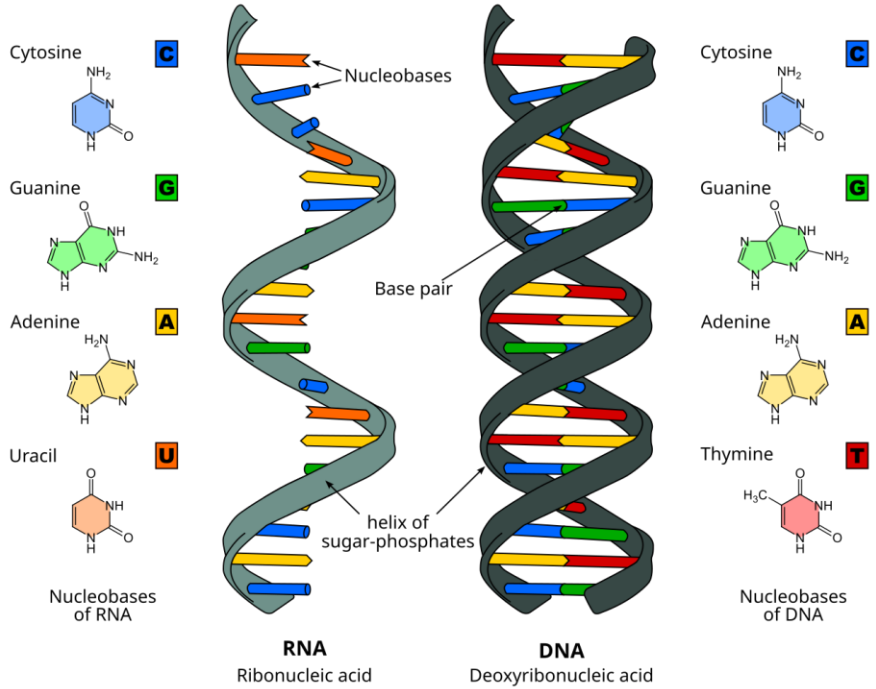
Exam note

Draw the two strands antiparallel, and label covalent and hydrogen bonds. You do not need to draw the helix, or to remember the numbers of hydrogen bonds.

The chemical structure of DNA. Madprime, CC BY-SA 3.0.

Differences between DNA and RNA

A1.2.7



Comparing RNA and DNA. Sponk, CC BY-SA 3.0.

	DNA	RNA
Strands	Two	One
Sugar	Deoxyribose	Ribose
Bases	A, C, G, T	A, C, G, U

Sketch it

Ribose has an -OH group on the carbon where deoxyribose has only -H. Deoxyribose has one oxygen atom fewer, which is where its name comes from.

Why base pairing matters

A1.2.8

Process	How pairing is used
Replication	Each strand of DNA is a template, so bases pair with free nucleotides to give two identical molecules
Transcription	A strand of DNA is a template for mRNA, with U pairing with A
Translation	Anticodons on tRNA pair with codons on mRNA

Key idea

Complementarity depends on hydrogen bonds, which form only between the correct pairs. A pyrimidine and a purine have the right shape to fit, and the correct atoms lie opposite each other. This is why information can be copied and used.

Limitless capacity to store information

A1.2.9

Length of sequence	Calculation	Possible sequences
2 bases	4 × 4	16
3 bases	4 × 4 × 4	64
10 bases	4 to the power 10	Over 1 million

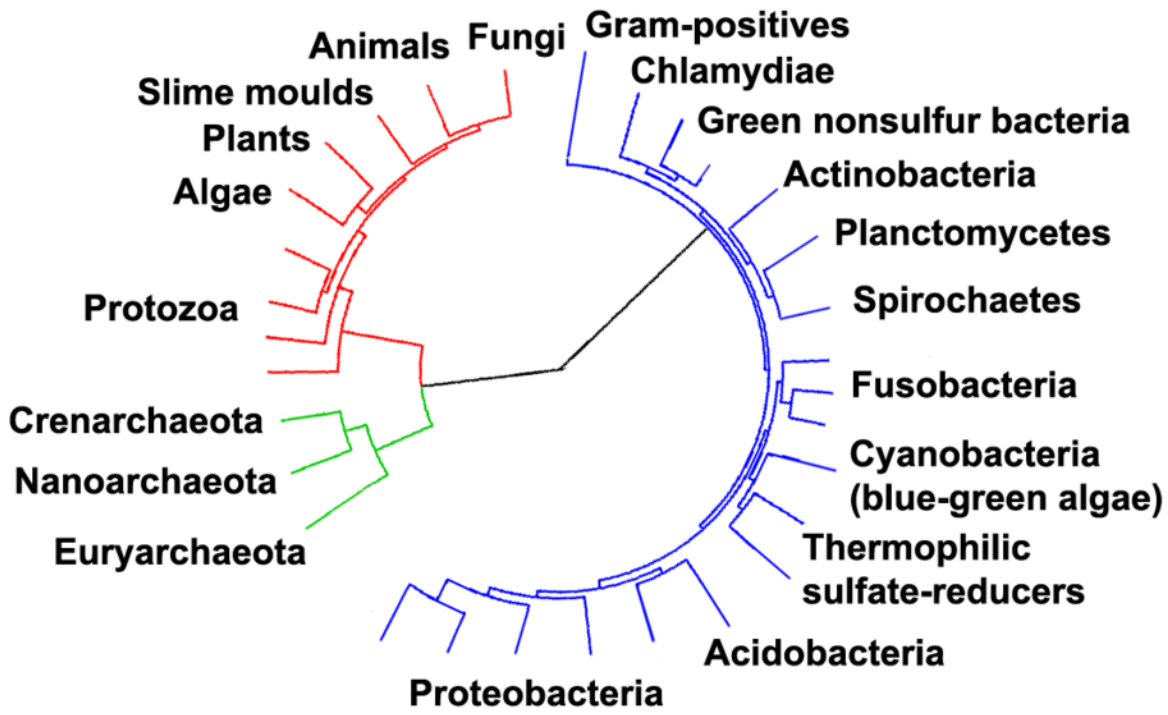
- Any length of DNA molecule, and any base sequence, is possible
- A human cell stores about 3 billion base pairs in each set of chromosomes
- It is an extremely compact way to store data, and one gram of DNA could hold hundreds of millions of gigabytes

Discussion

Scientists have stored books and films in DNA. What might make it better than a hard drive for long-term storage?

The code as evidence of common ancestry

A1.2.10



A tree of life built from gene sequences. TimVickers, public domain.

- Almost all organisms use the **same genetic code**
- The chance of this arising separately is extremely small
- The best explanation is **universal common ancestry**
- A few small variations exist, but you need not memorize them

Example

A firefly gene put into a tobacco plant makes the plant glow: the plant reads the gene in the same way as the firefly does.

Check that you can explain

1. Why DNA is the genetic material
2. How to draw a nucleotide
3. What the backbone is
4. How RNA forms by condensation
5. How to draw a section of DNA
6. Three differences between DNA and RNA
7. How to sketch ribose and deoxyribose
8. How base pairing allows copying and expression
9. Why DNA has such a large capacity
10. How the code shows common ancestry

Exit activity: 5 minutes

On your own and without notes. Hand this in as you leave.

1. List the three parts of a nucleotide.

2. State three differences between DNA and RNA.

3. A section of DNA is 4 bases long. Calculate how many sequences are possible.

Image credits

DNA Structure+Key+Labelled.pn NoBB.png – Zephyris – CC BY-SA 3.0

Nucleotides 1.svg – Boris (PNG), SVG by Sjef – Public domain

DNA chemical structure.svg – Madprime – CC BY-SA 3.0

Difference DNA RNA-EN.svg – File:Difference DNA RNA-DE.svg: Sponk / translation: Sponk – CC BY-SA 3.0

Collapsed tree labels simplified.png – TimVickers at English Wikipedia – Public domain

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