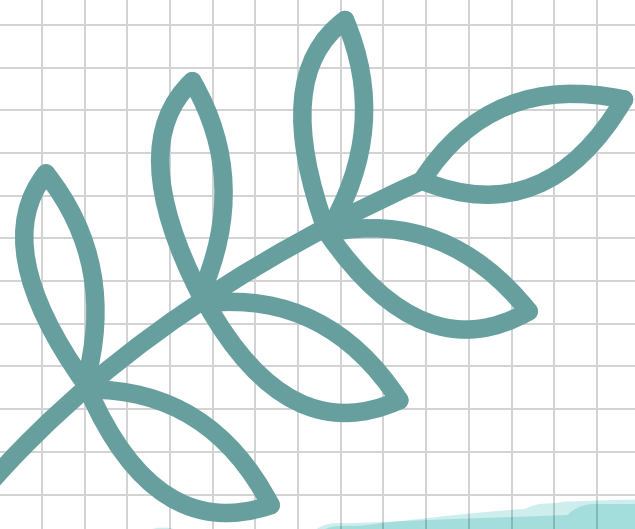
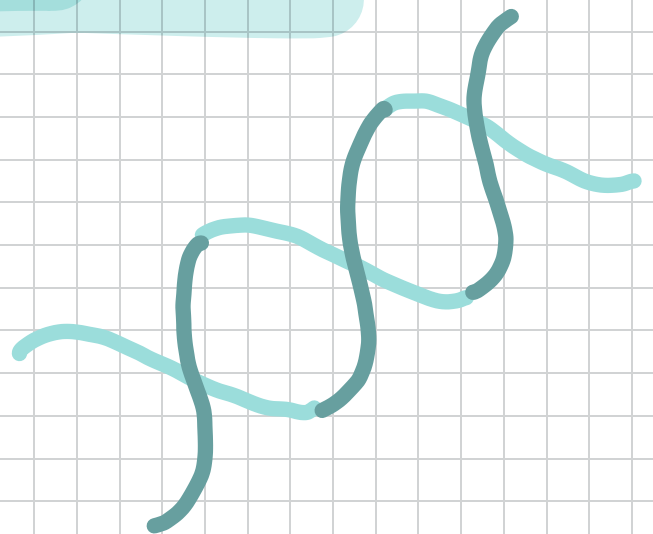




# DNA: The Code of Life



# Introduction

- two kinds of nucleic acids => deoxyribonucleic acid (DNA)  
=> ribonucleic acid (RNA)
- DNA => found in nucleus  
=> controls functioning of cell
- cells divide by mitosis => DNA copied  
=> complete set carried to nucleus of each daughter cell
- to work properly, body needs something to tell protein-making area what types of amino acids to use + in what order to use them
- info found on special nucleic acid molecules

## Deoxyribonucleic Acid

### Location

- mainly found on chromosomes in nucleus
- also occurs in mitochondria + in plastids like chloroplasts of plants

### Chromosomes

- found inside nucleus
- DNA they contain helps nucleus carry out two important functions
  - => nucleus controls activities of cell
  - => contains genetic code (set of instructions) that stores information to pass on to next generation of cells
- for most of its life, nucleus doesn't contain chromosomes
  - ↳ instead DNA occurs as very thin threads called chromatin
- each nucleus contains about 1 metre of chromatin threads
- during cell division, full set of DNA must be passed on to nucleus of each daughter cell
- ∴ threads of DNA must be organised so it can move safely without breaking
- DNA does this by carefully winding up into chromosomes
- in chromosome, DNA protected + supported by proteins called histones
- DNA wound round histone
- histones => important in packing chromosomes

### Genes

- name for small piece of DNA molecule
  - ↳ carries info about how to make specific chemical body needs + keep cells in healthy state
- nucleic acids store this info
- locus = specific place on chromosome where each gene (length of DNA/RNA) found

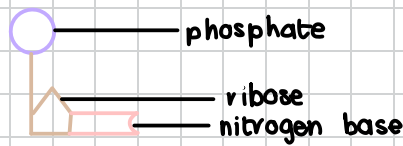
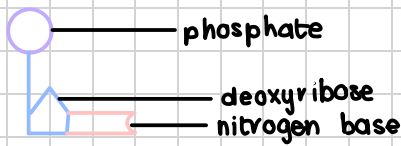
## Discovery of structure of DNA

- 1953
- 1866, Gregor Mendel discovers inheritance of characteristics
- DNA codes for/stores hereditary characteristics
- 1869, discovery of DNA
  - ↳ made up of 4 nucleotides
    - => Adenine
    - => Guanine
    - => Cytosine
    - => Thymine
- 1951, James Watson and Francis Crick investigate the structure of DNA
  - ↳ investigated structure because they believed structure would help understand function

↳ biggest question in science at the time

- sequence of 4 nucleotides can store info
- Rosalind Franklin shone x-rays through crystals of DNA (died @ 38 from cancer)
  - ↳ pattern form indicated that DNA has a helical shape (twisted shape)
- 1962, Maurice Wilkins, boss of Watson + Crick, and W+C got Nobel prize

## Types of Nucleic acids



### Deoxyribose nucleic acid

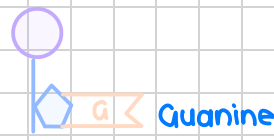
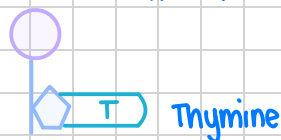
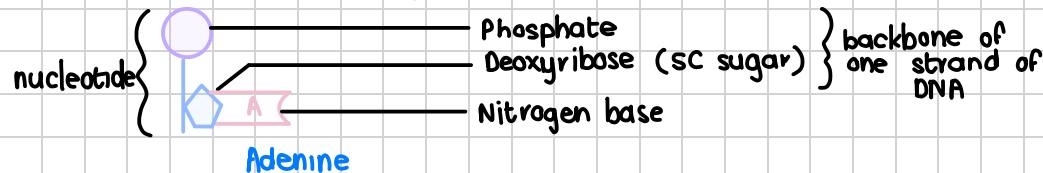
Nucleotides => guanine  
=> cytosine  
=> thymine  
=> adenine

### Ribose nucleic acid

Nucleotides => guanine  
=> cytosine  
=> uracil  
=> adenine

## Structure of DNA

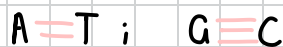
5 Carbon sugars called pentoses



Adenine } 2-ring molecules  
Guanine } purine bases

Thymine } 1-ring molecule  
Cytosine } pyrimidine base

- 1 purine base bonds with a pyrimidine base  
- Hydrogen bonds join nitrogen bases into base pair



- longer chromosomes carry more genes
- genome
  - ↳ chromosomes + genetic material
- amino acids = building blocks for proteins

- nucleotides can join end to end in order to make long strand
- strand has backbone of alternating phosphate + sugar units, with nitrogenous bases sticking out

## Role of DNA

### Gene

- DNA = code
- gene => small section of DNA that has info needed to make one particular protein in body
- all cells hold same DNA but each express differently
- DNA uses order of nitrogenous bases along one of its strands as info for sequence of amino acids
- info called genetic code
- complete set of all genetic codes needed to live + grow called genome
- everyone's genetic code = 99,9% the same
- genetic code for each amino acid found as 3 nitrogenous bases along DNA strand
  - ↳ called triplet code
  - ↳ arranged on mRNA

- some triplet codes act as full stops to show end of info about protein
- genetic code = universal code
- nearly all living organisms have same triplet codes for same amino acids
- $\therefore$  possible to move gene from one organism + put it into cells of different organism
  - ↳ basis of genetic engineering

## Non-coding DNA

- DNA that doesn't contain info for making proteins
- some involved in regulating coding regions of DNA
  - ↳ tells gene to turn on/off  $\Rightarrow$  won't produce protein
  - $\Rightarrow$  can't express itself
- non-coding DNA makes DNA profile
  - ↳ technique that identifies DNA from individual by analysing some of many sections of non-coding DNA
  - ↳ in non-coding = sections called short tandem repeats (STRs) (sections of repeating nucleotides)
  - ↳ for any given STR, you'll have inherited different numbers of repeats from each parent
  - ↳ different numbers of repeats in STR makes fragments of DNA different lengths
  - ↳ when different lengths of fragments spread out, they give different DNA profile
  - ↳ made by analysing DNA for 10 different STRs
  - ↳ valuable tool for criminal investigations + forensic science
    - $\Rightarrow$  DNA profile collected @ crime scene may be compared with DNA profile of suspects

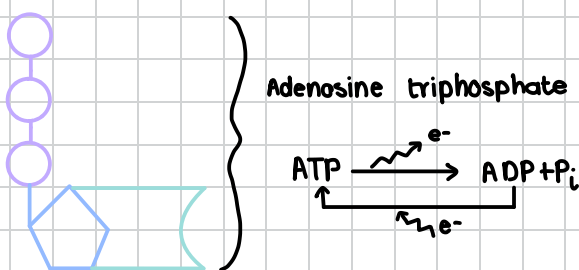
## RNA vs DNA

### Structure (DNA)

- double stranded helix
- large molecules of more than a million base pairs
- similar look, very different functions

### Structure (RNA)

- single stranded molecule
- much smaller from 150 - a few thousand bases



- polymerase chain reaction = genetic engineering where we mimic DNA replication  
 ↳ take sample of DNA + amplify it in test tube so DNA profiling can be done

## Replication

- DNA  $\Rightarrow$  genetic material needed by each cell
  - $\Rightarrow$  must be able to copy itself exactly before cell division
- special structure of DNA can make exact copies because
  - $\Rightarrow$  nitrogenous bases complementary because they join w/ different numbers of hydrogen bonds
  - $\Rightarrow$  bonds joining complementary pairs = weak + easily broken so 2 strands open up quickly to expose nitrogenous bases
  - $\Rightarrow$  2 backbones of phosphate + sugar = identical
- necessary for mitosis
- steps  $\Rightarrow$  one end of double helix starts to unwind
  - $\Rightarrow$  enzymes break hydrogen bonds between complementary nucleotides so molecule unzips
  - $\Rightarrow$  nitrogenous bases become exposed

- ⇒ free nucleotides in nucleus bond to exposed nitrogenous bases
- ⇒ final result = formation of 2 identical DNA molecules

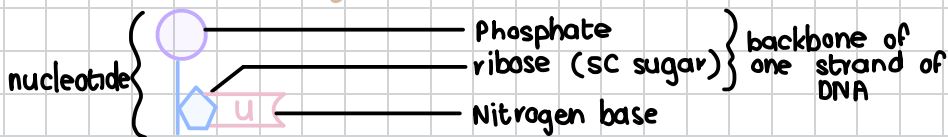
# Ribonucleic Acid

Types of RNA + locations in cells

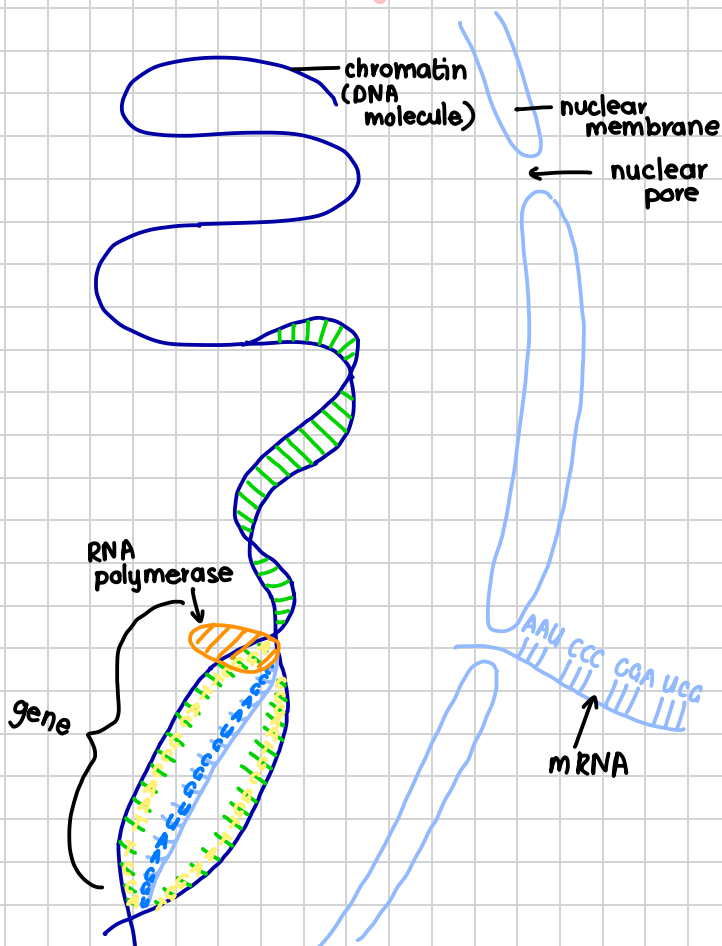
- 3 types ⇒ mRNA: Messenger RNA
  - ↳ found in nucleus
  - ↳ leaves nucleus + enters cytoplasm to code for correct arrangement of amino acids
- ⇒ rRNA: Ribosomal RNA
  - ↳ found in ribosomes
- ⇒ tRNA: Transfer RNA
  - ↳ found in cytoplasm
  - ↳ attaches to specific amino acids + slots them in specific place to build protein

## Structure of RNA

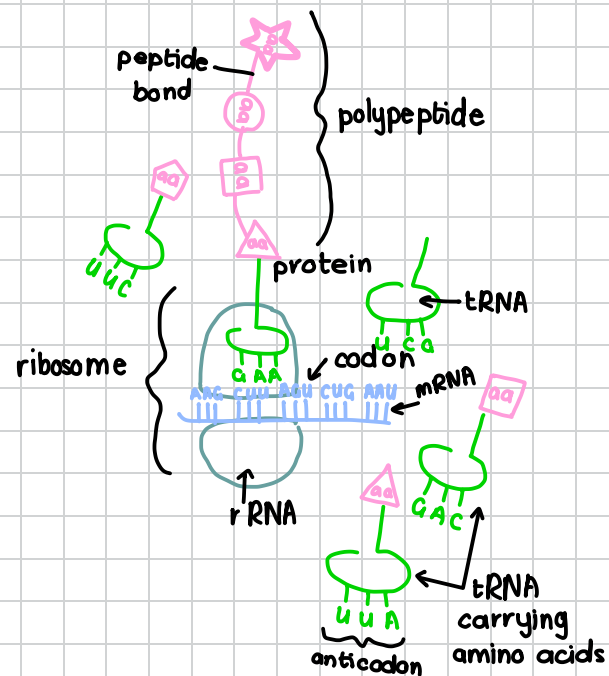
Uracil replaces thymine



## Protein Synthesis



Transcription



Translation

## Transcription

- when specific protein needed, gene responsible for instructing its formation chemically "switched on"
- when gene switched on, DNA helix unwinds along small part of molecule
- part then unzips to expose rows of nitrogenous bases
- in nucleoplasm there are many free RNA nucleotides
- RNA nucleotides attach themselves to their complementary bases on one of strands
- enzyme RNA polymerase joins them together
- to complete transcription, mRNA set free from its DNA pattern
- leaves nucleus through nuclear pores + passes into cytoplasm
- attaches to ribosome
- section of DNA closes up + winds up into helix again

## Translation

- rRNA combines w/ proteins to form nucleoprotein called ribosome
- several ribosomes may be attached to single mRNA @ any time
- ribosomes bind mRNA + carry out protein synthesis
- tRNA molecule always has site for attachment of its particular amino acid @ one end
- @ other end = group of 3 nitrogenous bases acting as binding site to mRNA molecule
  - ↳ complementary to codon on mRNA
  - ↳ called anticodon
- tRNA transfers amino acids in cytoplasm to mRNA attached to ribosome
- specific tRNA for each type of codon
- process puts amino acid in exactly right place
- info in nitrog. base sequence on mRNA now been translated into order of amino acids in protein
- ribosome passes along mRNA + makes protein by attaching amino acids to each other
- tRNA set free again + moves away to collect another specific amino acid
- amino acids linked in order corresponding to info on DNA

mRNA formed carries exactly same info as DNA it was made from because nitrog. bases always complementary. We say info has been transcribed from gene made of DNA into mRNA. Process called transcription

### NOTES

#### Proteins:

- speed up chemical reactions of metabolism (e.g. enzymes)
- control body processes (e.g. some hormones)
- protect body from diseases (e.g. antibodies)
- stabilise pH of tissues (e.g. soluble blood proteins)
- support internal structures (e.g. collagen)
- control movement of substances into + out of cells (e.g. ion channels in membranes)
- carry substances like oxygen (e.g. haemoglobin)
- stop loss of blood (e.g. fibrin)
- contract to allow muscles to work (e.g. actin + myosin)
- store food (e.g. albumin + casein)
- external structures on body (e.g. hoof, horn + hair)

## Genetic code

- most chemicals within cells similar regardless of type of cell/ species of organism
- organisms + cells differ in their proteins + DNA
- DNA of different species differs in sequence of bases along length
- sequence = code that determines which proteins synthesised
- genetic code: sequence of triplets that mRNA carries to cytoplasm to make proteins cell needs
- each triplet has code for particular amino acid
- all triplet codes universal
- specific order of triplet codes along one strand determines specific protein made
- individuals unique because they have different sequences of triplet codes + ∴ different genetic codes