HN

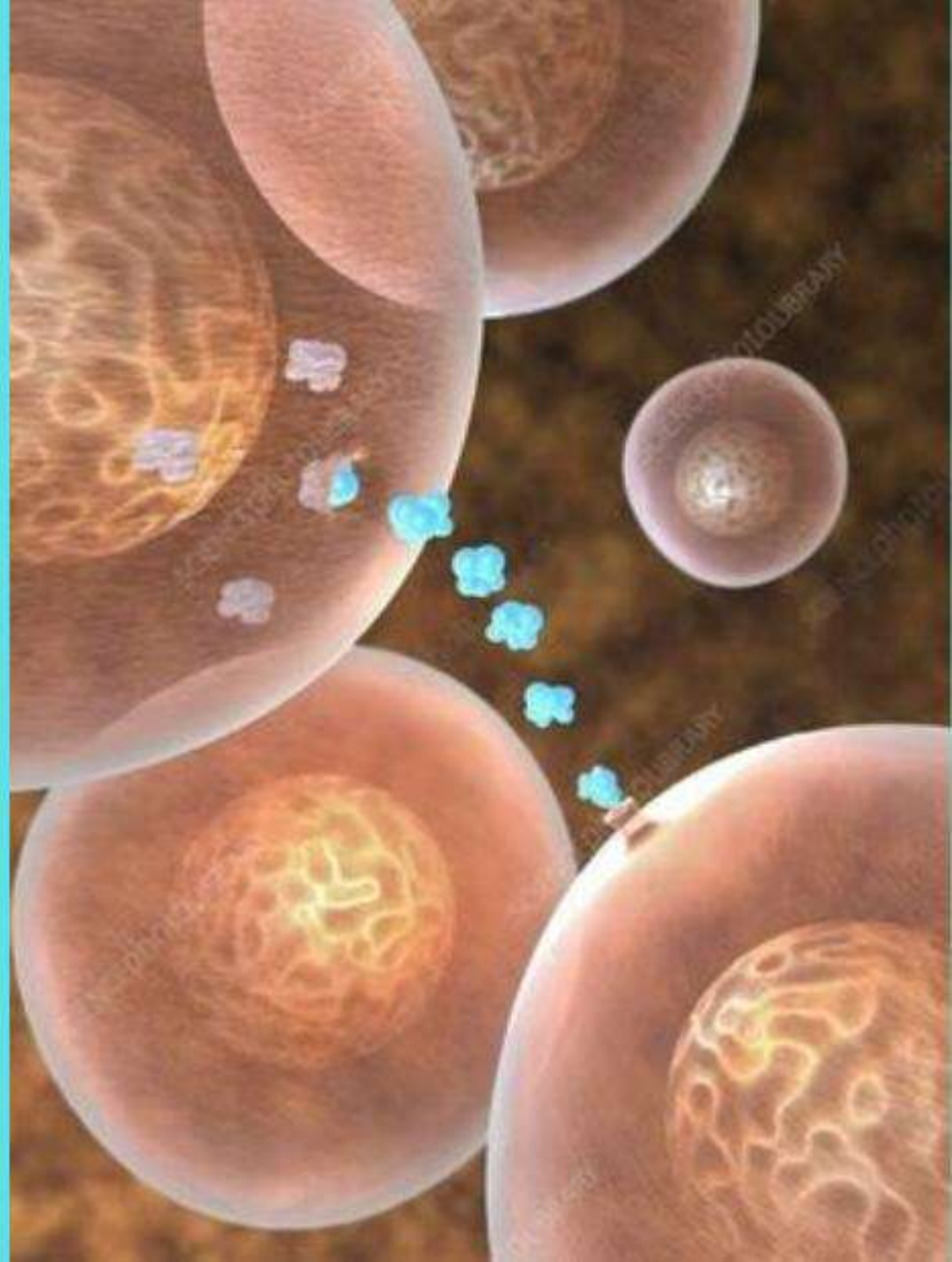
SEASON 2

Understanding Cancer

Lecture 1
Introduction to Cancer

DR HAFSA WASEELA ABBAS

www.hafsaabbas.com



What will we learn today?

- **What is cancer? *Can we cure it?***
- **Cell communication**
- **A brief insight into the history of cancer**
- **An overview of the DNA, genes and chromosomes.**
- **What causes our genes become faulty?**

An ideal way of learning:

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

5 mini-lectures.

Approximate total time: 1 hour

Divide over 7 days at your **own pace**.

Challenge yourself with a quiz!

How to support your learning?

- **Key facts with diagrams by HN designs presented in a simplified way.**
- **Glossary to help understand what key words mean.**
- **Summary doodle revision posters by HN designs.**
- **Quizzes to test your knowledge and reflect.**
- **Reference list for further reading.**

Acknowledgements: Special thanks to my parents, family, friends and colleagues for their support and the respected teachers and health professions who taught me and installed the passion of cancer/oncology.

What is cancer?

Can we cure it?

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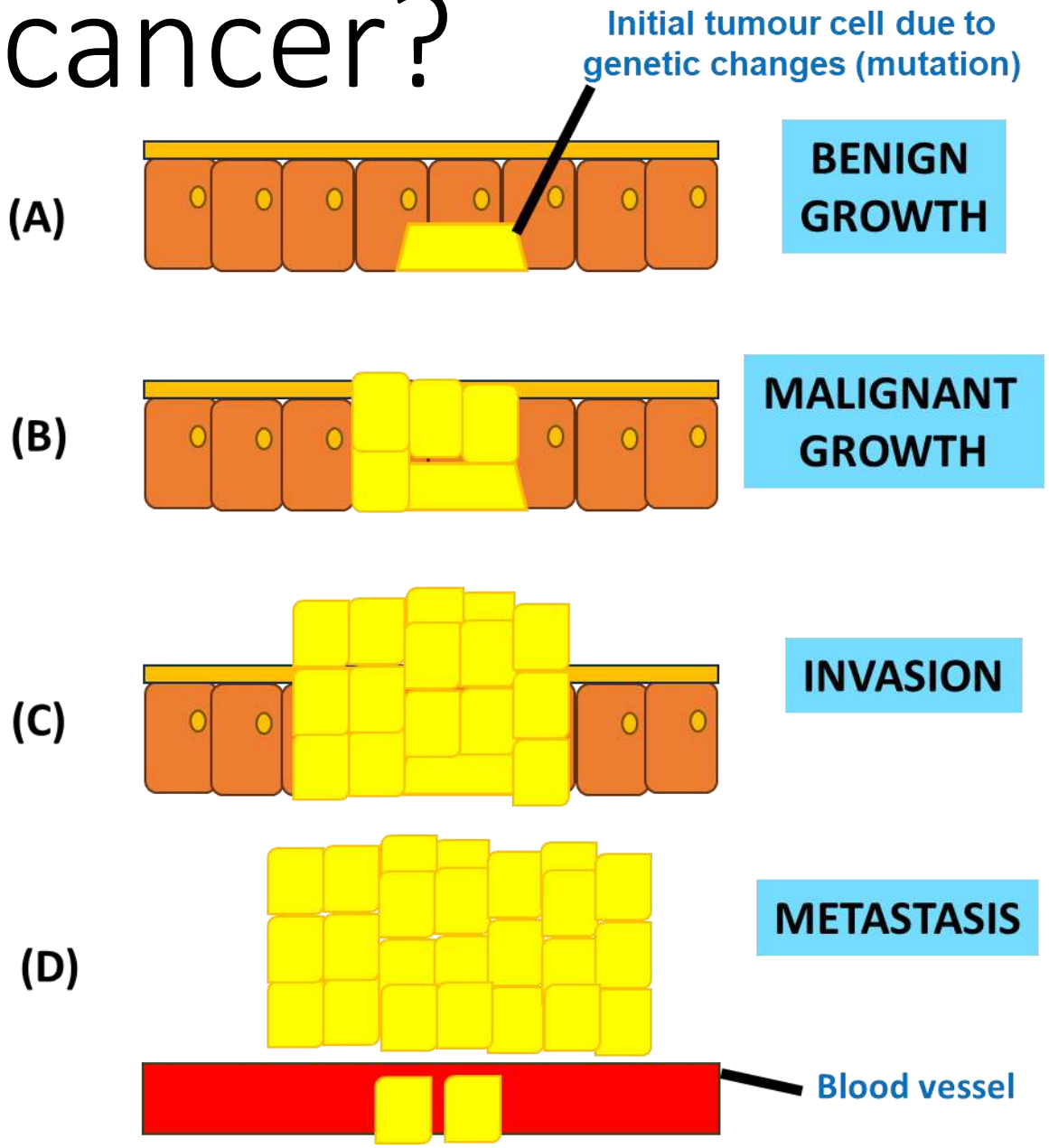
Key Facts: What is cancer?

Cancer is a disease characterised by the **uncontrolled growth of the body cells** at the original site **(primary tumour)** that can **spread to other parts of the body** via the **blood and lymph vessels** to form **secondary tumours** that are **malignant and invasive.**

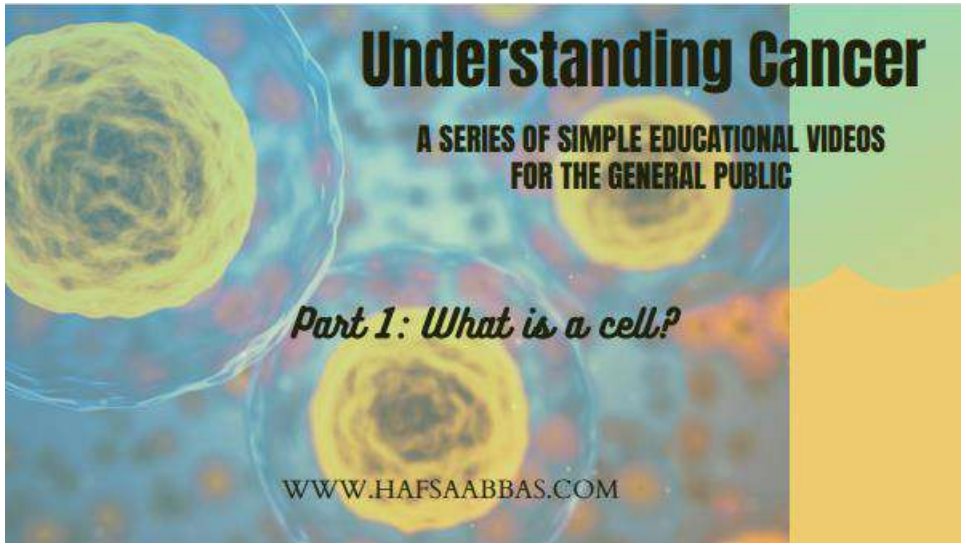
This is known as **metastasis.**

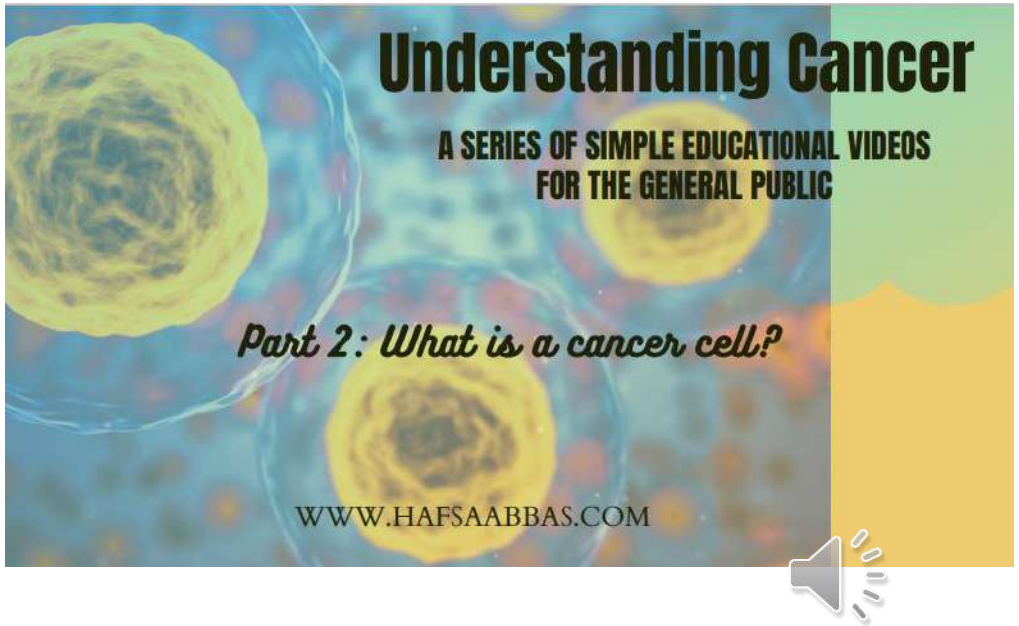
Lymph vessels are tube-like structures that carry green fluid containing white blood cells to fight infection and disease.



REMINDER

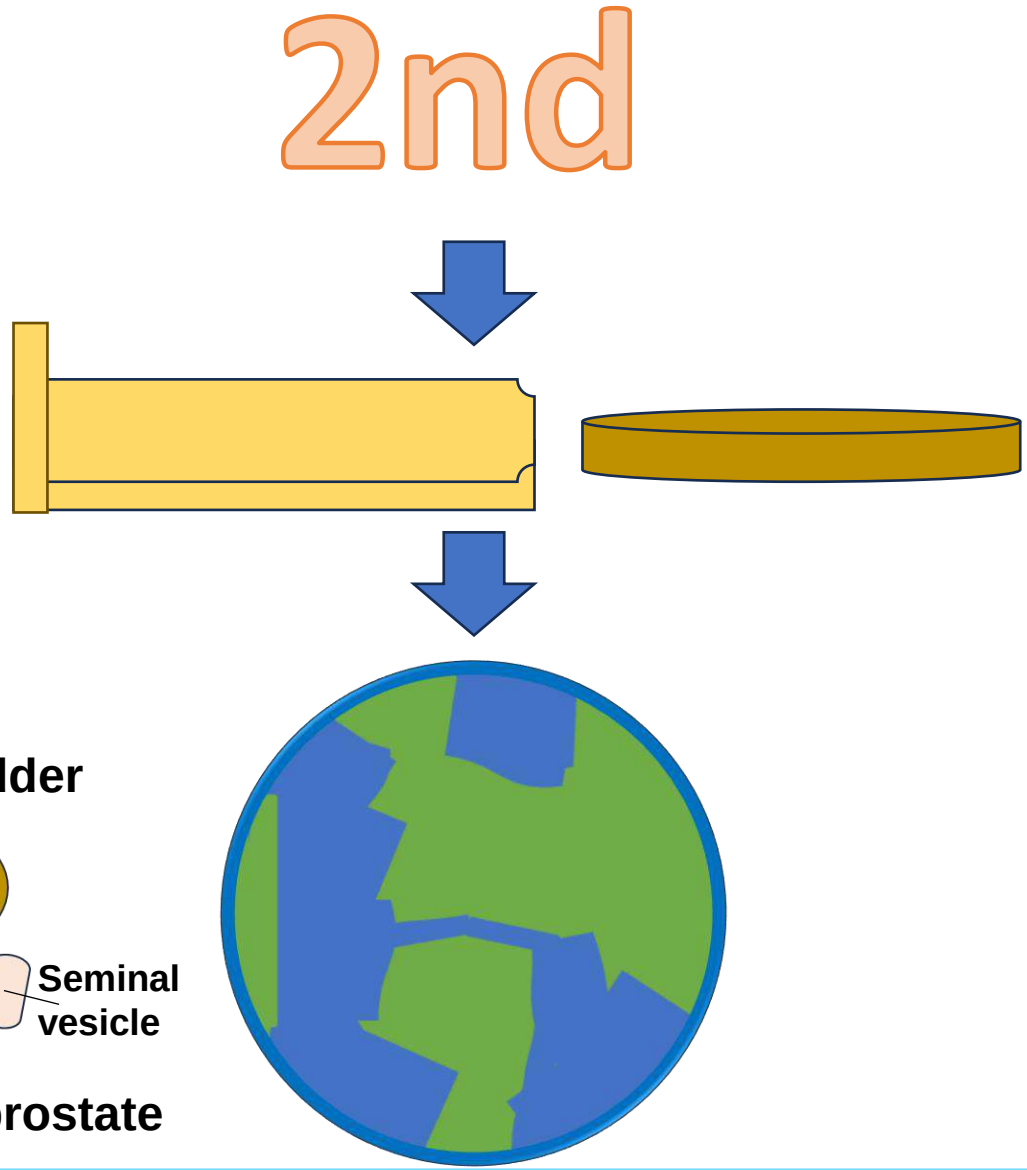
Please visit Season 1: Lecture 1 and 2 for a recap on what a cell is and key differences between normal and cancer cells.





Key Facts: Cancer statistics

- **Cancer** is the **second-most leading cause for deaths around the world.**
- It accounts for **9.6 million deaths** in **2018.**
- **Cancer Research UK reported that between 2017-2019, 167142 deaths** were caused by **cancer.**
- **In 2018, half of all cancer deaths** was associated with **lung, bowel, breast or prostate cancer. This was reported by World Health Organisation.**



Key Facts: Is there a cure for cancer?

Possibly YES!

Who knows?

- **The number of cancers can be treated successfully but depends on the following:**

Age	When was it caught?	Lifestyle factors
• ***Are they elderly?***	• ***Early onset?***	• ***Exercise***
• ***How strong is their immune system to fight infection?***	• ***Late onset?***	• ***Diet***
	• ***Relapse (returned)?***	• ***Smoking***
		• ***Alcohol intake***
		• ***Work/occupation with chemicals/factories?***

However, with **improving methods and advanced technology being developed over time, cancers can be DETECTED EARLY and TARGET THEM BEFORE** they can be **LIFE-THREATENING.**

The **primary goal of treatment for metastatic cancer** is to **CONTROL THE GROWTH OF THE CANCER** or to **RELIEVE THE SYMPTOMS** its causing as it can affect how the body works.

Cancer education

LOWERS BURDEN

- **Patients**
- **Families**
- **Health authorities**
- **Communities**

Cell Communication

Key Facts: Why is cell communication important?

1

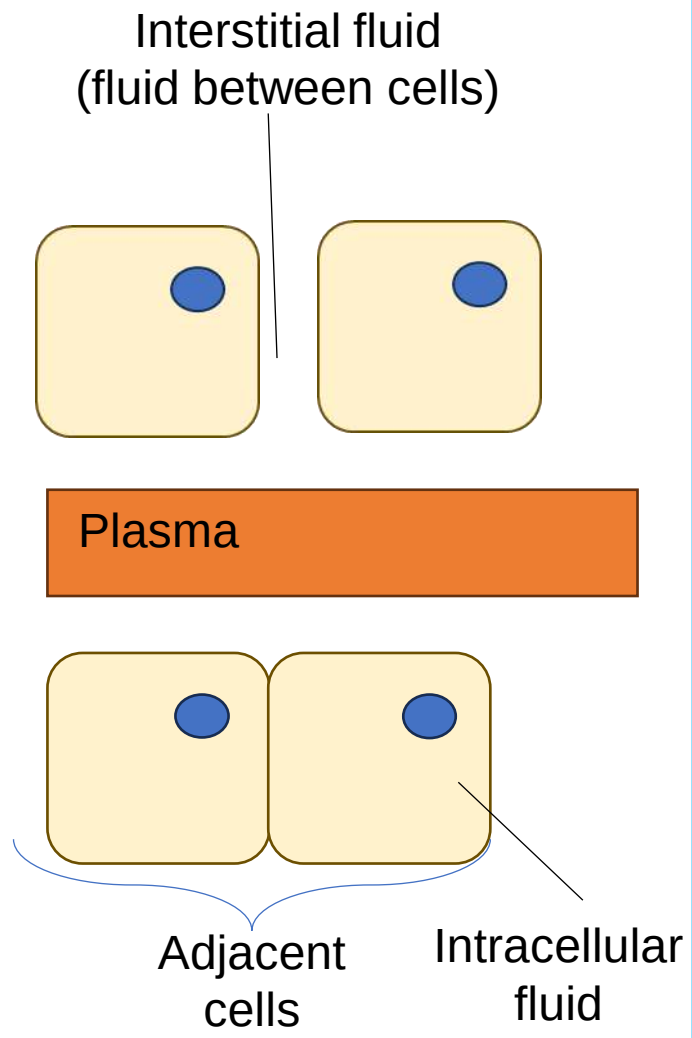
- Cells can **sense and respond to signals** in their **extracellular environment.**
- The **extracellular environment** is the area outside the cell e.g. **plasma and interstitial fluid**
- All **plasma membranes/cell membranes separates the intracellular from the extracellular environment.**

2

- **Cells coordinate activities** within the whole organism**.**

3

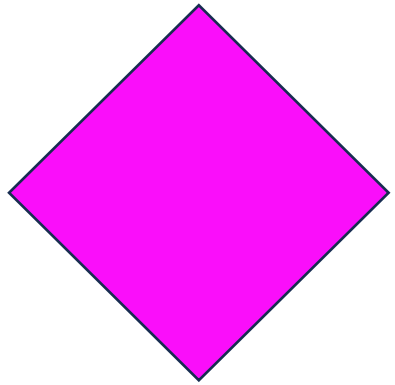
- **Cells communicate to one another especially adjacent cells.**
- Adjacent cells are **cells that are attached,** and **do not have other cells between them.**
- **This affects the behaviour of cells close and distanced.**



Key Facts: What is a signal?

A signal is a substance that influences the **properties of the cells.**

Amongst the **cellular activities are growth and how cells divide**.



A brief insight into the history of cancer

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Key Facts: Edwin Smith

There are a number of scientists that helped us understand what cancer is today.

Edwin Smith visited Luxor in 1862 and discovered the **EARLIEST** record of cancer on **Egyptian papyrus.**

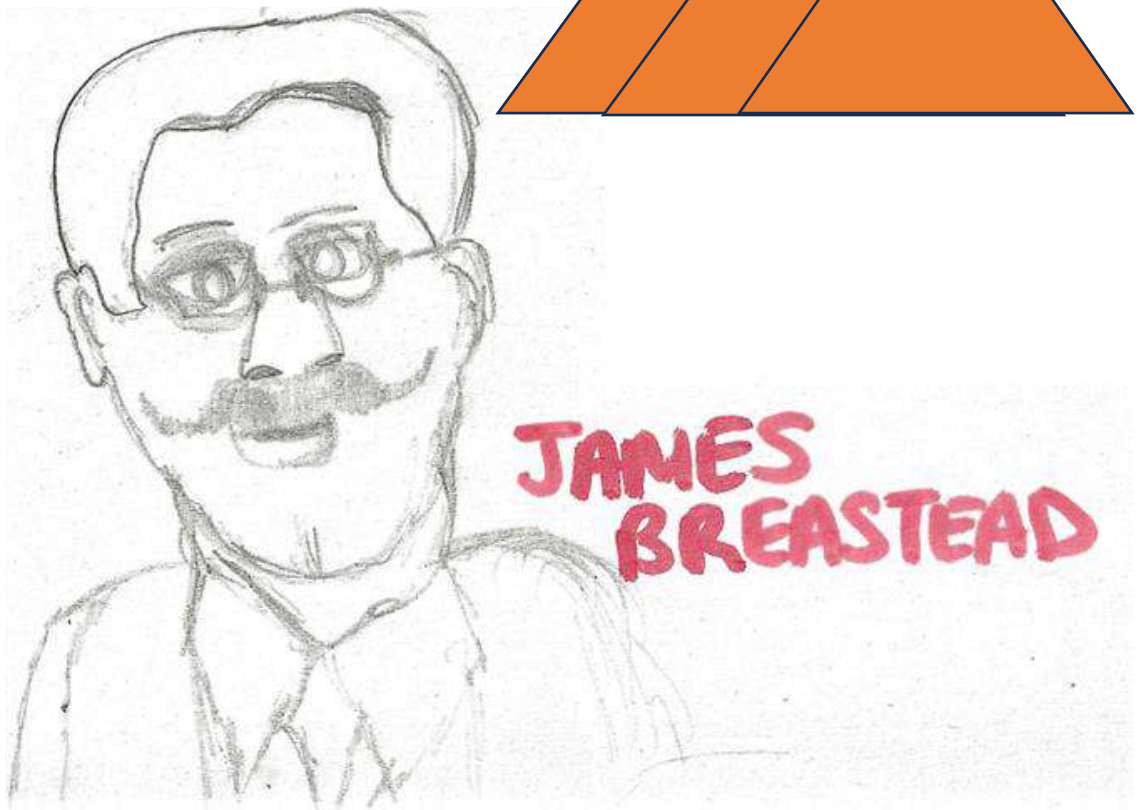
It was estimated 1600 BCE.

Records of cancer patients on Egyptian papyrus discovered by Edwin Smith

Source: National Library of Medicine, 2016

Key Facts: James Breasted

- In 1925, James Breasted translated the records from **hieroglyphics at the University of Chicago.**
- There were **48 cancer cases** recorded at the time.
- **Abscess** is an infected area that contains pus (dead cells and bacteria) and this was treated using **cauterization** (burn skin/wound) using red-hot iron.
- There were also records of patients with **swollen tumours.**
- **No treatment were recorded** by unknown physician.
- In 2018, six bodies of cancer patients were discovered in the Western desert of Egypt.



Key Facts: Hippocrates

In 400 BCE, Hippocrates discovered:

- **Tumours were rich in blood** and resembled **the limits of the crab.**
- Gangrene- tissues block and decay due to infection or limited blood supply.

Key terms derived from Ancient Greek

Greek: oncos

English:

Swelling.

Oncology: Medical profession for cancer.

Key terms derived from Ancient Greeks

Greek: carcinos.

English:

Carcinoma (most common type of cancer begins in the skin or lining of organ tissues

Key terms derived from Ancient Greeks

Greek: apoptosis

English:

Dropping off

Key Facts: Galen

600 years later after Hippocrates, Galen made records **for**

cancer patients he treated.

The Latin word for **crab is ‘cancer’** which is still used

today.

Key Facts: Avicenna (Ibn Sina)

The Persian physician wrote **Canon of Medicine in 1025**.

His **book was predominantly** used for study and was considered as an **encyclopaedia**.

It was translated in a **number of languages including Latin.**

He was described as the **first cancer surgeon who also used plants as a treatment strategy.**

Key Facts: Joseph Needham

Joseph studied **Chinese medicine a lot and worked in agriculture.**

He developed a **number of ways to help cancer patients with this pathway.**

An overview of the DNA, genes and chromosomes

Key Facts: Nucleus

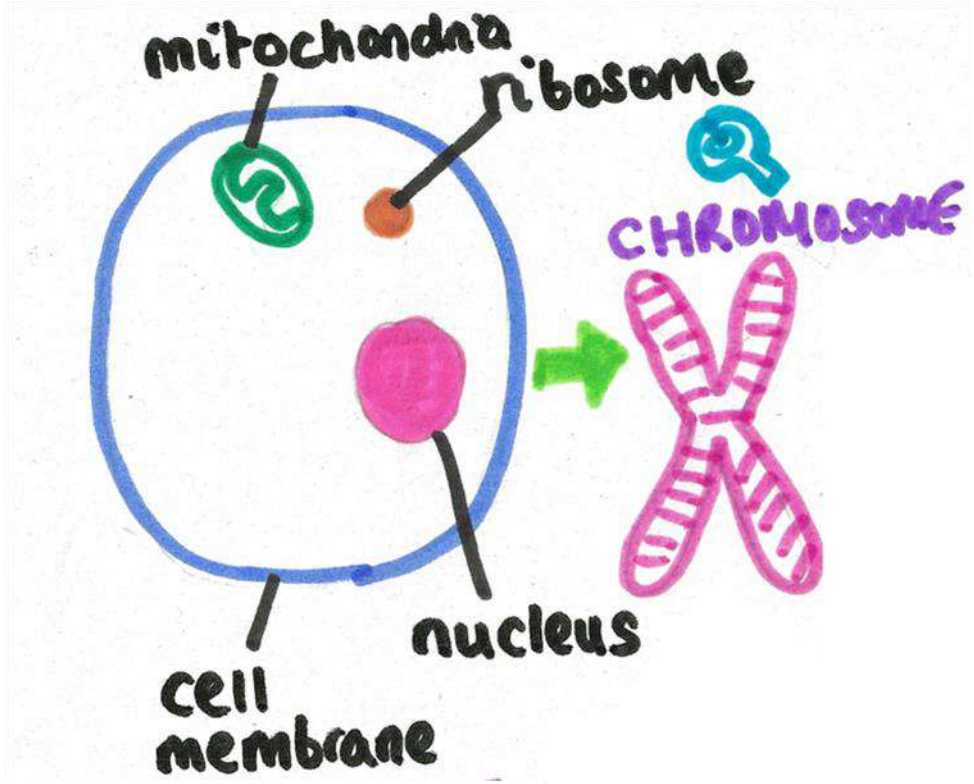
Our body is made of millions of **cells.**

Inside the cell, there are little organs called **organelles.**

One of these organelles are key to controlling the cell and its activities.

It is called the **nucleus.**

The nucleus has **genetic information** in the form of **chromosomes.**

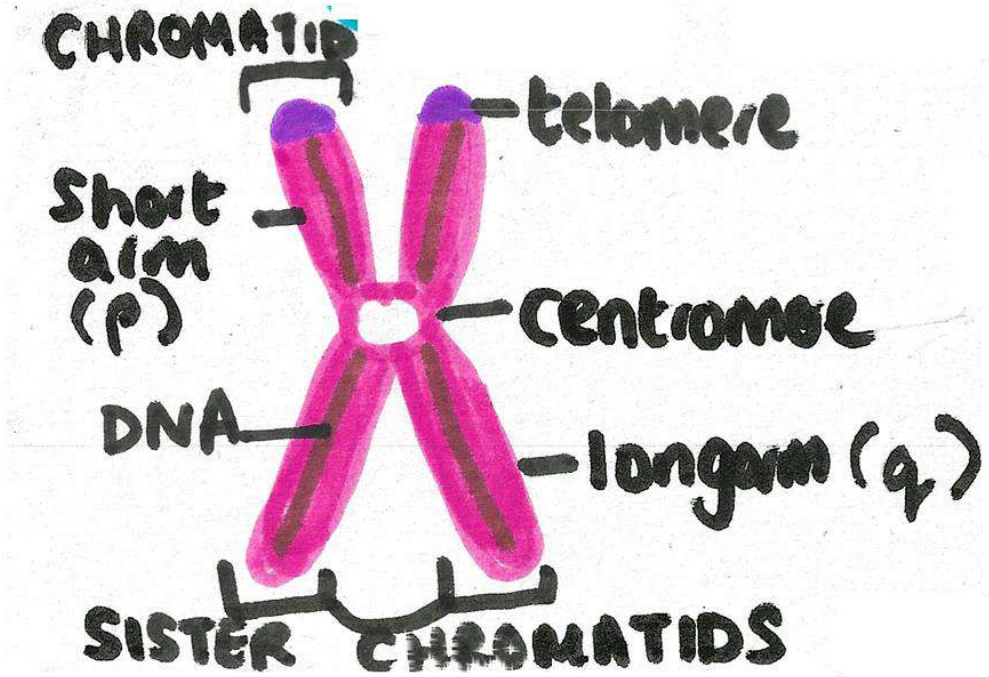


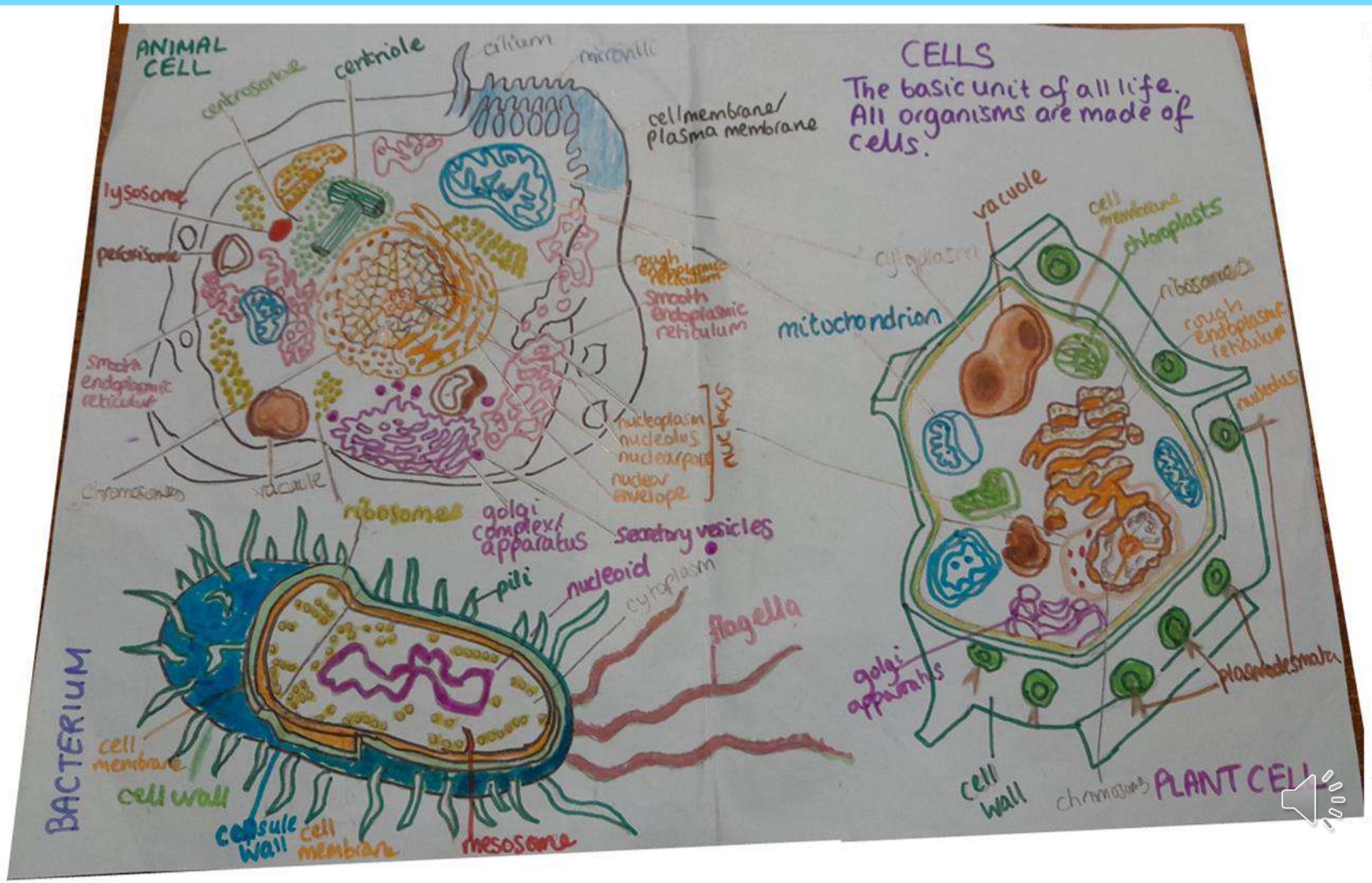
Key Facts: Chromosomes

Chromosomes are **long thread-like structures** made of **DNA.**

In each **body cell**, there are **23 pairs of chromosomes.**

This excludes **sperm (male) and egg (female) cells.** They are **sex cells (gametes)** that have **23 chromosomes each only.**




ANIMAL CELL
centrosome
centriole
cilium
microvilli
cell membrane/ plasma membrane
lysosome
peroxisome
rough endoplasmic reticulum
smooth endoplasmic reticulum
smooth endoplasmic reticulum
nucleoplasm
nucleolus
nuclear pore
nuclear envelope
nucleus
chromosomes
vacuole
ribosomes
golgi complex/ apparatus
secretory vesicles
pili
nucleoid
cytoplasm
flagella
BACTERIUM
cell membrane
cell wall
capsule
cell wall
cell membrane
mesosome
CELLS
The basic unit of all life.
All organisms are made of cells.
vacuole
cell membrane
chloroplasts
cytoplasm
ribosomes
mitochondrion
rough endoplasmic reticulum
nucleus
golgi apparatus
plasmodesmata
cell wall
chromosomes
PLANT CELL

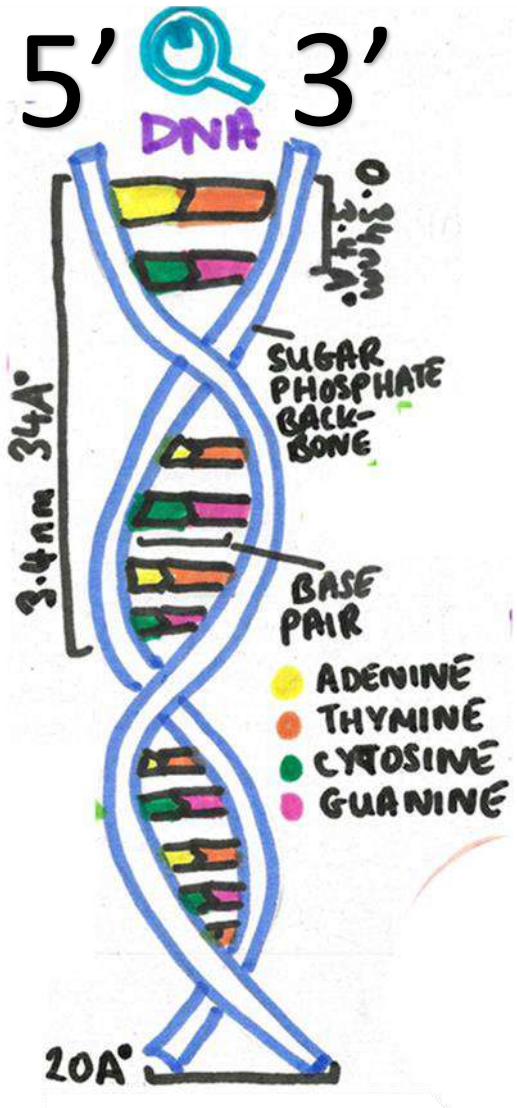
Key Facts: DNA

Abbreviation:

Deoxyribonucleic acid

Shape:

- 3D twisted ladder structure known as the **double helix**.
- **Diameter** of the DNA: 20A/2nm.
- The **distance between the two nucleotides**: 3.4 A.
- **Length**: 34A. 10^8–10^9 nm.
- It is a **long, thin polymer** that has **two DNA strands** with many **short monomers called nucleotides**.
- **Two DNA strands** are **antiparallel:** The 5’ end of one DNA strand is parallel with the 3’ end of the other DNA strand.



Key Facts: The Watson-Crick model of DNA

Before Watson and Crick, Friedrick Miescher, P. A. Levene, W.T. Astbury, Maurice Wilkins and Rosalind Franklin helped Watson and Crick to further study **the DNA structure.**

Maurice Wilkins and Rosalind Franklin discovered the image of DNA through **X-ray crystallography.**

The **X-ray diffraction** picture of DNA helped Watson and Crick to further study the **DNA structure and components** leading to the model developed in 1953.

DNA on Xray crystallography

Source: North, A (n.d)

Key Facts: Structure of DNA nucleotide

The DNA is a polymer that is made of short monomers called **nucleotides.**

Each nucleotide consists of:

Phosphate group

The **phosphorous element is** attached to **four oxygen atoms**.

Sugar molecule

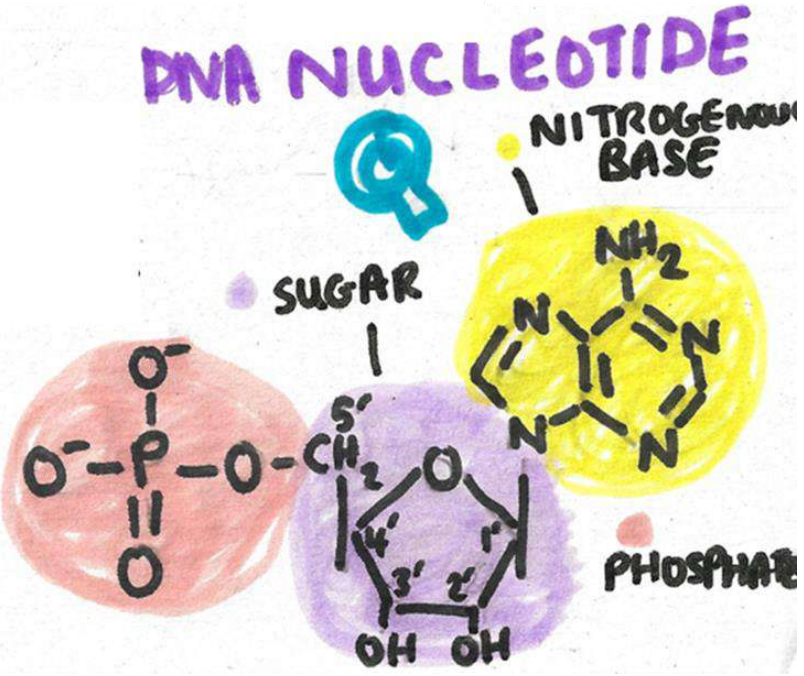
A **cyclical five carbon ring structure** called **ribose**.

There is **no oxygen group in the 3rd carbon (deoxyribose).**

Base

Nitrogenous base.

Four types: **adenine, cytosine, guanine and thymine**



Key Facts: Types of nucleotides

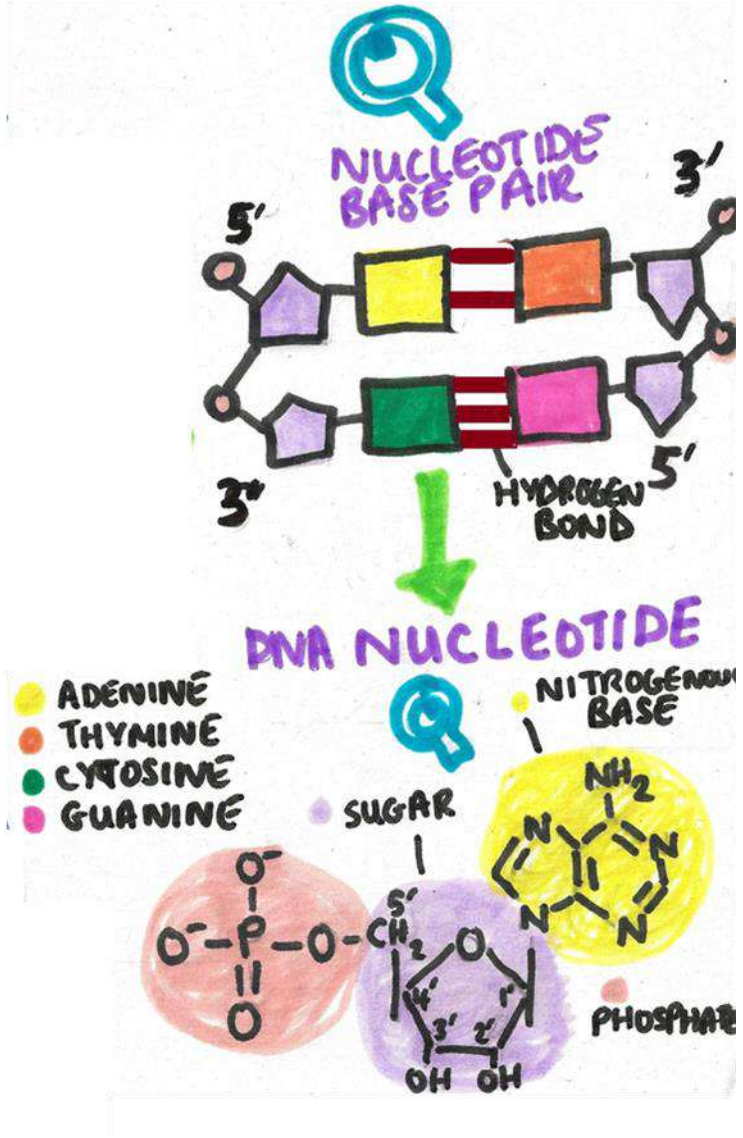
There are **four types of nucleotides.**

They differ based on the type of base but the sugar and phosphate are the same.

The **hydrogen bonds** join the bases together.

This is called **complementary base pairing** to create consistency in the two **DNA strands.**

- Adenine (A) joins with thymine (T) with **two hydrogen bonds.**
- Guanine (G) joins with cytosine (C) with **three hydrogen bonds.**



Key Facts: A step further on bases

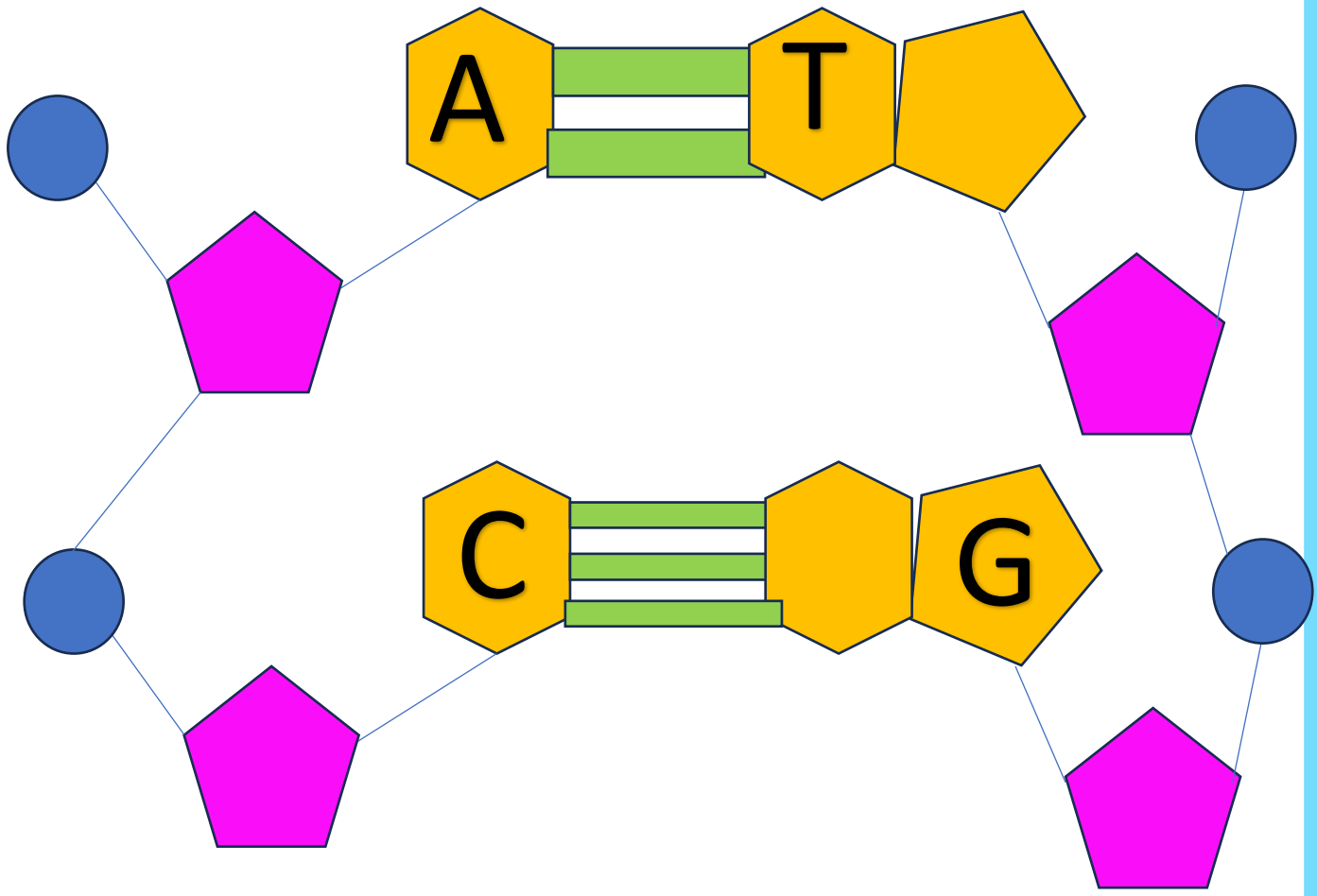
- **Purines** are five membered ringed bases:

Adenine and guanine.

- **Pyrimidines** are double-ring dix-membered ringed bases:

Cytosine and thymine.

- A **purine complementary binds with pyrimidine.**



Key Facts: Chargaff's rules

The sum of purines is equal to the number of pyrimidines.

The base composition of A + G = T + C

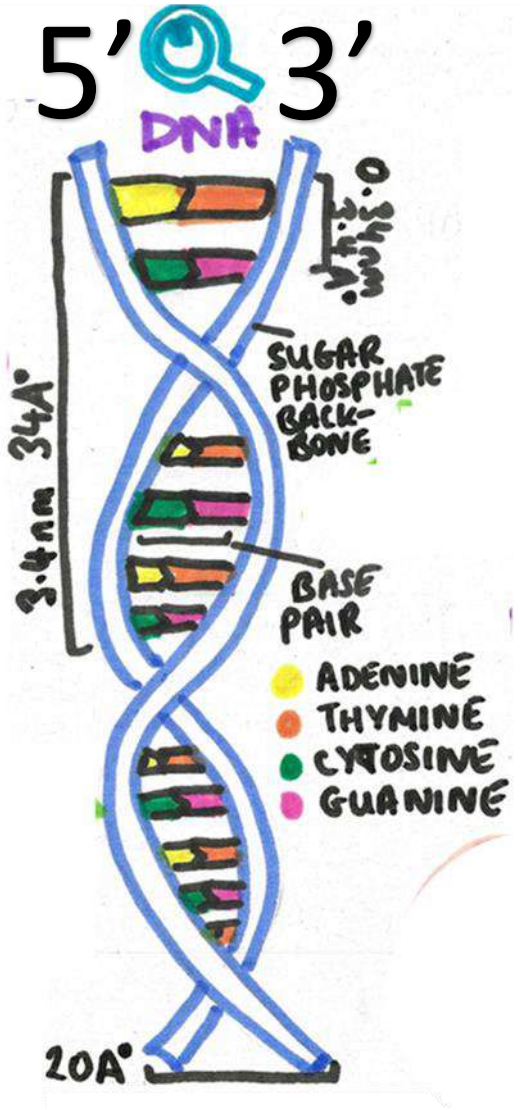
The base composition of A + T is **NOT EQUAL** to **G + C.**

Key Facts: Sugar-phosphate bond

Each nucleotide is attached to another nucleotide via **phosphodiester bonds.**

The sugar-phosphate backbone is **negatively charged** and **hydrophilic (water-loving).**

This allows the DNA backbone **to form bonds with water.**



Key Facts: Sugar-phosphate bond

- The phosphate group is attached to:

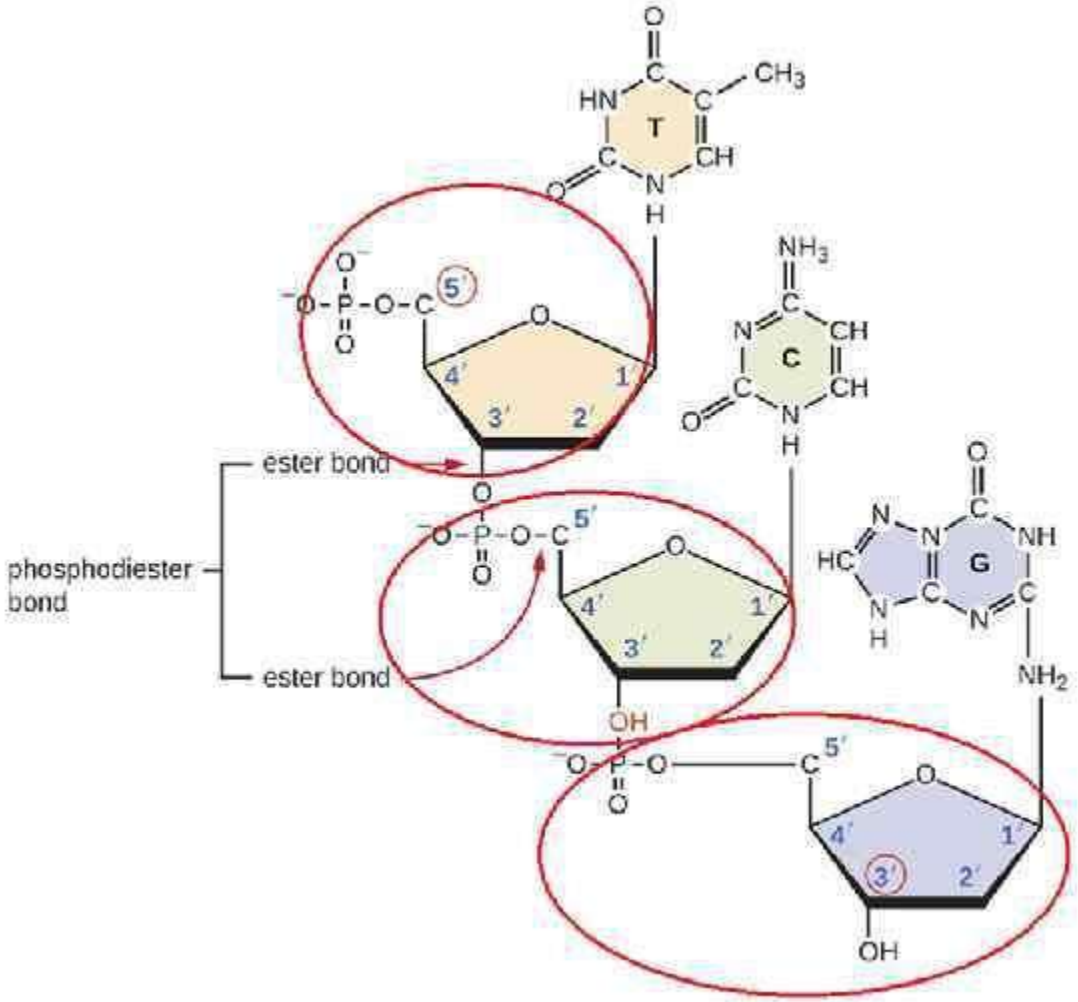
The 5' carbon of the sugar on one nucleotide.

- The **free -OH (hydroxyl) group is attached to:**

The 3' carbon of the next nucleotide.

- The base is attached to the 1' carbon.

These bonds are 3’**-5’ phosphodiester bonds** which provides **DNA stability.**



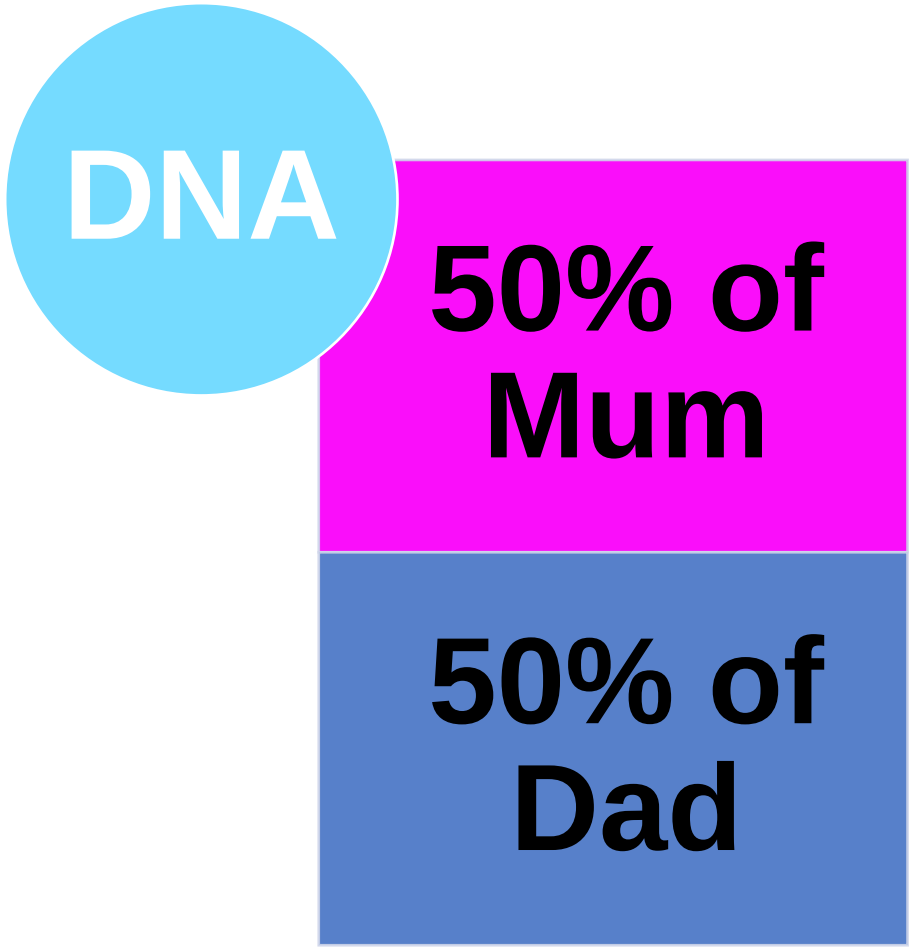
Key Facts: Functions of DNA

- The length of DNA helps to be **compacted into a small volume but is accessible.**
- It **stores all the genetic information** of the person to **build an organism or a life form.**
- It **stores instructions necessary to make proteins** which are needed for **growth and repair**.
- It is an **energy store for facilitating the transit of enzymes** called **DNA and RNA polymerases.**

Key Facts: DNA

Origin:

- **Half of the DNA is from our mother** and **the other half of the DNA is from our father.**
- There are **two copies for every gene**.



Key Facts: Gene

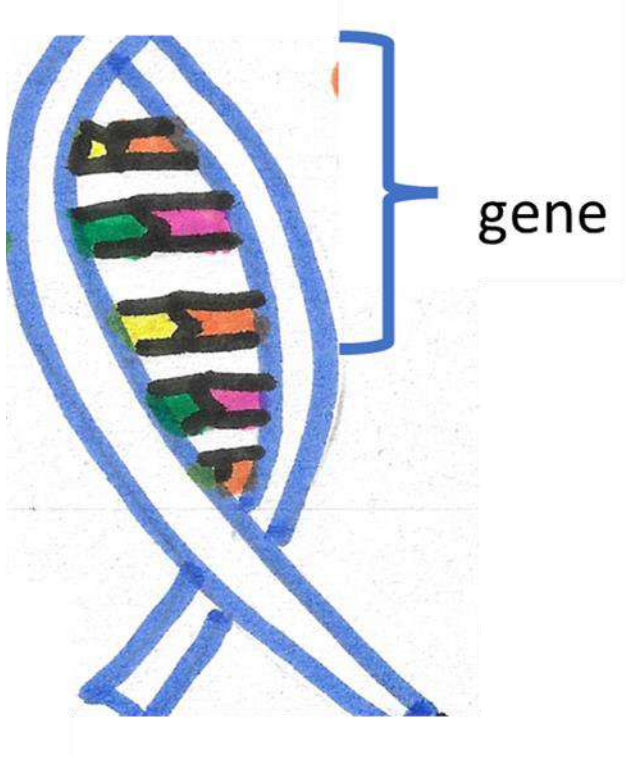
The gene is a **short section of the DNA**.

It contains instructions to tell the cell what to do.

It is estimated there are around **25,000 genes in humans.**

It affects and controls:

- ❑ **How we look like (phenotype)**
- ❑ **How we behave**
- ❑ **When to grow and divide.**



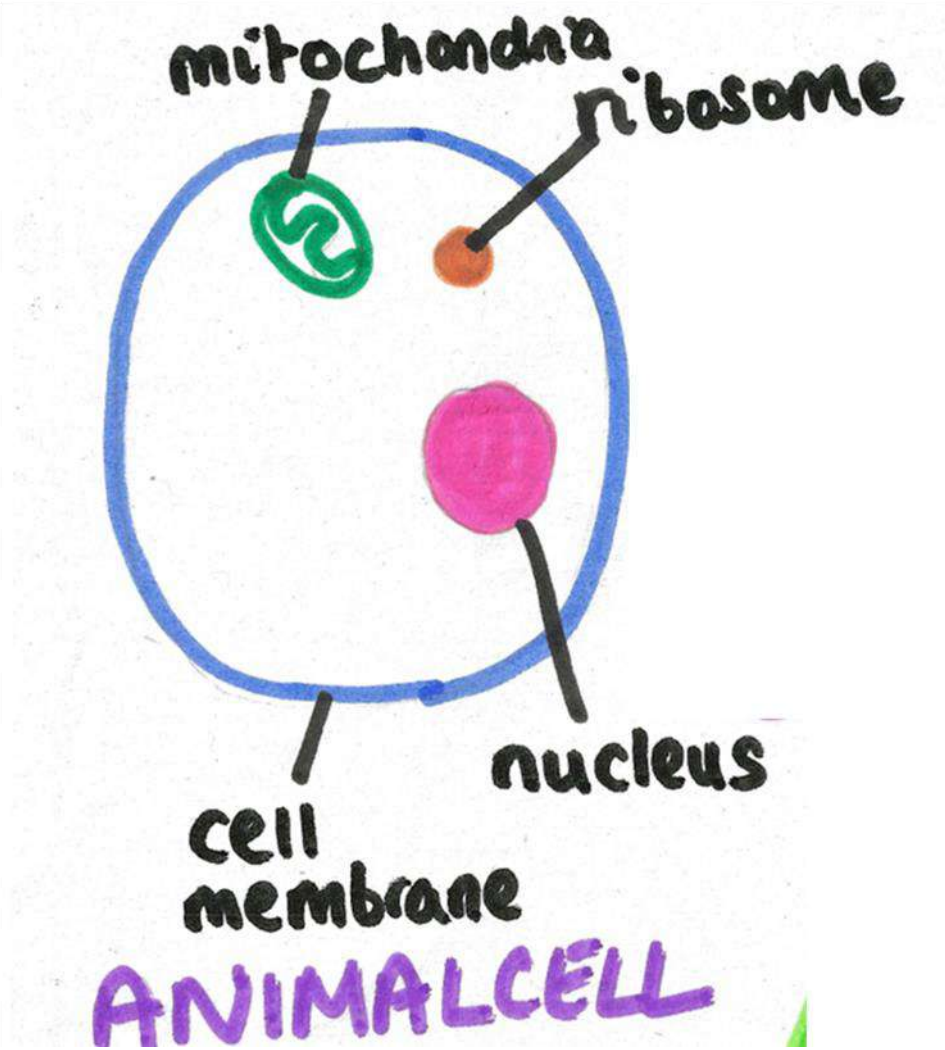
Key Facts: Protein

Proteins are produced in the **ribosomes.**

They could be **fragment, multiple specific or whole proteins**.

The main functions of proteins:

- ❑ **Speed up chemical reactions as enzymes**
- ❑ **Regulate body functions as hormones**
- ❑ **Protect the body from infections via immunoglobulins.**
- ❑ **Structural support and muscle movement.**

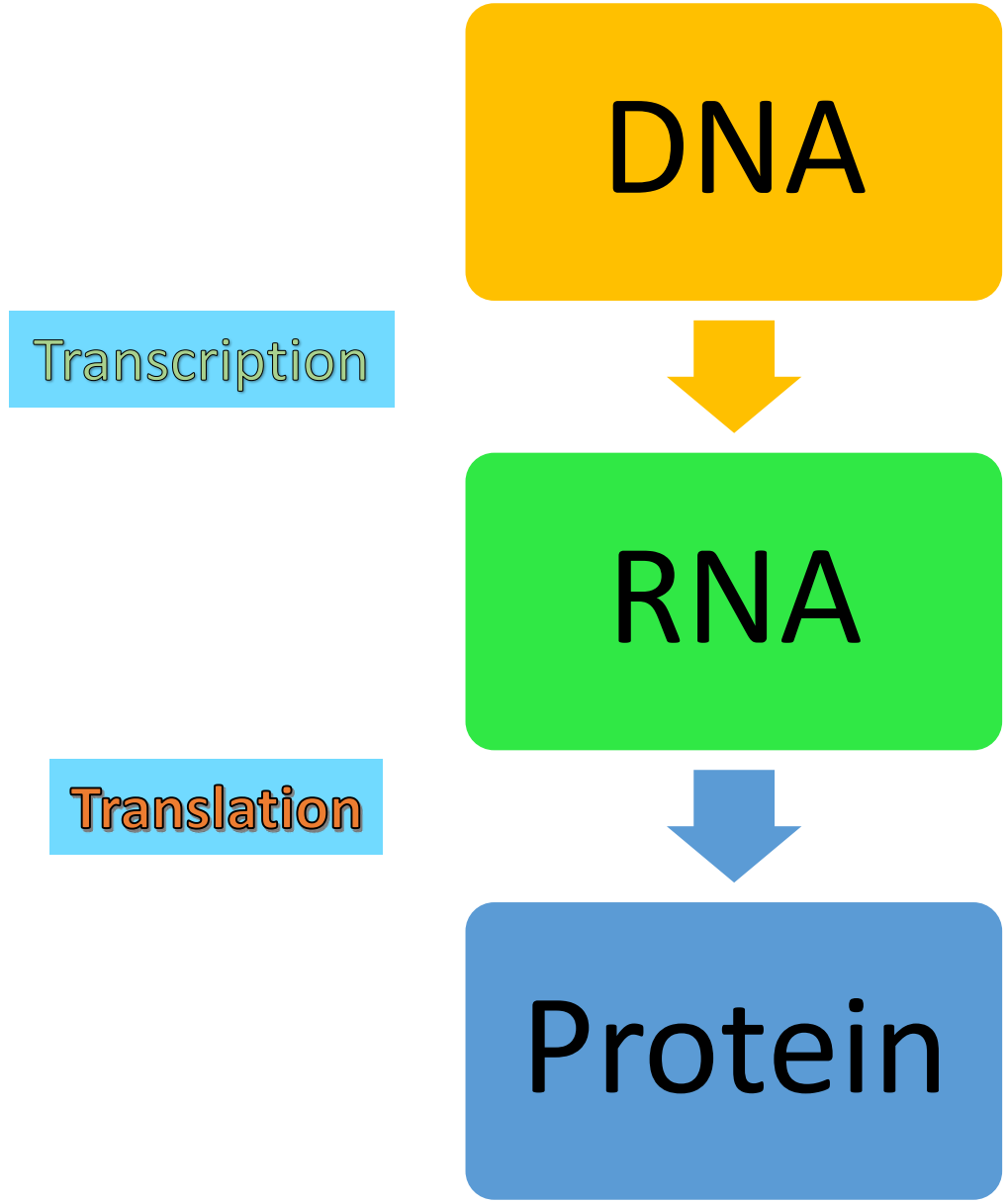


Key Facts: Protein

Genes encode proteins, and the instructions for making proteins require two steps:

Transcription is the process of using DNA as a template to make an RNA molecule:

Translation is the process of using an mRNA molecule (type of mRNA) as a template to make a protein.



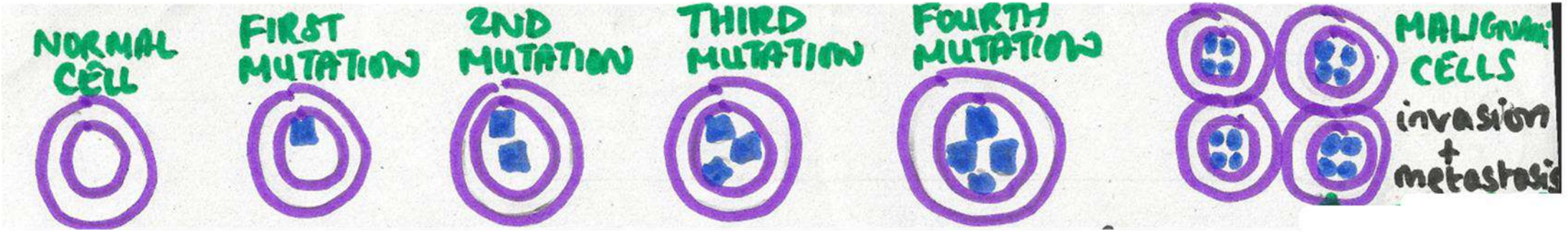
What causes our genes become faulty?

Key Facts: What is the main cause of cancer?

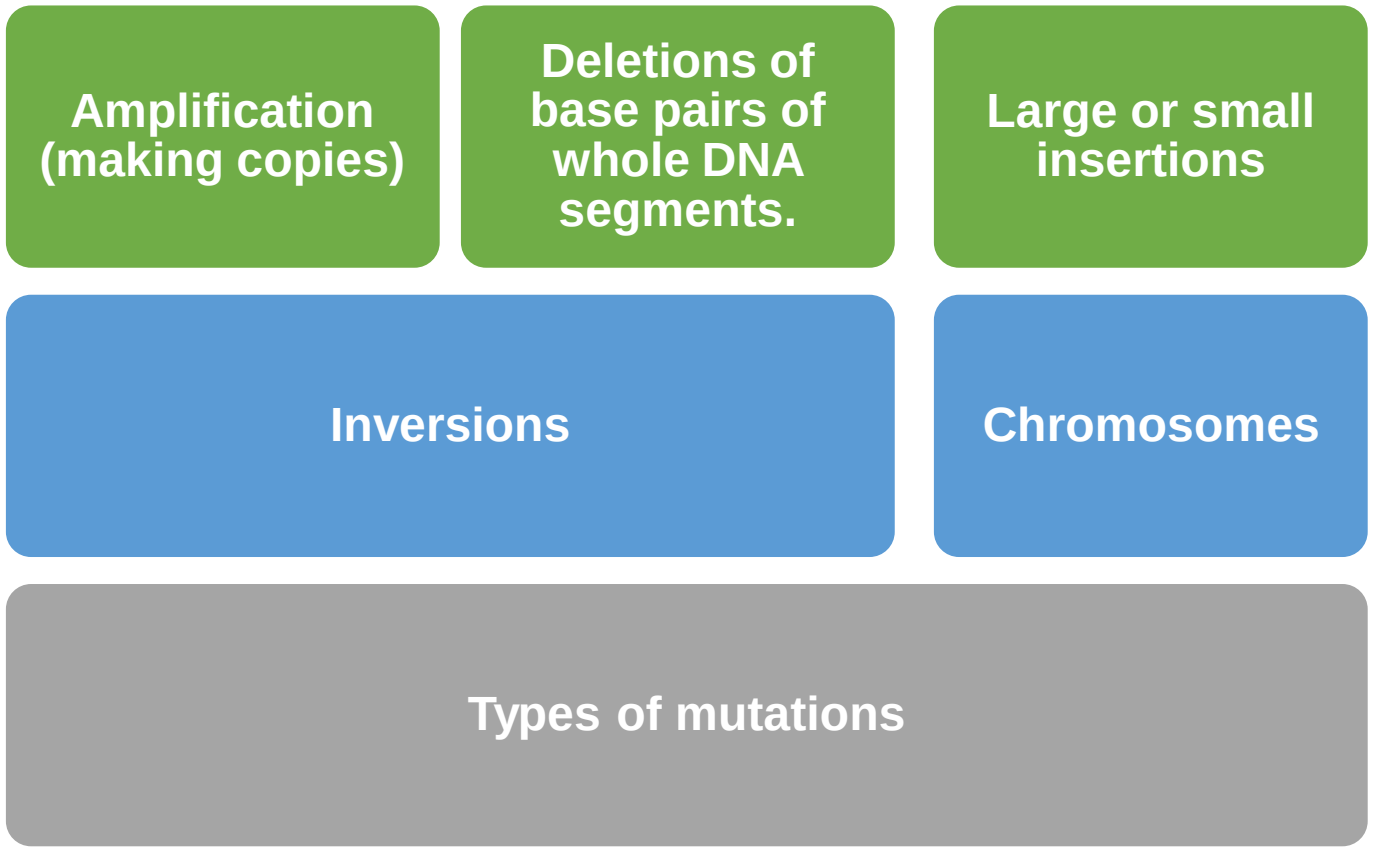
The root cause of cancer are **random changes in the genes** in the tumour cells called **mutations**.

Cancer cells **grow quickly (high proliferation)** which allows the **mutations to affect how normal cells divide and grow.**

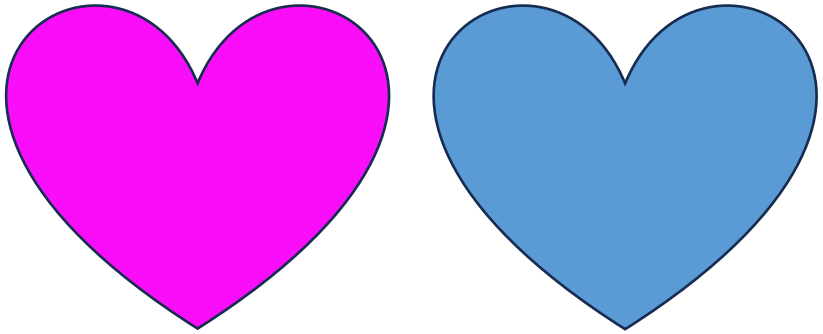
Unstable growth can cause congenital and development diseases to cancer.



Key Facts: Types of mutations

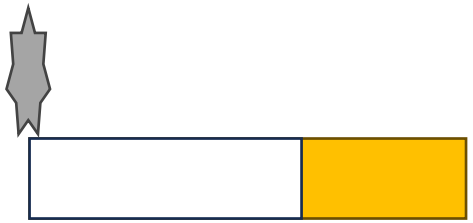


Key Facts: Risk factors of mutations

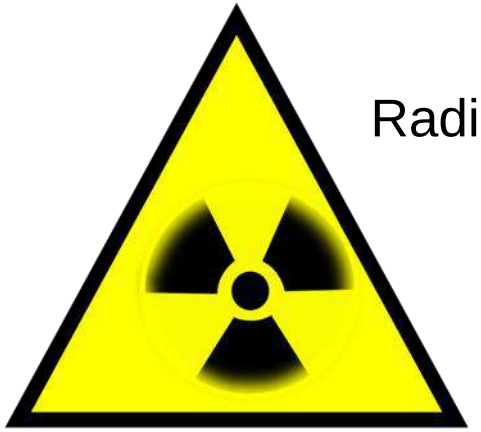


Natural process from our parents

SPONTANEOUS MUTATION



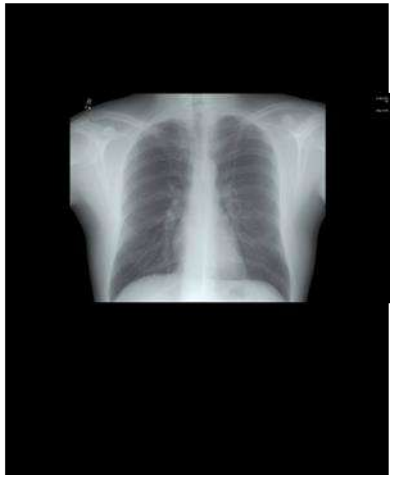
Tobacco smoke



Radiation

Chemicals released in air

Radiation from the sun (ultraviolet)



X-ray

INDUCED/ENVIRONMENTAL MUTATION

Key Facts: Types of genes

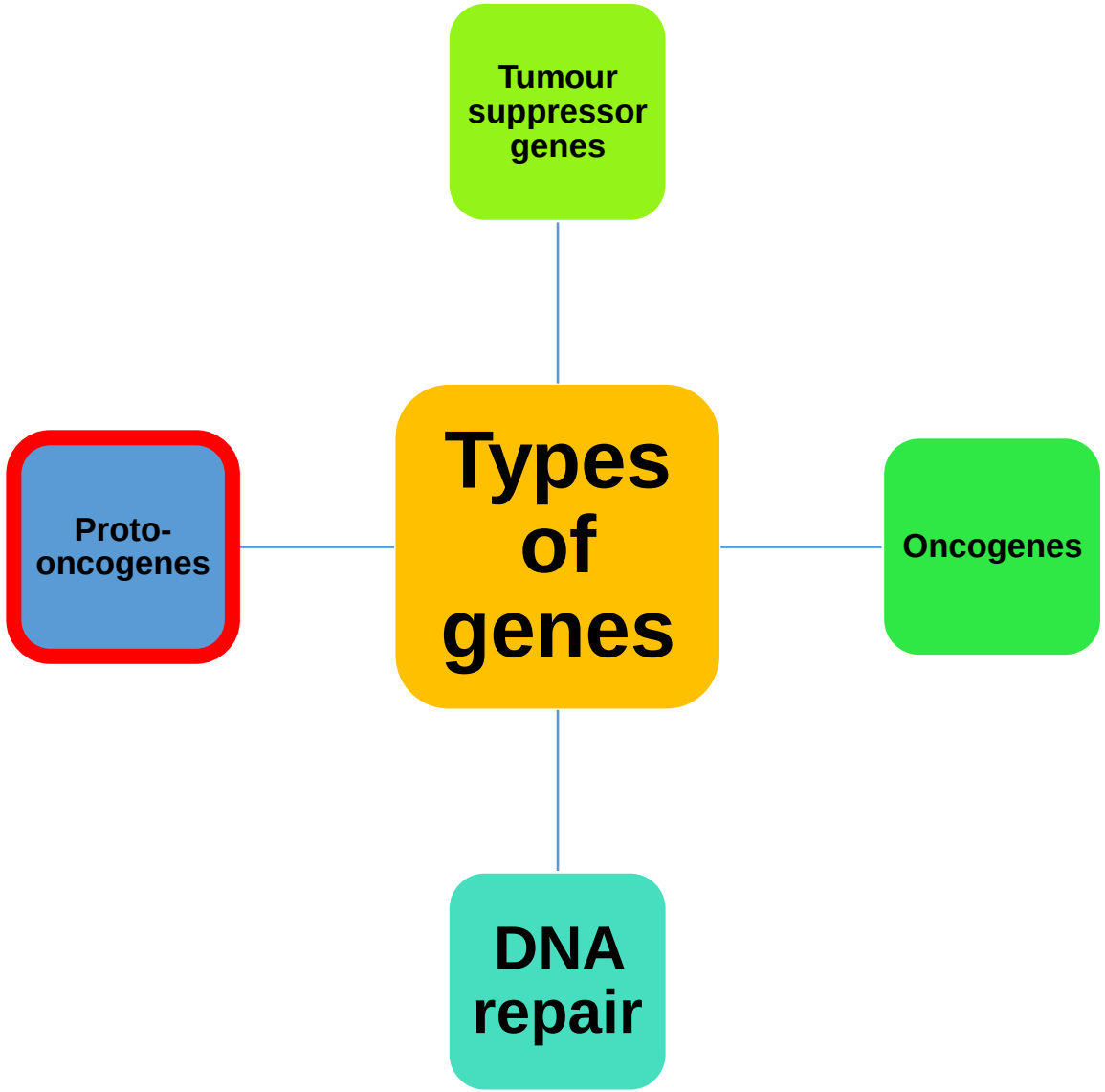
Proto-oncogenes (stimulatory)

- They are normal genes but if mutated can become **oncogenes.**
- They encourage and drive the **mutations (oncogenes) to allow cancer to grow**.
- There are about **70 proto-oncogenes in our DNA.**

Key example:

BCR-ABL protein in Chronic myelogenous leukemia (CML).

95% of CML cases and some ALL (Acute lymphoblastic leukaemia).



Key Facts: Types of genes

Oncogene

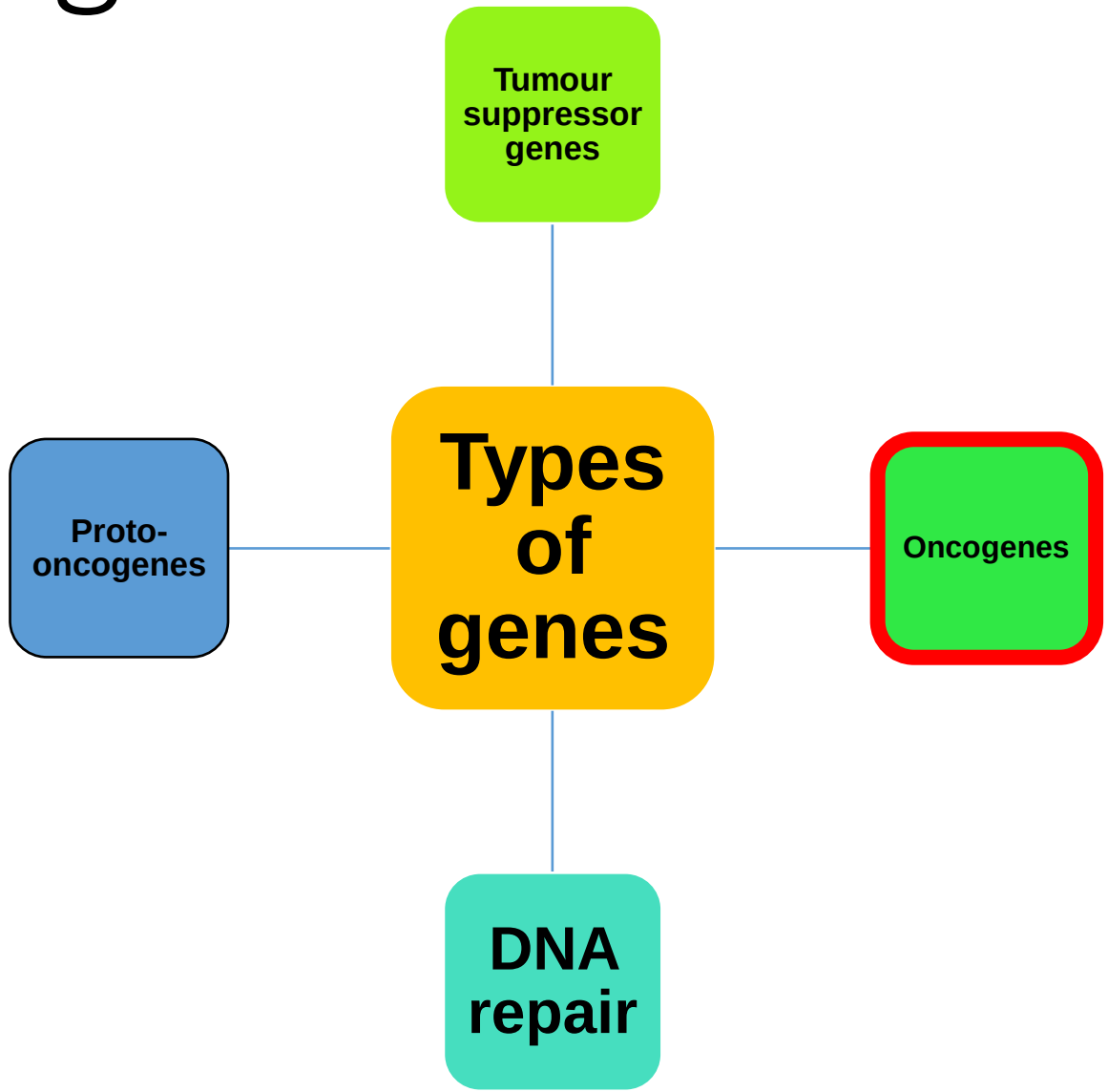
An **oncogene is a proto-oncogene** that has been mutated causing a gene to be **overactive** '**gain of function'.**

This leads to **unregulated growth.**

It is not passed from parents.

Key examples of oncogenes

- **HER-2/neu gene amplified in 30% of human breast cancers.**
- **Ras gene controls transcription of genes, regulating cell growth and differentiation.**
- **Myc protein is a transcription factor and controls expression of several genes.**
- **Src was the first oncogene ever discovered. The Src protein is a tyrosine kinase enzyme, which regulates cell activity.**
- **hTERT codes for an enzyme (telomerase) that maintains chromosome ends.**



Key Facts: Types of genes

Tumour suppressor gene

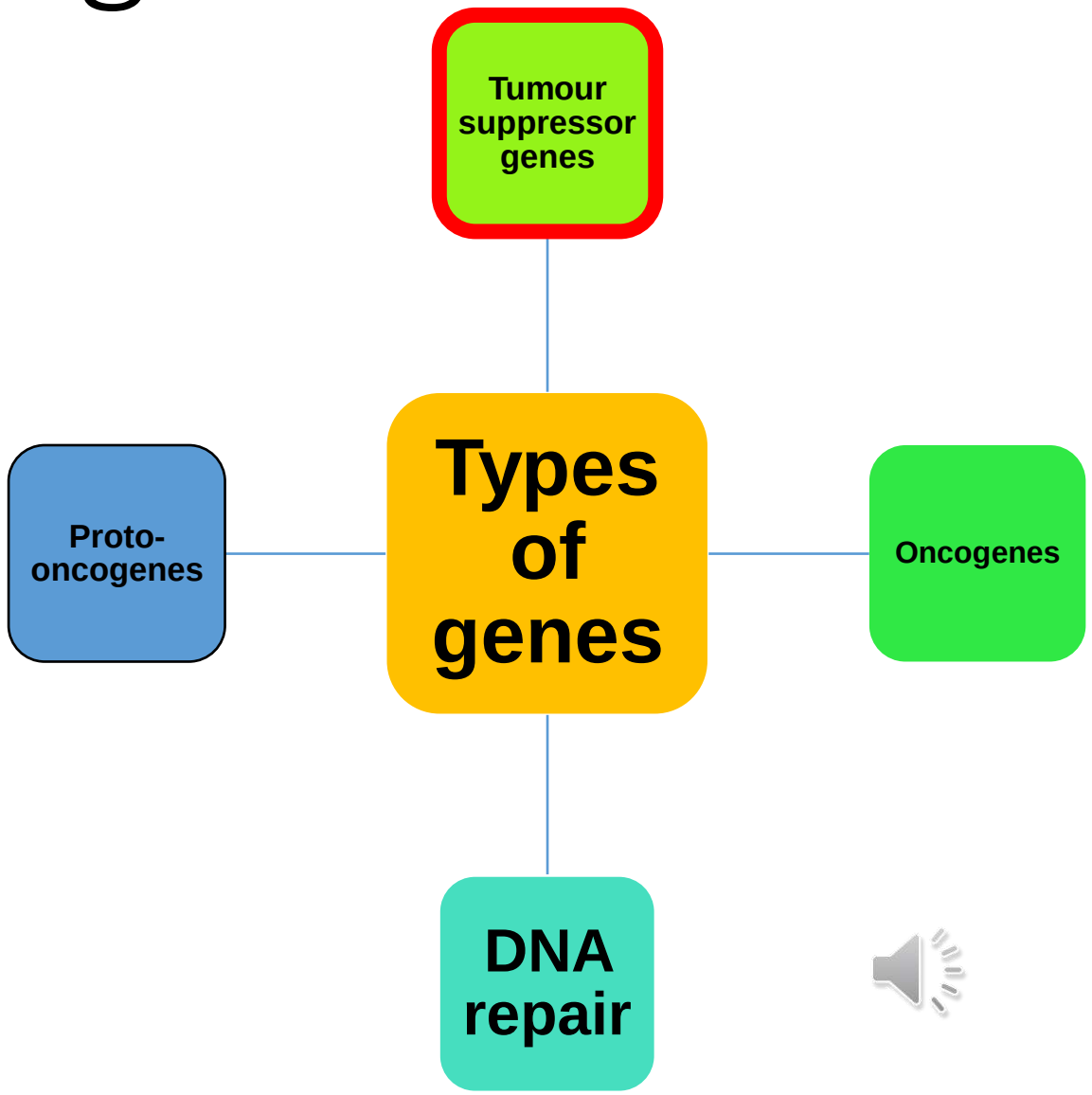
Normal tumour suppressor gene encodes protein to prevent cancer by:

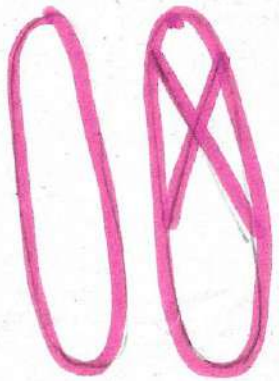
- **slow or stop cancer growth by DNA repair**
- self destruct via a process called **apoptosis.**

One mutated copy of gene increases risk of develop cancer because the other copy is normal and functional.

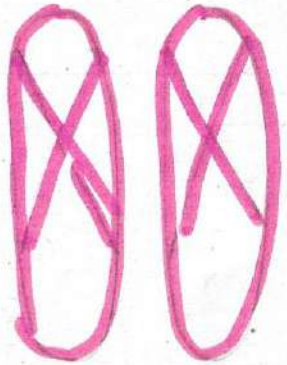
Remember: There are two copies for every gene. 50% from mother and 50% from father.

Loss-of-function mutations when both copies of the gene are mutated causes cancer.

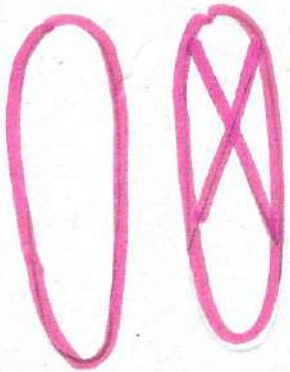




TYPE OF GENE	EXAMPLE	EFFECT	RESULT
ONCOGENE	GROWTH INDUCER	DOMINANT Growth without regulation	ABNORM GROWTH



TUMOUR SUPPRESSOR GENE	GROWTH INHIBITOR	RECESSIVE loss of growth inhibition	ABNORMAL GROWTH



TUMOUR SUPPRESSOR GENE	DNA REPAIR PROTEIN	HAPLOINSUFFICIENT lower gene dose.	ABNORM GROWTH

Key Facts: Examples of tumour suppressor genes

Tumour Suppressor Gene	Role
P53	A transcription factor that regulates cell division and cell death.
P14ARF	It prevents degradation of P53
Rb (retinoblastoma)	It encodes for retinoblastoma protein. It alters the activity of transcription factors and therefore controls cell division
APC (Adenomatous polyposis coli)	It regulates tumour growth, cell adhesion and migration. Deletion or inactivation of APC is linked with colorectal cancer.
VHL (Von Hippel-Lindau)	Mutation Can Lead To Cerebral Haemangioblastoma (blood vessel tumours) and renal cell carcinomas (kidney cancer)
CDKN2A	It encodes the p16-INK4a protein that functions in how cell divides, differentiate and die via senescence and apoptosis.
BRCA (BReast CAncer gene)	It regulates DNA Repair And Cell Cycle
PTEN (Phosphatase and tensin homolog)	It regulates cellular activities by inhibiting how cells move (motility), cellular proliferation, survival and growth by inactivating PI 3-kinase-dependent signalling.
WT1, WT2 (Wilms Tumour)	A Transcription Factor needed for normal cellular development and survival. WT1 plays both oncogenic role and tumor suppressor.
Nf1, Nf2 (Neurofibromin)	It negatively regulates the Ras oncogene.

Key Facts: Types of genes

DNA repair genes

They code for proteins that **correct errors before cell division takes place**

Cells containing mutated DNA repairs can lead to:

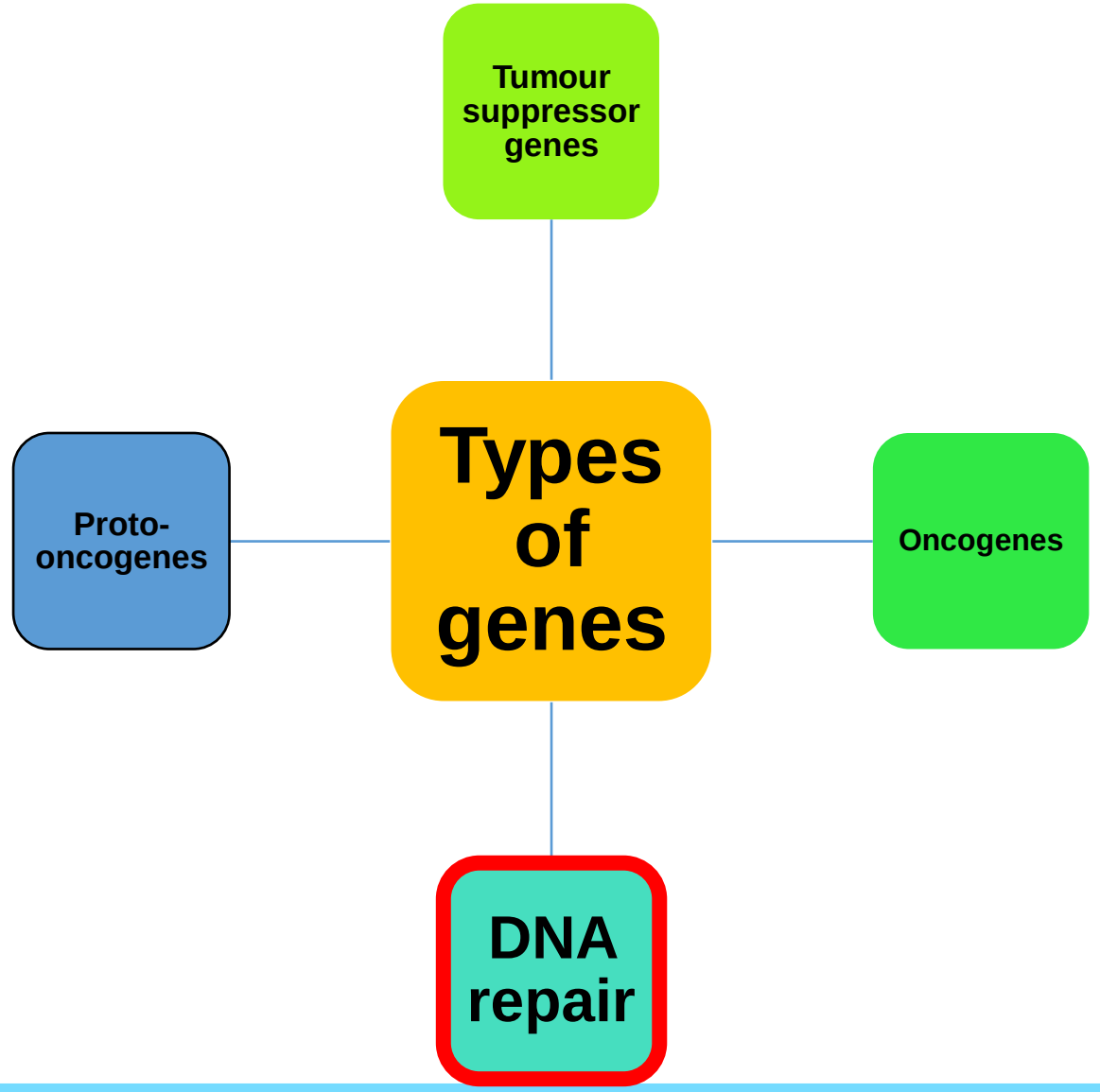
a) Other genetic mutations in **tumour suppressors and proto-oncogenes.**

b) Changes in chromosomes e.g. **deletions and duplications.**

This can cause cells to become **cancerous.**

Key examples:

- BRCA1 and BRCA2
- Ataxia-telangiectasia mutated (ATM) released when **cell damage and plays role in cell cycle progression.**



By the end of this lecture, you should understand the following:

- **Cancer** is a disease caused by **random changes in the genes** called **mutations**. This leads to **uncontrolled cellular growth at the primary site that** can **spread to other parts of the body to form secondary tumours** that are **malignant.**
- **A number of scientists and archaeologists have helped shape our understanding of cancer.**
- **Cell communication** is important to understand on how **cells sense, respond to signals, and coordinate activities.**
- **Largest to smallest: Cell → Nucleus → Chromosome →DNA →gene.**
- **Genes encode proteins**, and the instructions for making proteins require **transcription and translation**.
- Genes can become faulty based on **mutations passed from parents (spontaneous) or environment (induced).**
- **Proto-oncogenes** stimulate cell division. **Tumour suppressor genes** inhibit cell division**. DNA repair genes repair** errors that occurs during cell division in the cell cycle**.**

Tips:
What to do next?

Read and make notes

- **In conjunction with the glossary, please make notes on what you learnt and highlight any points.**

Try a quiz

- **To reinforce your understanding.**
- **It's a fun way of learning alone or with a friend.**

Check out our summary posters

- **This summarises key concepts of this lecture show.**

Interested to learn and read more?

Please have a read of our further reading list.

Require further assistance?

Book a 10-15 minutes meeting on Zoom

Reference list for further reading

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Next week

HN

SEASON 2

Understanding Cancer

Lecture 2

Hallmarks of cancer

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