FORENSIC SCIENCE!

https://youtu.be/IgAQg7GD4K8

Class VII

Michael Glynn

michael.glynn1.staff@ctyi.org

https://centrefortalentedyouthireland.wordpress.com

8 – 12 Class, PM

Spring Term, 2020

HI GUYS!!!

First of all and most importantly, hope you are all safe and well.

It was a pleasure for Síofra and I to teach you this year, you were a wonderful class.

Feel free to explore all the stuff we have for you at your leisure, no stress at all…

Do have a look at the video on these slides too! In it I manage to break my pen, make the screen go black for over a minute and try and fail to spell *pneumonia*!!! Feel free to skip to bits you're more interested in too, I've put extra bits of info. in these slides if you want them…

https://youtu.be/IgAQg7GD4K8

- Don't worry if you want to skip bits! Do as much as you want or what interests you most, I've included videos and extra stuff in the slides…

- I've designed this material so you can basically do whatever you want – you can do everything, you can do some things, you can focus more on the quizzes/puzzles or you can listen to the videos…

- While there's hopefully lots of stuff here that you can learn, class is also designed to be fun!!!

- Although I don't have my usual bag of tricks with microscopes and fingerprint gadgetry, we do have some cool stuff in the slides and activities for you as well on the webpage

- And you don't need to study anything! Just have the craic. The quizzes do however relate to material from class, so have a look out for words in red/notes/pictures etc.!

- Please, please, please get in touch!!! You're more than welcome even just to say hi!

- I've received a good few emails already and a couple of comments on the webpage, but do send more!!! Would love to know how you're getting on.

- Let me know if you liked/disliked anything about the classes, if you have a question, if you learned anything interesting on your own, what was your favourite experiment, if you did any experiments at home, or if you have any forensic science memes to share! : p If there's anything more you'd like me to cover, I can whip something up for you and post it on the webpage or send it in an email.

Webpage: https://centrefortalentedyouthireland.wordpress.com

My CTYI email: michael.glynn1.staff@ctyi.org

On the webpage itself, scroll down to find the 'forensic science' class content. There's a link on the right too labelled 'DCU Forensic Science' if you'd like to share anything with me

STUFF TO DO ;D

The webpage at https://centrefortalentedyouthireland.wordpress.com has all our materials for class

- A message for the class and parents/guardians, with an outline of all the material covered in class so far, including experiments and practicals carried out during each session
- Two sets of slides
- Word wall/brainstorm
- Class recordings
- The **ultimate** quiz
- Sherlock Holmes puzzles
- Extra materials – Cool videos, interesting websites, recommended reading, museums and exhibits
- Experiment vids (pending)

If for any reason you can't access the above on the webpage, please don't hesitate to email me at michael.glynn1.staff@ctyi.org and I'll send the materials on to you directly

MAIN POINTS for CLASS VII

- DNA is super important in forensic science – it explains how each of us is different, and how material from humans left at a crime scene can be used for genetic analysis to help identify suspects, victims and others present at the scene of a crime

- Chemistry is used by forensic scientists to perform the different experiments needed to help in the work of crime-solving. Chemistry also helps us understand how biology works. As we have seen and will see more of later, physics helps us understand the mechanics of the natural world. Each of these areas blend together to help us in understanding forensic science.

- Evolution explains how our genetic differences arose, and many of these differences are important biometrics in forensic science – fingerprints, eye colour, facial features, bone structure, blood (blood groups!) etc.

SOME QUICK DEFINITION REMINDERS! ☺

- Forensic Science – applying scientific principles and techniques to the matters of criminal justice.
- Biometrics - biological measurements – e.g. fingerprinting, retina scans and facial recognition
- DNA = Deoxyribonucleic acid
- RNA = Ribonucleic acid

- Biology – the study of living things
- Chemistry – the study of the composition and properties of substances, and the reactions between substances…
- Physics – the study of nature, matter and energy
- Matter = a substance that occupies space and has mass
- The main branches of 'science' are biology, chemistry and physics, but there are lots of different disciplines in between. Lots in science relates to other areas of learning like psychology, medicine, computer science etc.

'Mass' refers to substances that can be weighed out. If we were baking a cake and needed to weigh 500 grams of butter, we could also say our stick of butter has a 'mass' of 500 grams.

FORENSIC PPE

Protective goggles

Respirator mask

Nitrile Gloves

Fluid-repellant facemask

Protective suit

Shoe covering

At the crime scene...

In the lab...

Personal Protective Equipment

Spatula

Protective Goggles

Lab Coat

Buttons!
→ can remove quickly in an emergency

Gloves! ↙
- Latex
- Nitrile
- Neoprene

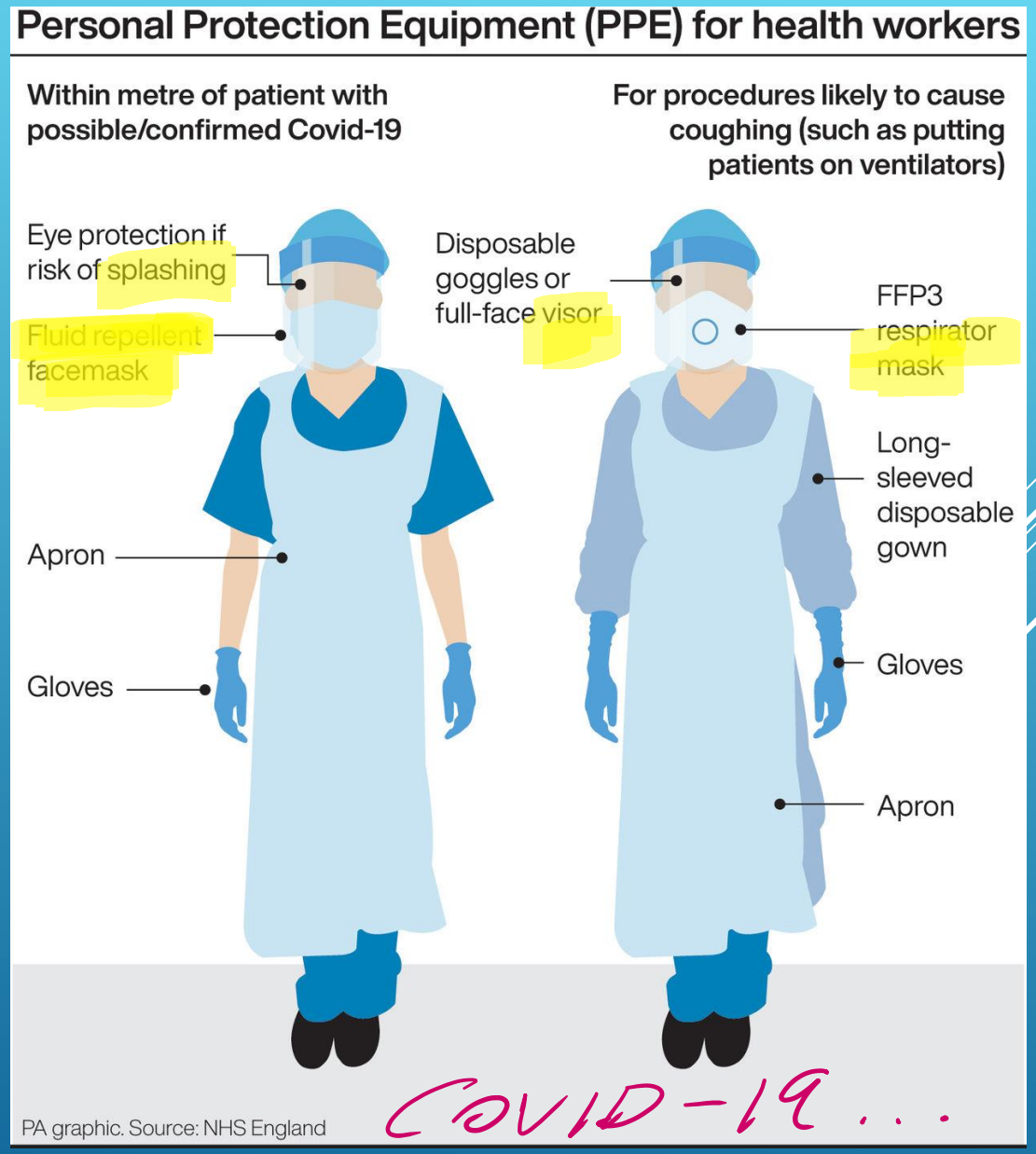
Comparing...

Extremely dangerous environment...

Radiation Emergency PPE

A 'liquidator' on the roof of reactor no. 4, Chernobyl 1986 - homemade protective gear made from lead!

Medical PPE

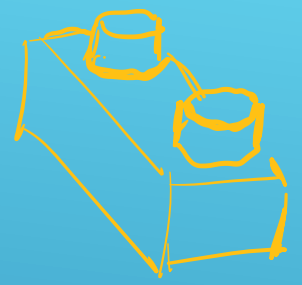


COVID-19...

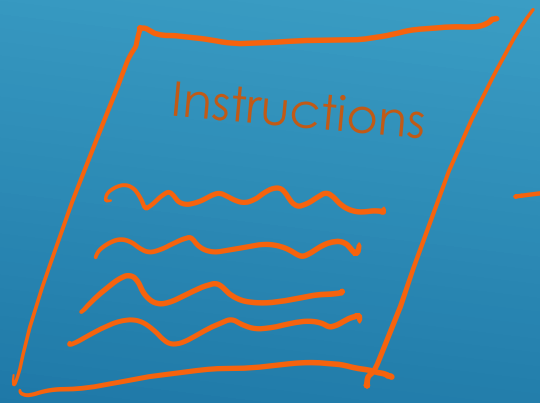
CHOOSING OUR PPE

- Avoiding contaminating the crime scene – fingerprints, blood, foot/shoeprints
- Avoiding danger to ourselves the crime scene – blood (bloodborne pathogens)
- Necessity – we might only need the most advanced protective gear in certain situations (biohazards, radiation emergencies), but perhaps not for typical crime scenes

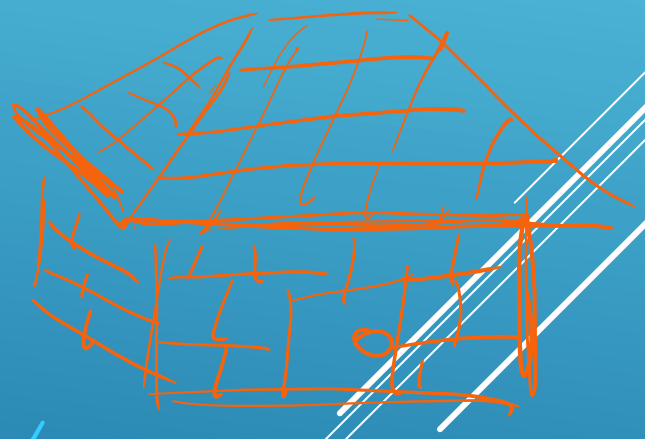
The Genetic Code ⇒ Making Lego!!!



The blocks themselves are like the 'amino acids' that make up proteins!



Moving/ Placing Blocks



translation

DNA → RNA → Protein!

transcription

- Making proteins is like making lego… DNA is like the instruction manual for making proteins in the body
- Proteins are vital in our body in order to perform functions and make structures (like muscle!). Proteins are made up of some 20 different kinds of amino acids
- They also give rise to distinguishable characteristics which allow us to identify people – essential in forensic science
- Biometrics are biological measurements – e.g. fingerprinting, retina scans and facial recognition

- DNA Animations!!!

- https://www.youtube.com/watch?v=7Hk9jct2ozY This one is pretty cool…check out the parts where is says 'real time' speed for an idea of how fast all the parts are moving during DNA replication + transcription!!! The sounds are added in of course, don't worry about them : p /// 'DNA Replication' = DNA photocopying!

- https://www.youtube.com/watch?v=X_tYrnv_o6A Great explanation vid, but a bit complicated

- One of the proteins (helicase) spins as fast as a jet engine in real time!!!

THE GENETIC CODE!

'The Central Dogma...'

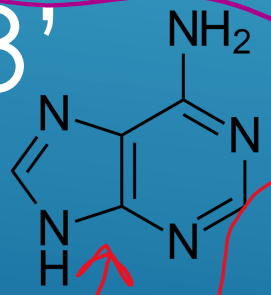
- Forensic Code Breaking!!!

DNA → RNA → Protein

5'-CCTTCGTTTT…-3'

transcription

translation



(Fragment of the PTC taste receptor gene TAS2R38!)

Adenine (A) – Thymine (T)

Guanine (G) – Cytosine (C)

Purines and pyrimidines…

Pairing Nucleotide Bases!

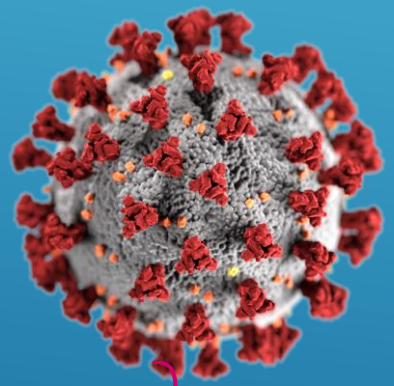
CCTTCGTTTT

GGAAGCAAAA

'Uracil' (U) replaces thymine as a base in RNA

The nucleotide bases 'slot in' to each other

SARS-CoV-2 virion



SARS-CoV-2 virion

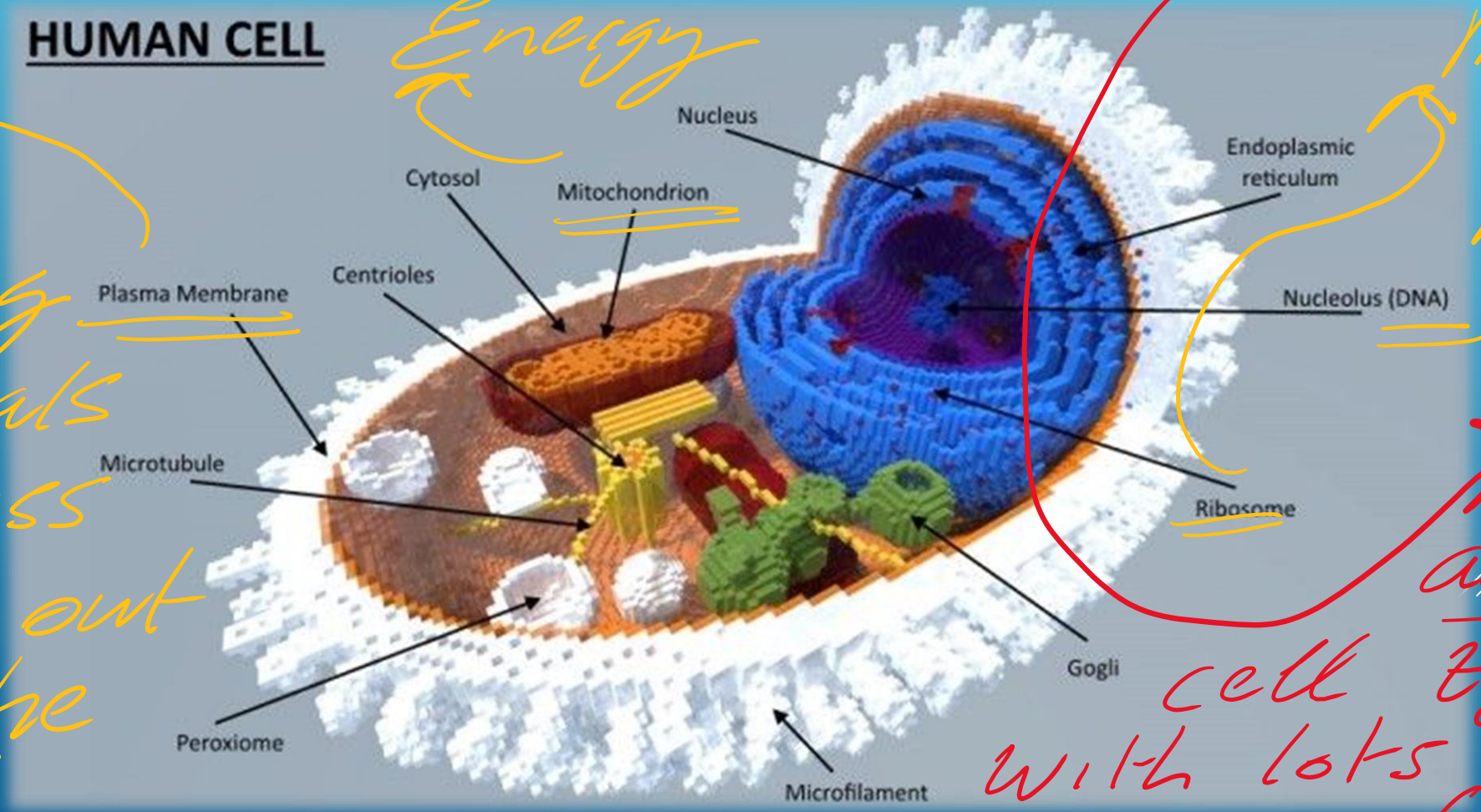
→ 'COVID19'

↳ 50-200 nanometers diameter

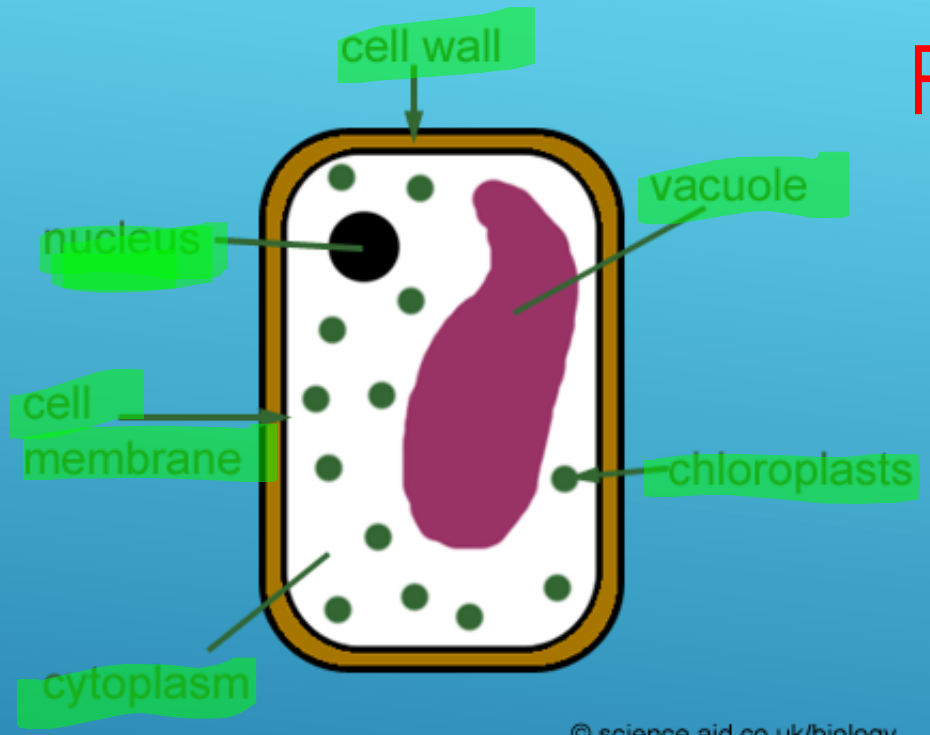
→ 'Spike proteins'

THE HUMAN CELL!

A human cell (made in Minecraft!)



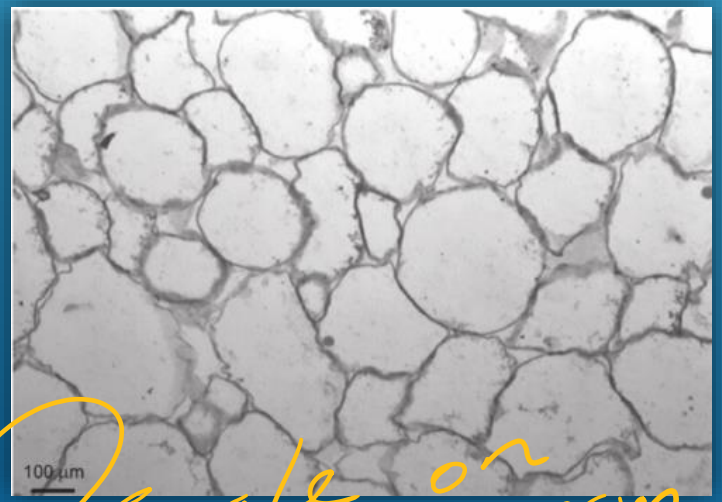
PLANT CELLS!

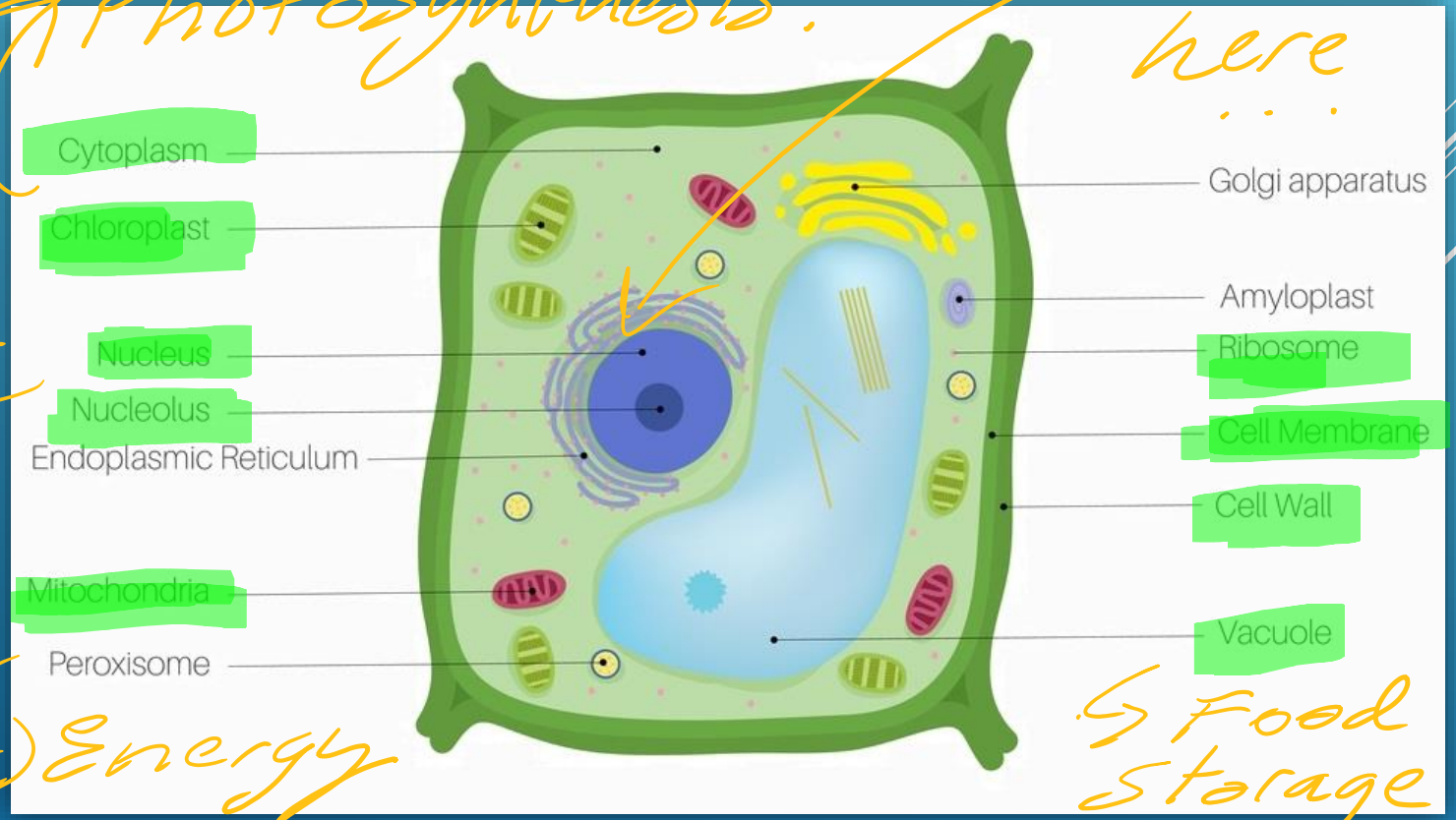


© science aid.co.uk/biology

How big?

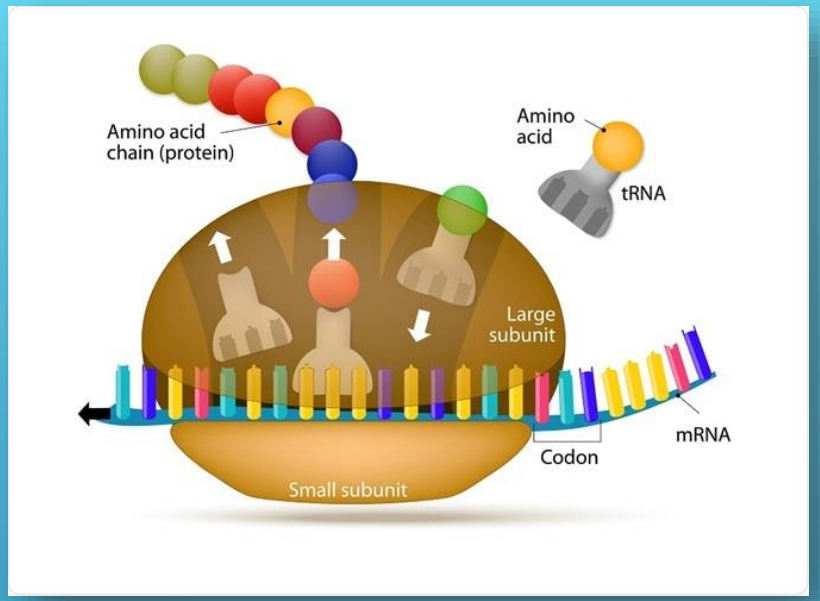
- Plant cells are generally between 10-100µm in length
- That's between 0.00001m and 0.0001m!





- ‘Cellular machinery’

- The ribosome – a biological machine; ribosomes make proteins

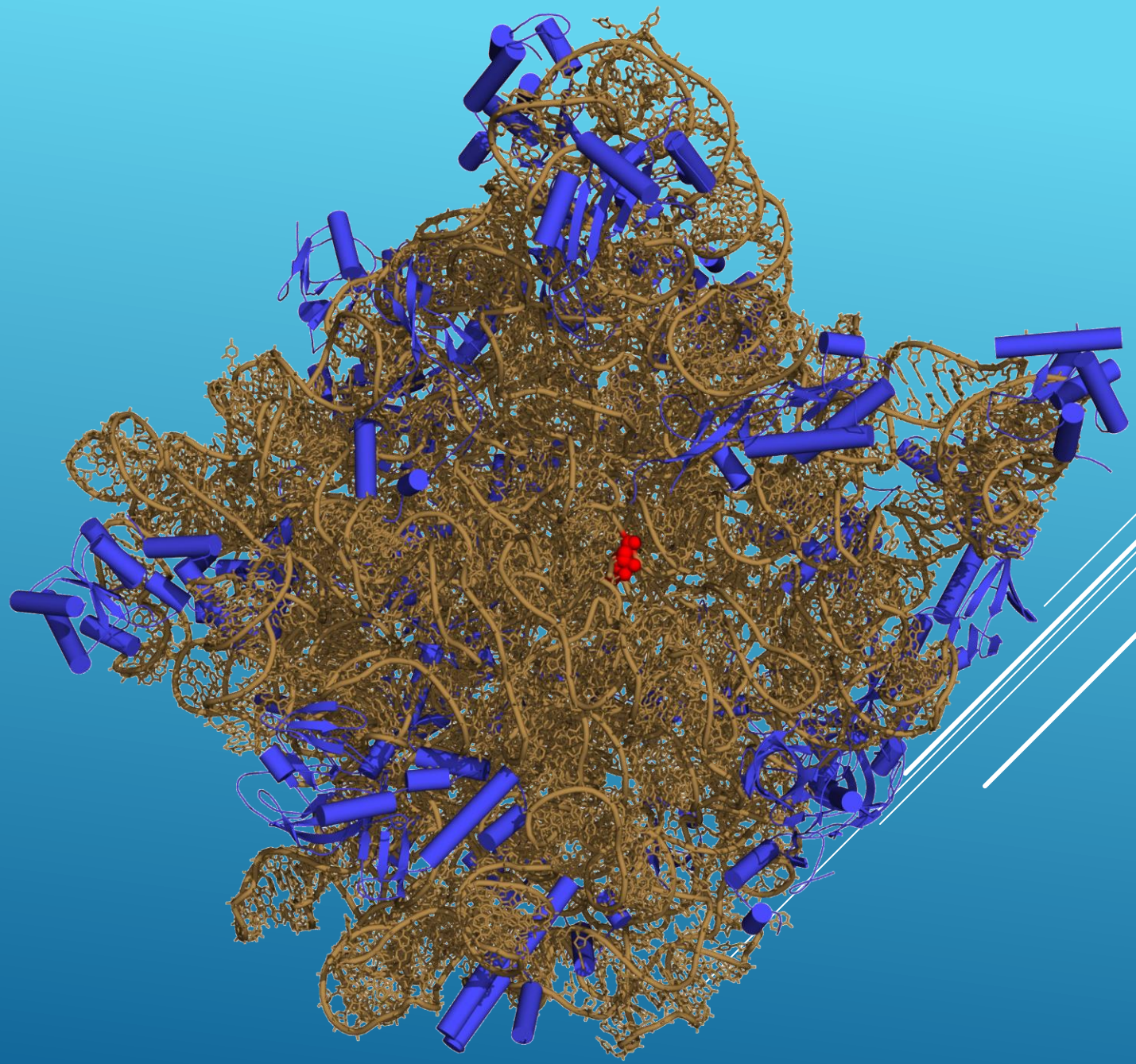


https://en.wikipedia.org/wiki/File:Protein_translation.gif

DNA Replication enzymes… = Photocopying!!!

The ribosome – a model of the 50S-subunit (ribosomes are made up of different subunits)

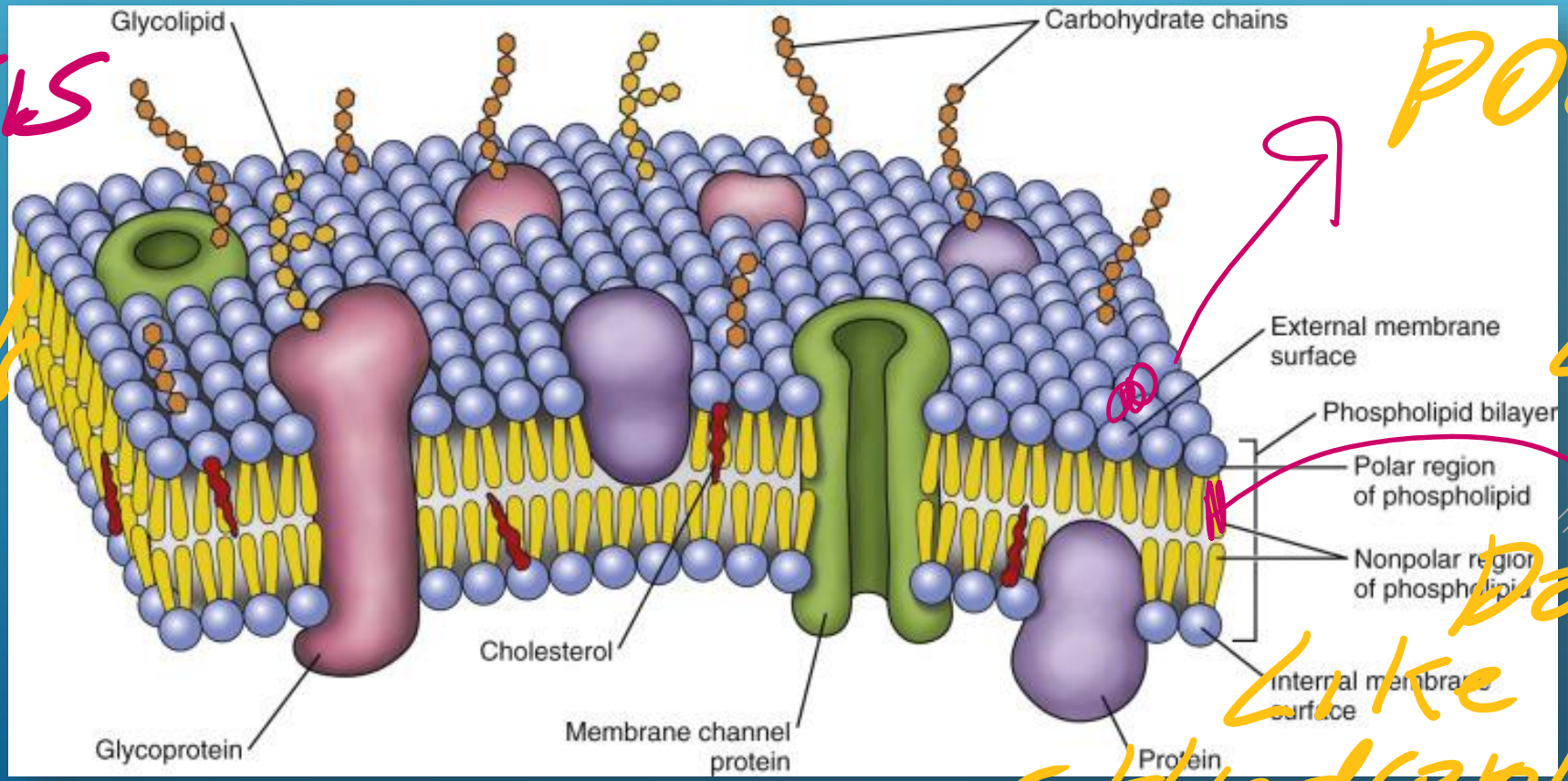
Ribosomes are involved in protein synthesis, ‘making’ protein



THE PHOSPHOLIPID BILAYER

Makes up membranes

Bilayer Formation via molecular self-assembly! (spontaneous): https://www.youtube.com/watch?v=lm-dAvbl330



Loves H_2O (Hydrophilic)

PO_4^{3-}

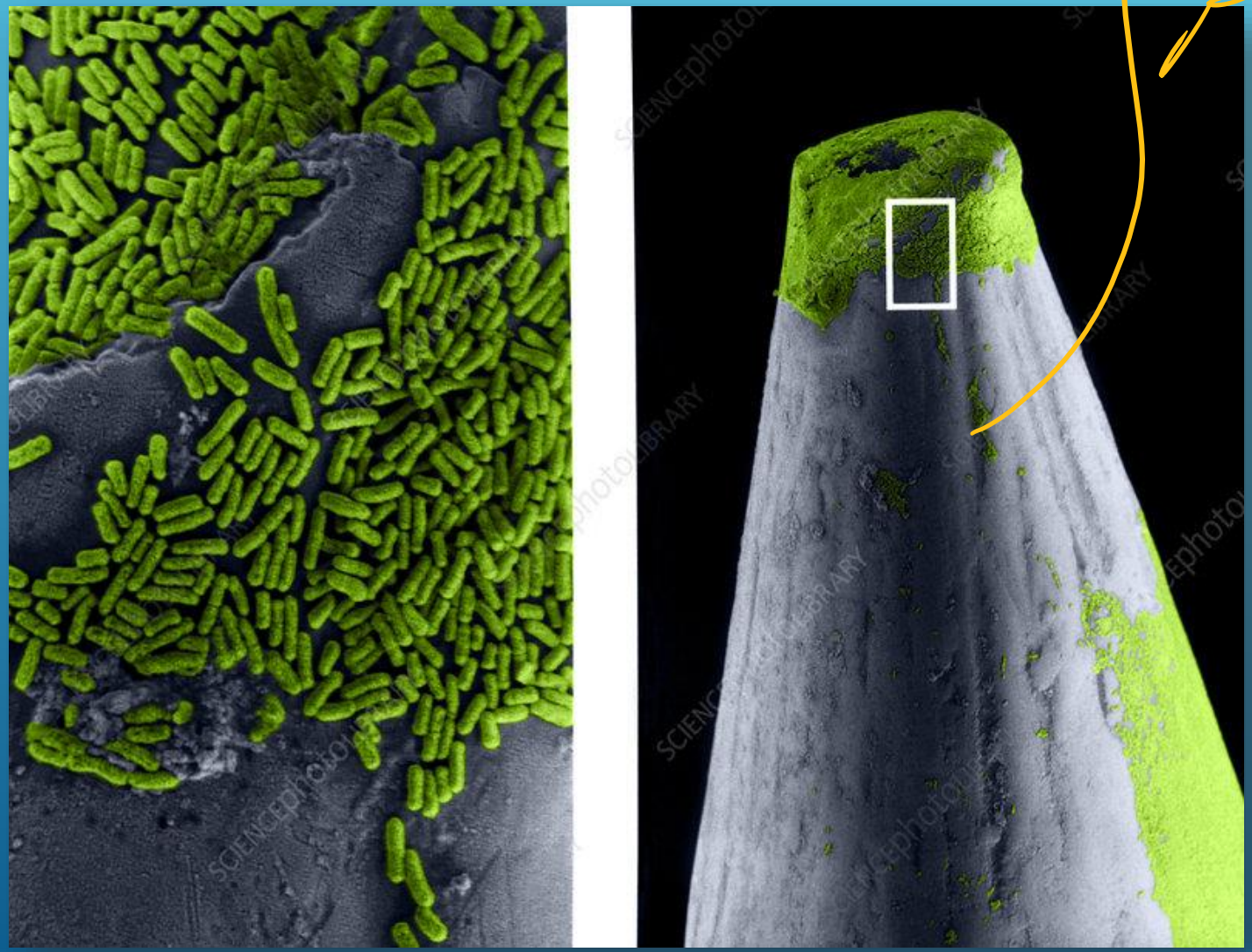
Lipids

Doesn't like H_2O (Hydrophobic)

Osmosis is how materials pass in + out

ESCHERICHIA COLI

tip of a pin



- These are *E. coli* cells on the tip of a pin

⇒ Prokaryotic cells (simple)

About 2 µm ('micrometres') long!

1 m = 1 million (1,000,000) micrometres!

- Scanning electron micrograph image (very powerful microscope). Also have 'Transmission electron microscopes'…
- Colour-enhanced image so we can view the bacteria on the pin

(In red/green)...

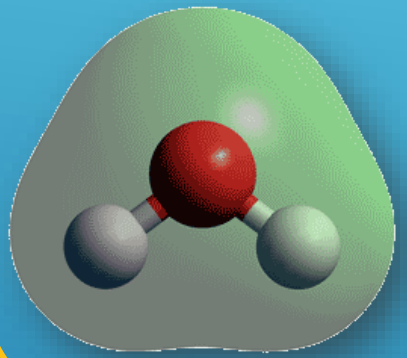
E. coli ⇒ prokaryotic cells

b) simpler cells, with no organised nucleus

'Rod-shaped' Bacteria

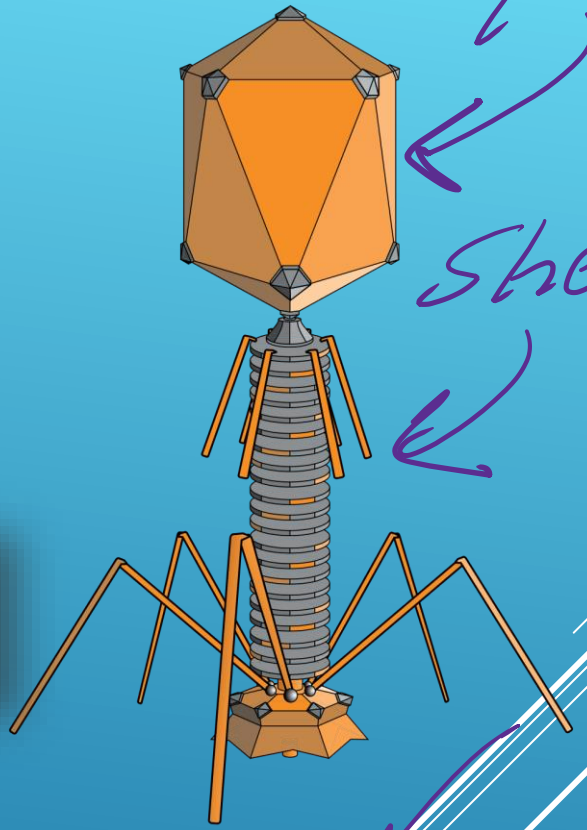
Red Panda

Some bacteria have structures called 'flagella'



Filovirus

Water molecule

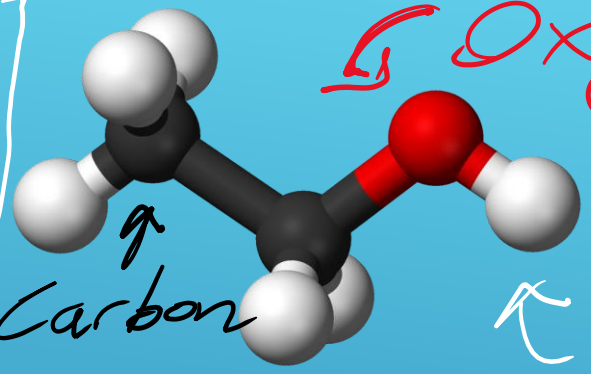


Capsid

Sheath

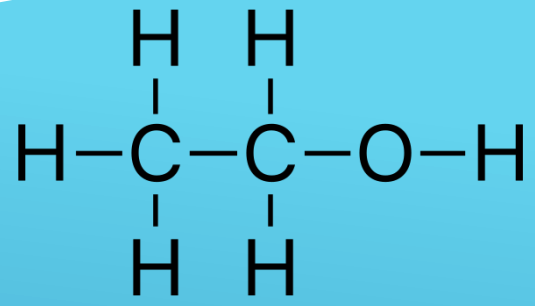
Tail Fibers

- What do these 'organisms' have in common?! Can you name them?



LAB PROTOCOL!

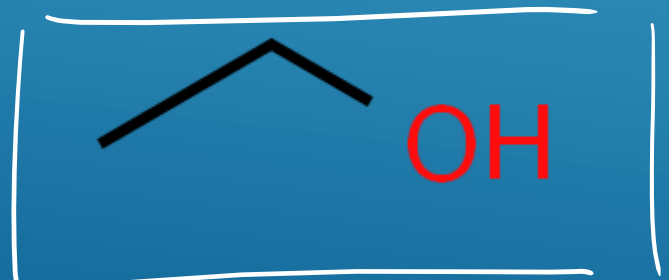
Same thing!



- Safety first! – Clean hands; care with sharp objects; protective clothing ('PPE'!)
- Aseptic technique – avoiding contamination
- Using chemicals – everything's a chemical!
- Ethanol – a colourless, 'volatile' and flammable liquid

'Ethanol'

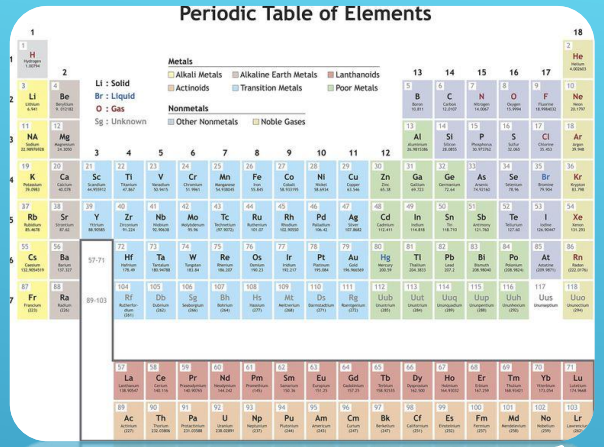
Same thing!



DCU Synthetic Chemistry Lab

Dr. Karen. Chemists!

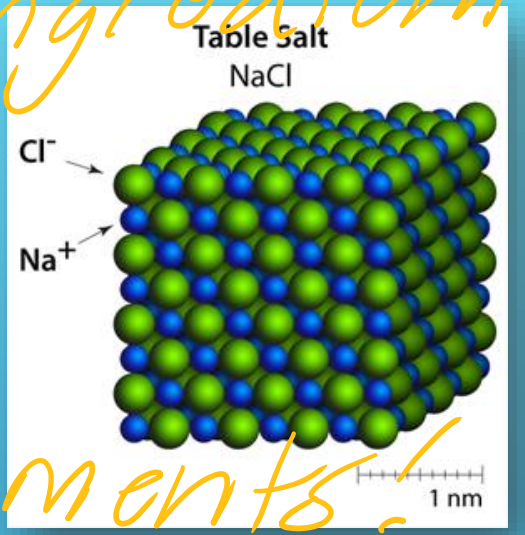
REAGENTS!



Periodic Table

Coconut Oil

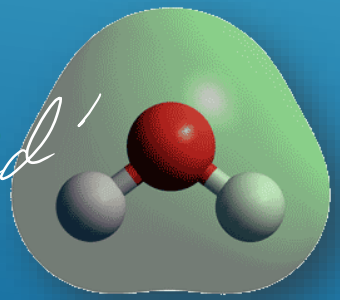
Ingredients for our experiments!



Extraction Mix =

- NaCl (Salt)
- Sodium laureth sulfate (in washing up liquid) – behaves similarly to soap as a foaming agent
- H_2O (Water)
- C_2H_5OH (Ethanol)

Surfactant



like in 'saturated' fats!

Palm Oil

long, saturated carbon chain...

LAB PROCEDURE

1. Assemble the apparatus; take caution; be aware of our surroundings and others around us!
2. Remove the green leaves from the strawberries
3. Place into the Ziploc bag, seal the bag and then gently mash for approx. 2 minutes until we get a fine pulp
4. Add the DNA extraction solution into the bag
5. Reseal the bag once more and mix for approx. 1 minute
6. Place the filter paper into the beaker
7. Open the Ziploc bag and pour our new solution into the filter paper – we get a filtrate and a residue
8. We then very carefully pour down the side of the beaker an equal volume of ethanol – no need to mix or stir!
9. Clean up our lab bench and wash our hands! ☺
10. Record our results…how do we explain them?

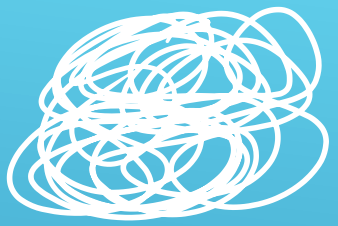
Contains our DNA!

DNA !!!

Sloppy strawberry waste…

WHY?

- The strawberries were crushed up and mashed in order to open the plant's cell walls
- The soap in the extraction mix helps to release the DNA by breaking down the nuclear and plasma membranes
- Salt helps to clump the DNA and helps to neutralise the negative charge of the DNA sugar-phosphate backbone
- DNA accumulates in the upper organic layer (with the ethanol); the other cellular material settles in the aqueous layer (with the extraction solution)
- The DNA is insoluble in ice cold ethanol – DNA precipitates

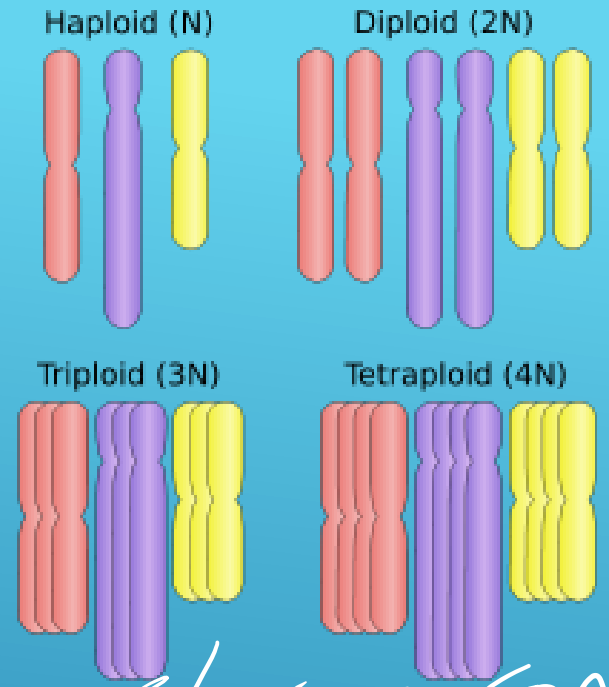


→ Chromatin! (Ball of DNA)

Why strawberries?

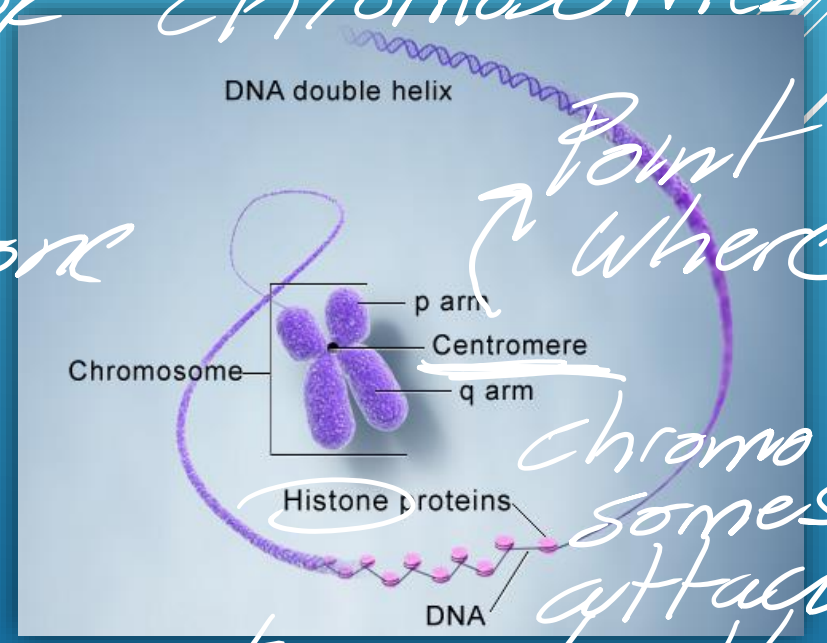
- They're octoploids, meaning they have eight copies of each chromosome, yielding much more DNA!

'Ploidy' = # of copies of chromosomes!



Why can we see it?

- So many threads concentrated in one location – chromatin = a mass of DNA and proteins before cell division takes place



Point where chromosomes attach to each other

What else can DNA be used for?

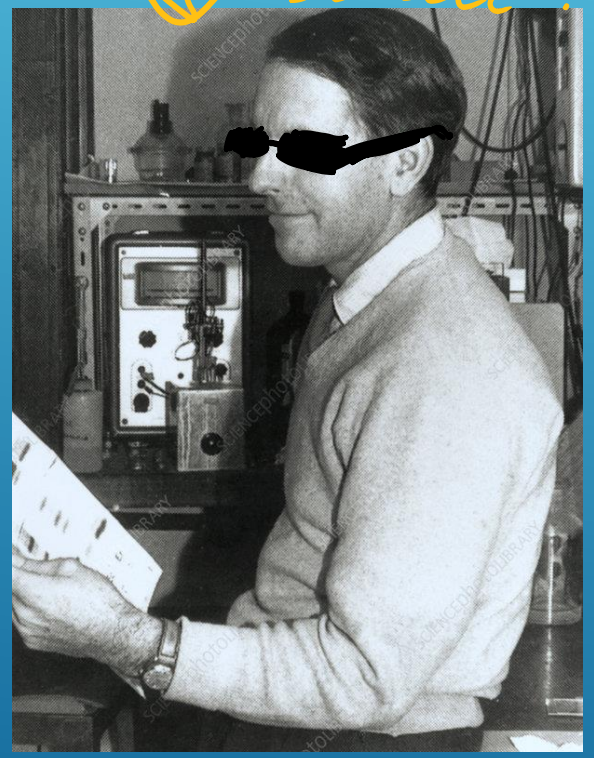
- DNA testing – ancestry tests

Forensics!

DNA → Histone

DNA SEQUENCING…

A cool dude…



Frederick Sanger examining DNA sequencing gel…

Set the stage for the Human Genome Project, 1990 – 2003

Franklin, Watson and Crick, 1953

The Genetic Code solved, 1961-1963

New methods to edit and change human genomes, 2010-2015

→ V. important for forensics…

→ Discovery of DNA

→ Genetic Engineering

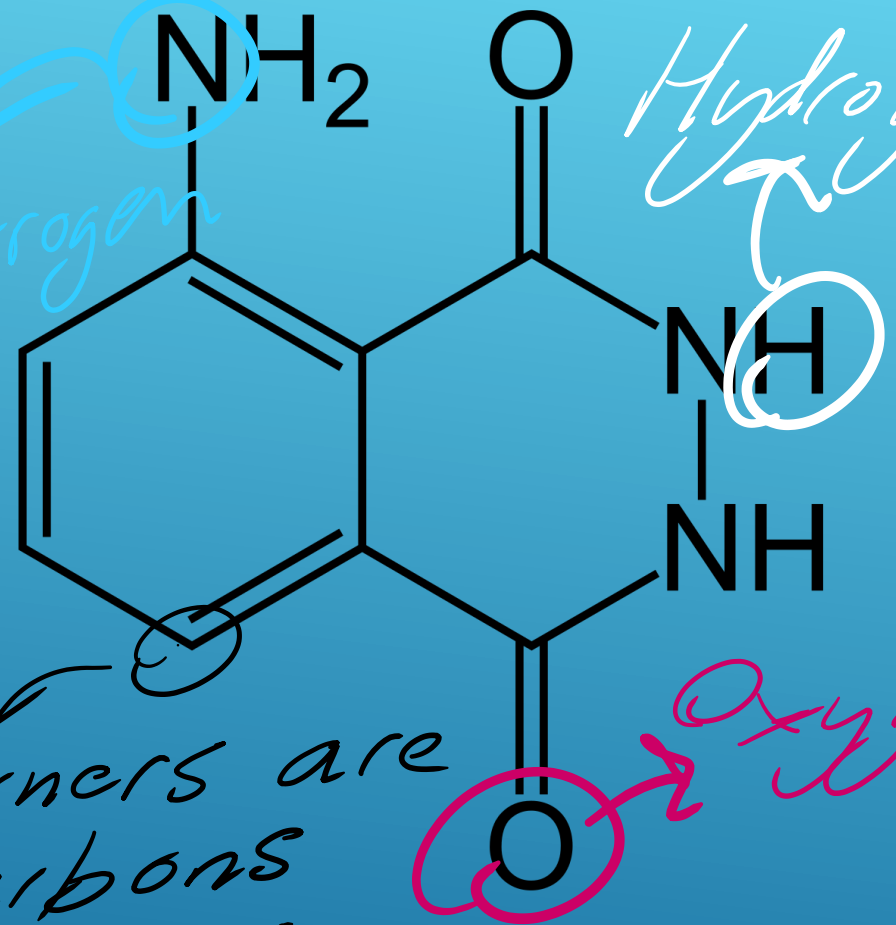
- CRISPR - Clustered Regularly Interspaced Short Palindromic Repeats
- Cas9 (CRISPR-associated protein 9) – RNA used as a guide molecule; Cas9 cleaves target strands of DNA

Biotechnology, medicine, immunology applications

GENETIC ENGINEERING

- Genes to enhance muscle strength, mass and endurance transferred to laboratory mice

Luminol



In blood!

Forensic scientists use it to make our blood glow blue so it can be seen!

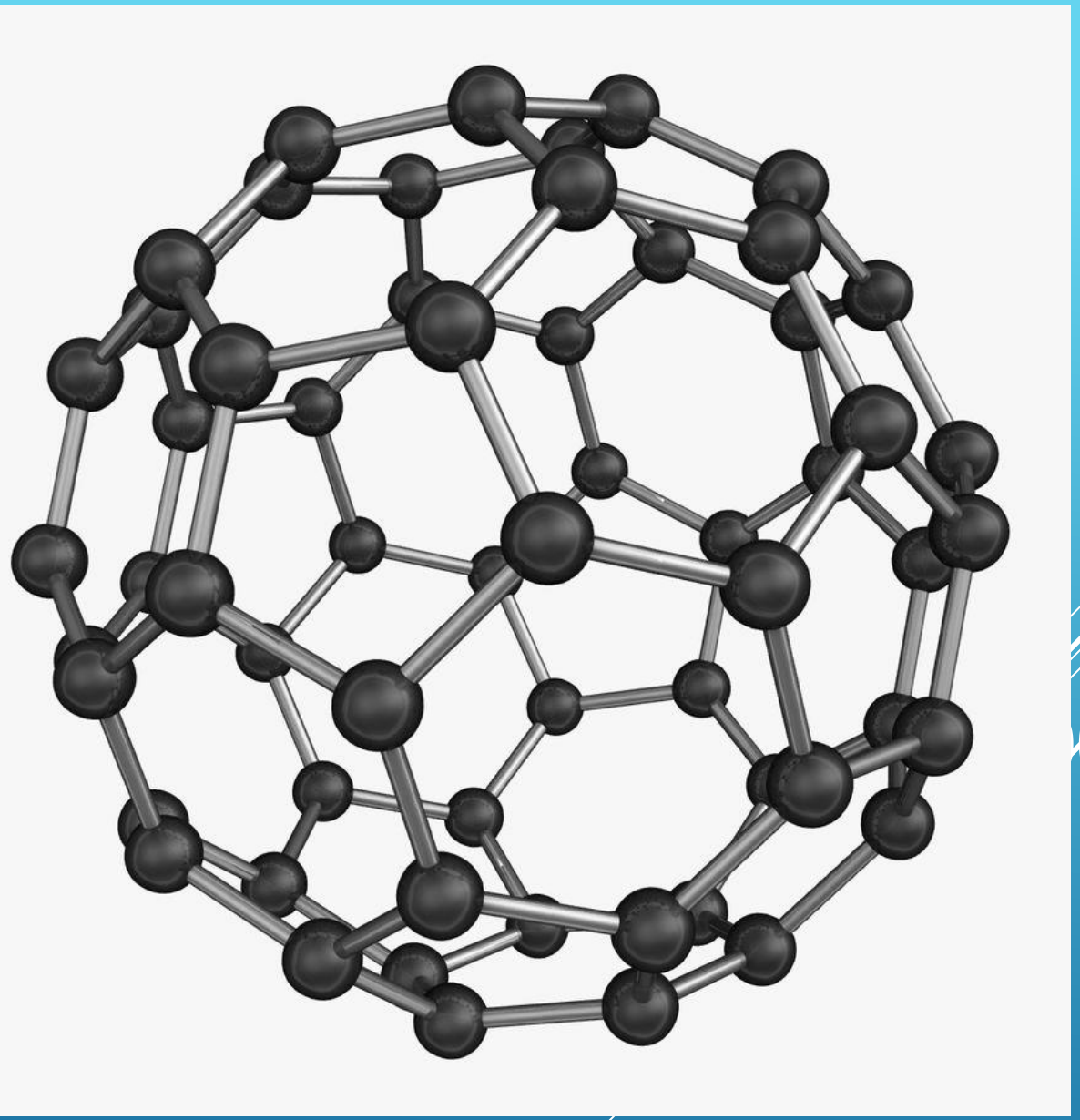
UV light more commonly used...

LUMINOL – CHEMILUMINESCENCE; BLUE GLOW; REACTS WITH HAEMOGLOBIN

Chemical change causes blue glow!

Remember our 'Bucky Ball'?

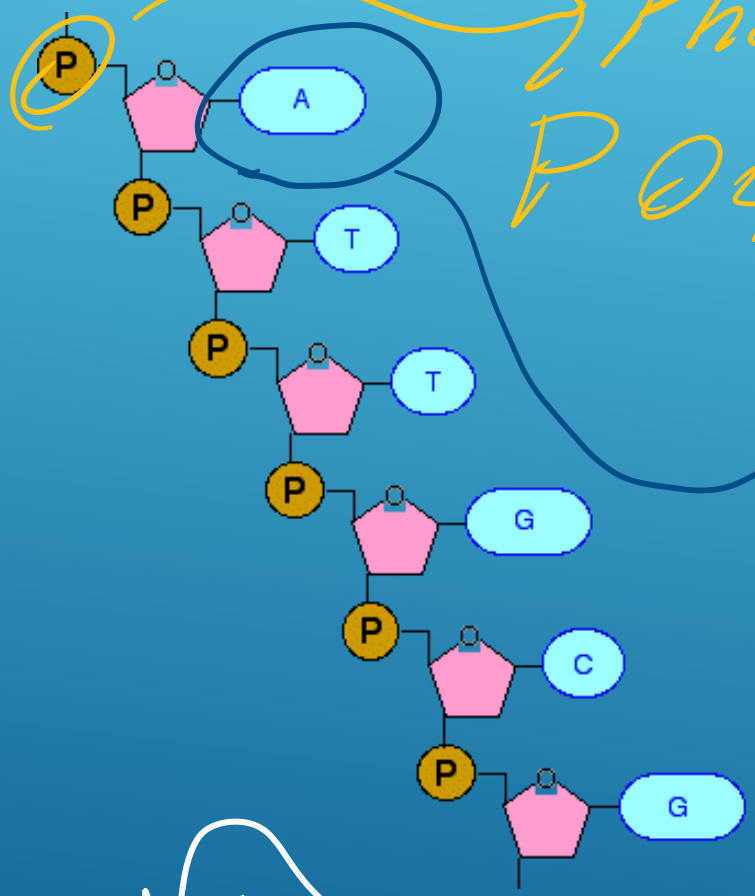
= An Allotrope of carbon (a different form)



non-toxic

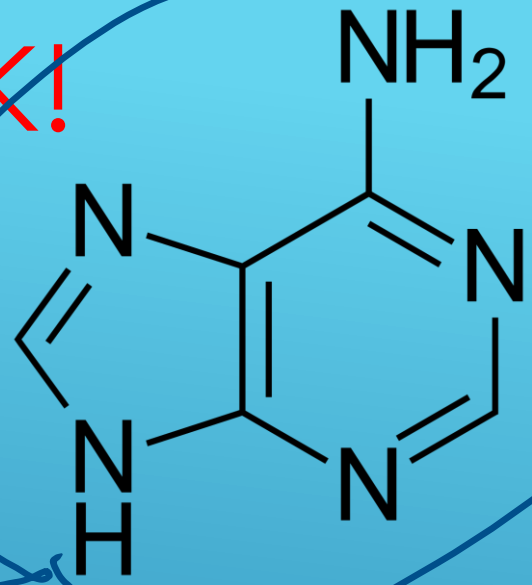
Another allotrope = graphite → in pencils!

DNA – A CLOSER LOOK!

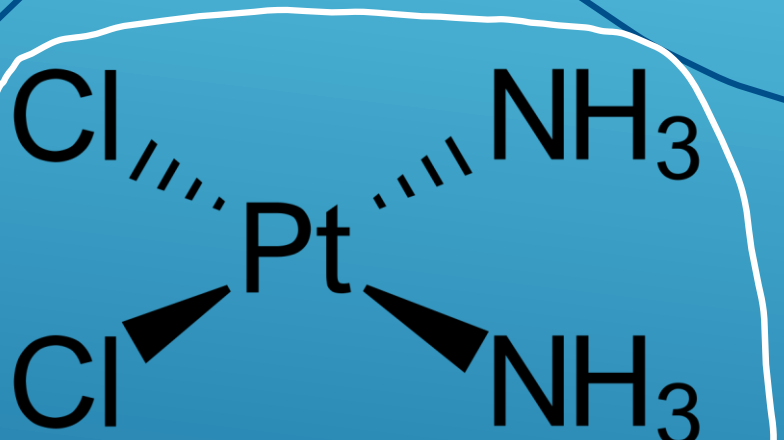


Phosphate, PO_4^{3-}

DNA base pairs!



Adenine



Cisplatin

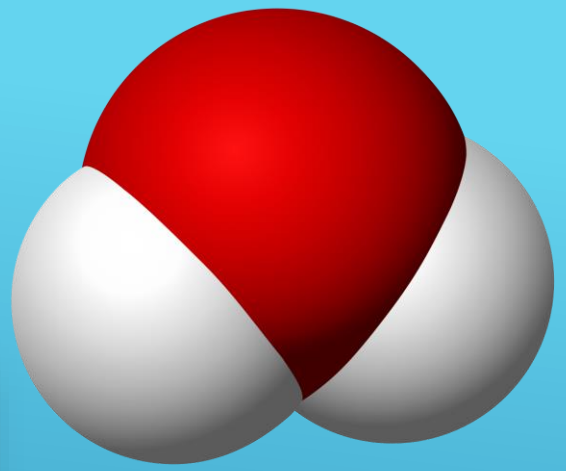
Works on DNA...

Cisplatin – interfering with the fastest proliferating cells...

Anti-cancer drug

CHEMISTRY AND FORENSIC SCIENCE…

- What's the chemical recipe?



H_2O!

Water vapour

Burning hydrogen with oxygen to make water…

Just like in *The Martian*!

Growing potatoes on Mars!

Matt Damon, chillin'

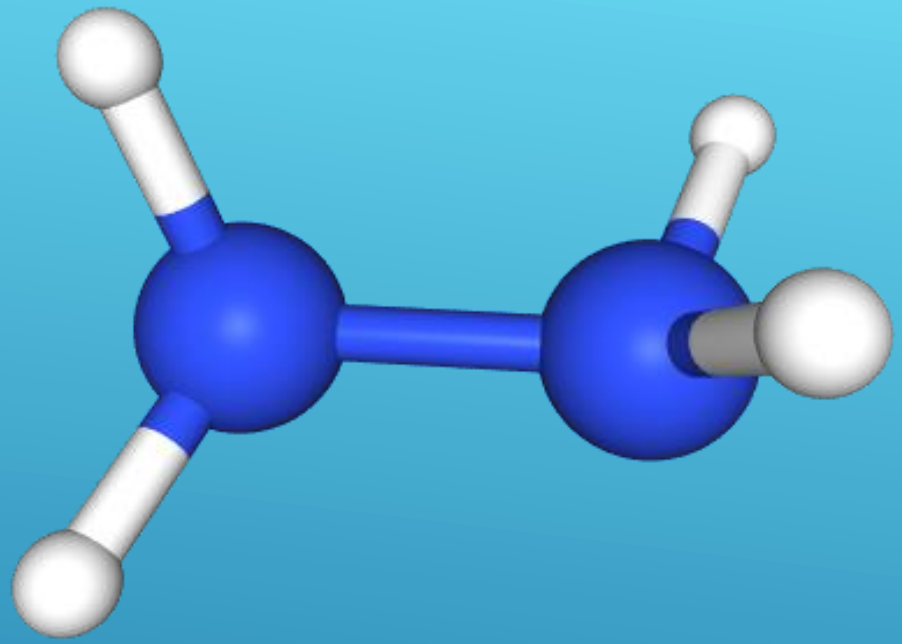
Special kinds of water forensic scientists use in a lab:

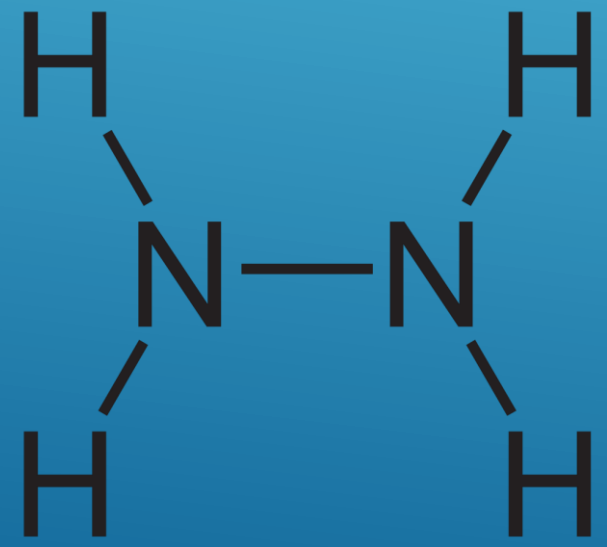
- Distilled water – water with dissolved solids is boiled and separated to get 'pure' water (but still has *ions)
- Deionised water – water passed through an 'electrically charged' resin to remove these ions

Like in a battery!

Cations = (+) ; Anions = (−)

*An ion is an electrically charged atom/molecule (+ or - !)





THE MARTIAN! – A RECIPE FOR WATER…

Can also use ethanol / surgical spirits

- Can you spot the 'isopropyl alcohol'? When did we use this in our lab in class? 0.o *

DNA Experiment. . .

- https://pubchem.ncbi.nlm.nih.gov/compound/Hydrazine#section=3D-Conformer (Hydrazine 3-D Model)

Just to have fun spinning the 3D model!

- https://www.youtube.com/watch?v=d0wjEgxAPY4
- https://www.youtube.com/watch?v=4PZ0Ydwx7xA

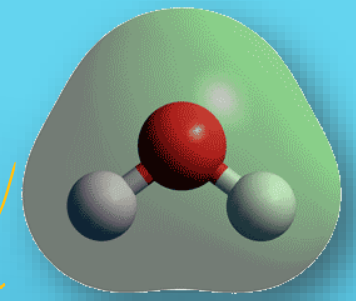
(Clips from *The Martian*)

What chemical elements make up a molecule of hydrazine? → Nitrogen, Hydrogen

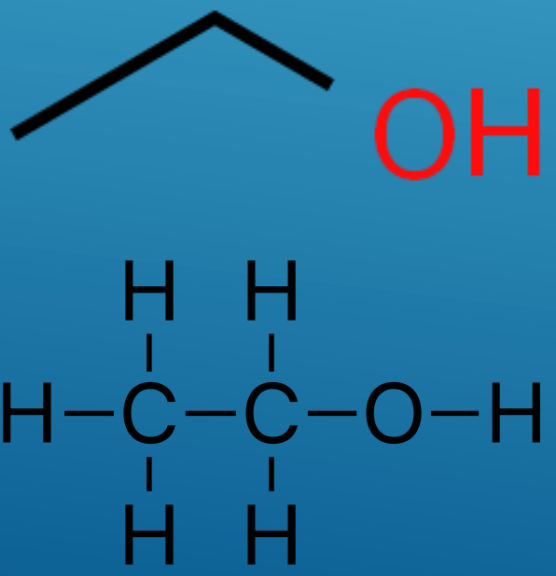
*Hint! – note isopropyl alcohol belongs to the 'alcohol' functional group ;)

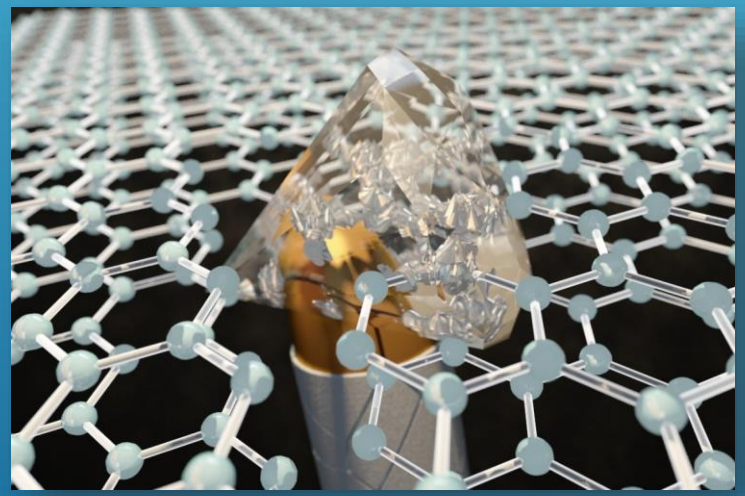
Looking at molecules and the periodic table…

'organic' molecules have carbon!



The atoms that make up 'organic' molecules are also found in 'inorganic'/synthetic molecules, just in different arrangements…

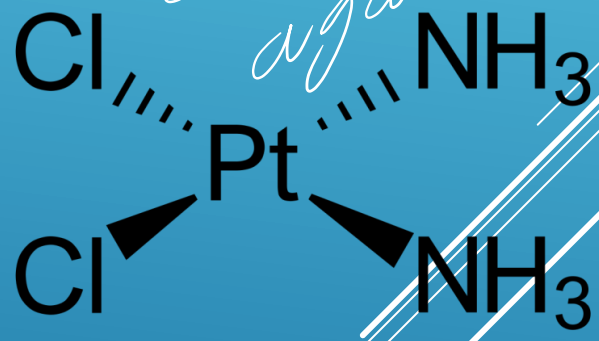




Graphene-based armour which could potentially stop bullets – two layers of stacked graphene…

another allotrope of C

cisplatin again!

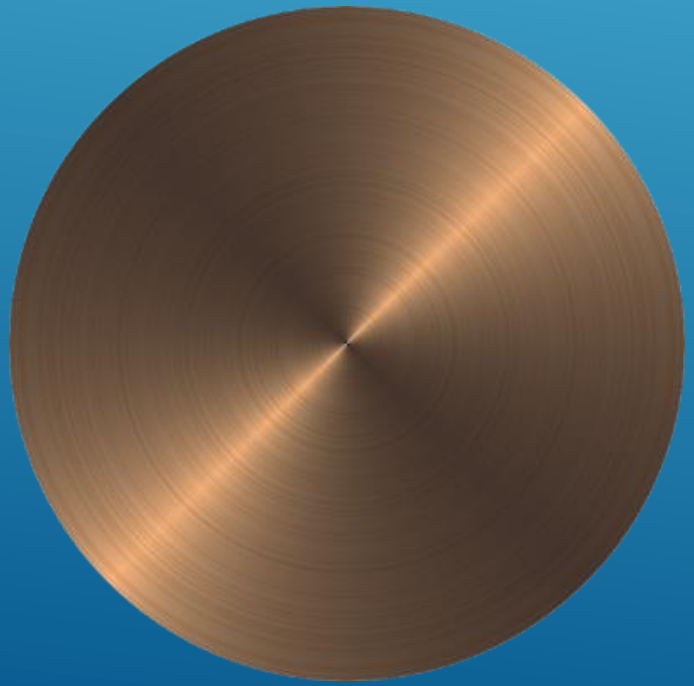


Interferes with the replication of the fastest proliferating cells…

SYNTHESIS OF COPPER METAL!

Copper Experiment!

- Copper metal is excellent at conducting electricity
- Can be used to make alloys (made by combining 2 more metals – can result in a stronger metal!)

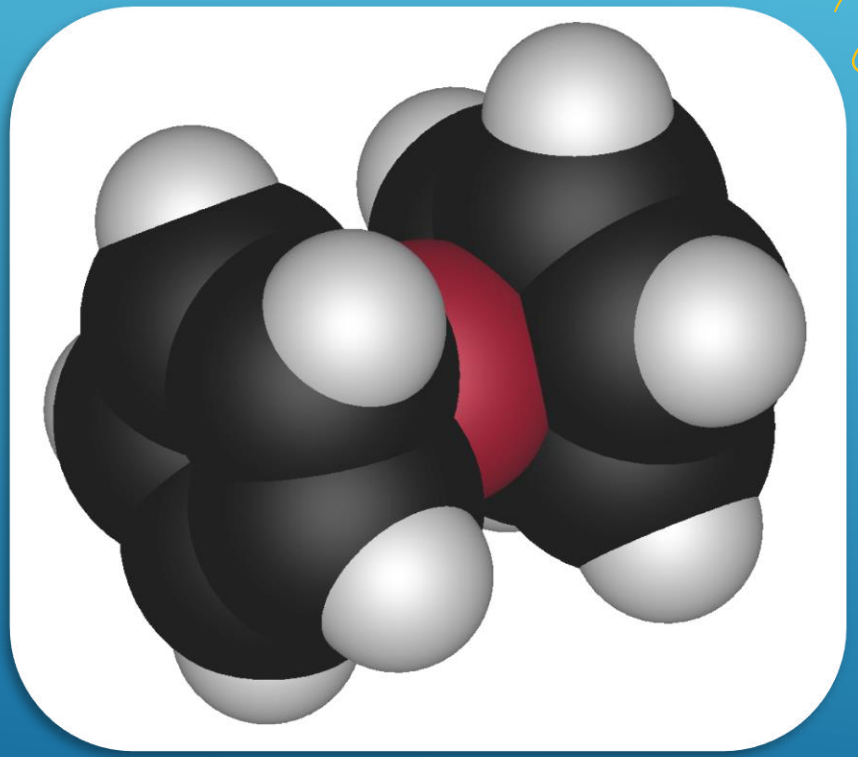


⇒ Oxidation (turns green)

A FERROCENE 'SANDWICH'!

'Molecules' contain atoms'!

More examples of molecules!

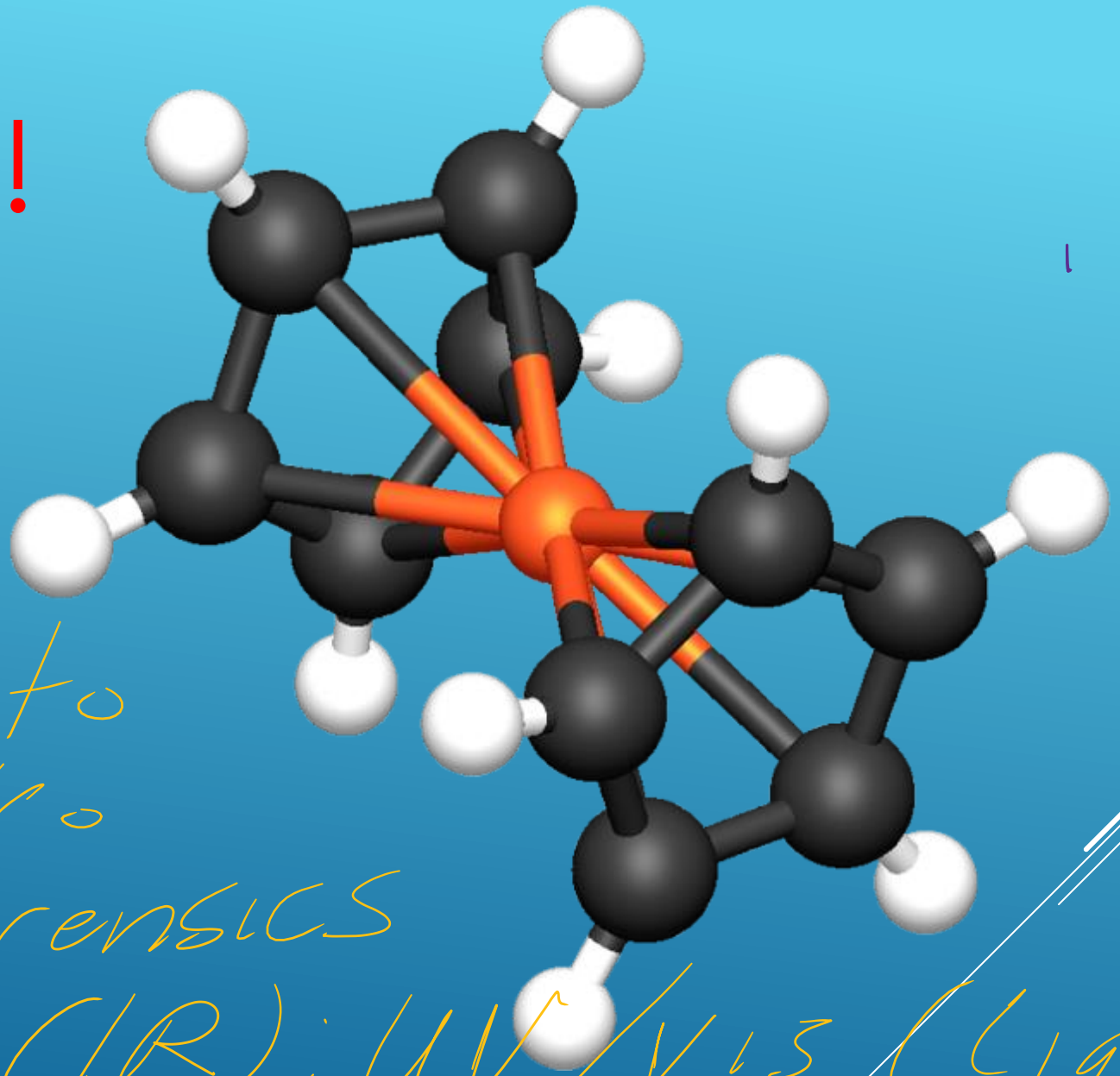


Ferrocene molecular structure, with an iron atom (Fe) in the centre!

What ferrocene looks like! Orange/brown, crystalline

FERROCENE!

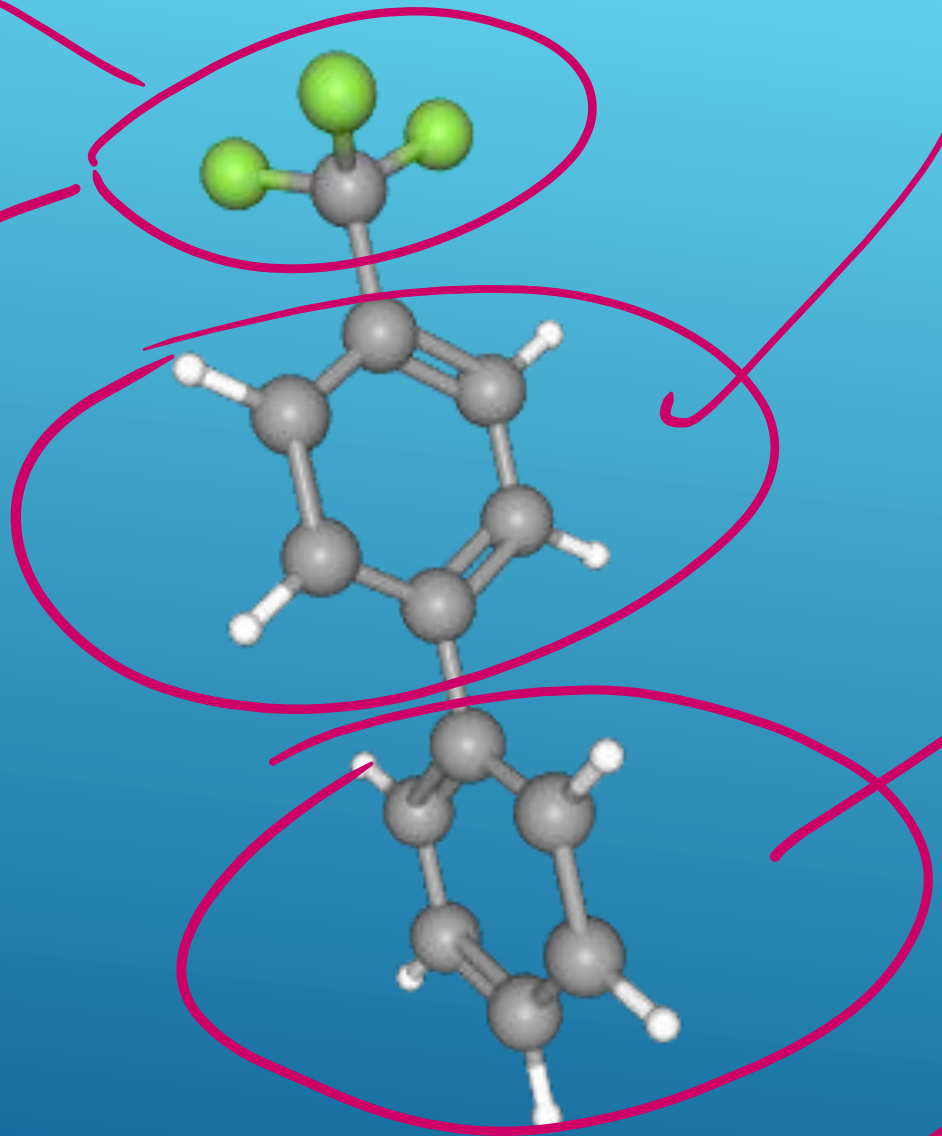
Another molecular structure of ferrocene…



Same techniques to analyse also used in forensics
⇒ Infrared (IR), UV/Vis (Light)

4-(TRIFLUOROMETHYL)BIPHENYL!

HOLY MOLY

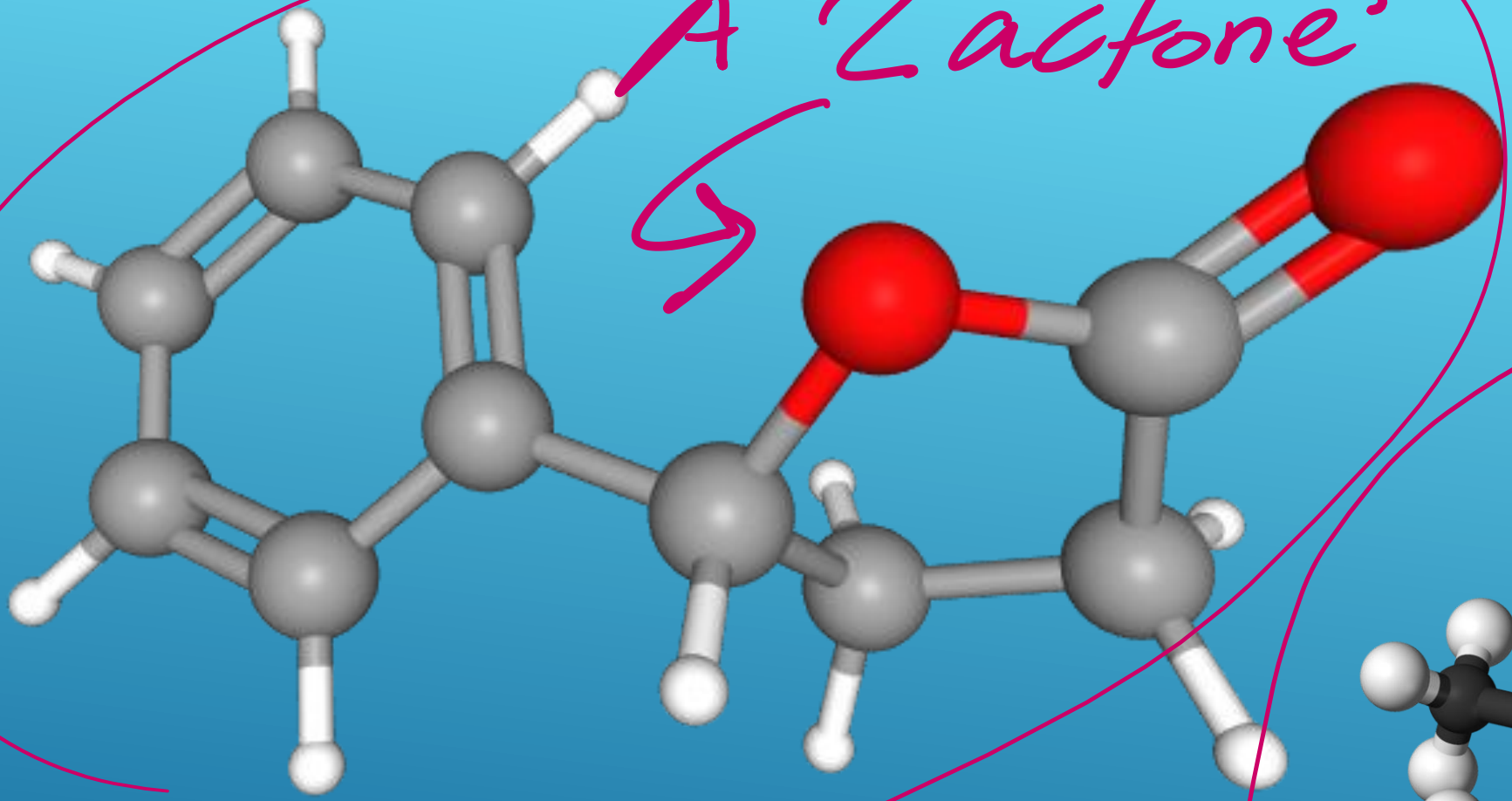


3 Fluorines (F)

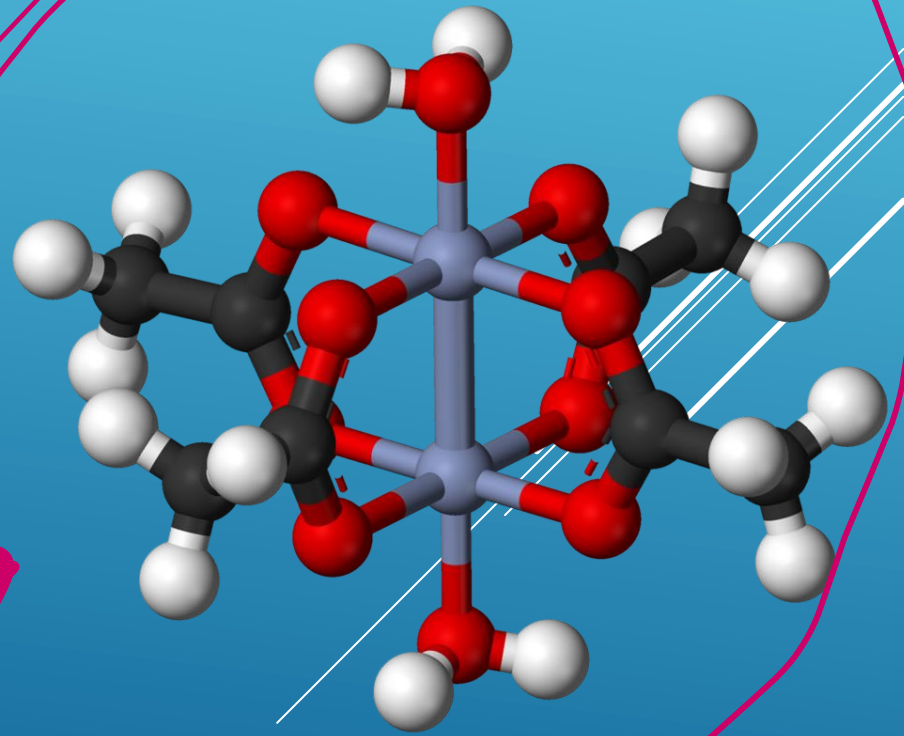
x2 Phenyl Rings

'Bi-' means 2 (Greek)

A 'Lactone'



More Molecules...



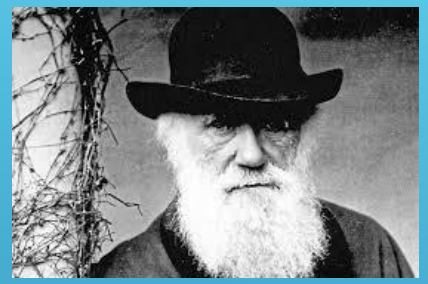
chromium(II) acetate

- How did the peppered moth adapt to its environment?
- What anthropogenic events (as a result of human activity) brought about these changes?

camouflage!

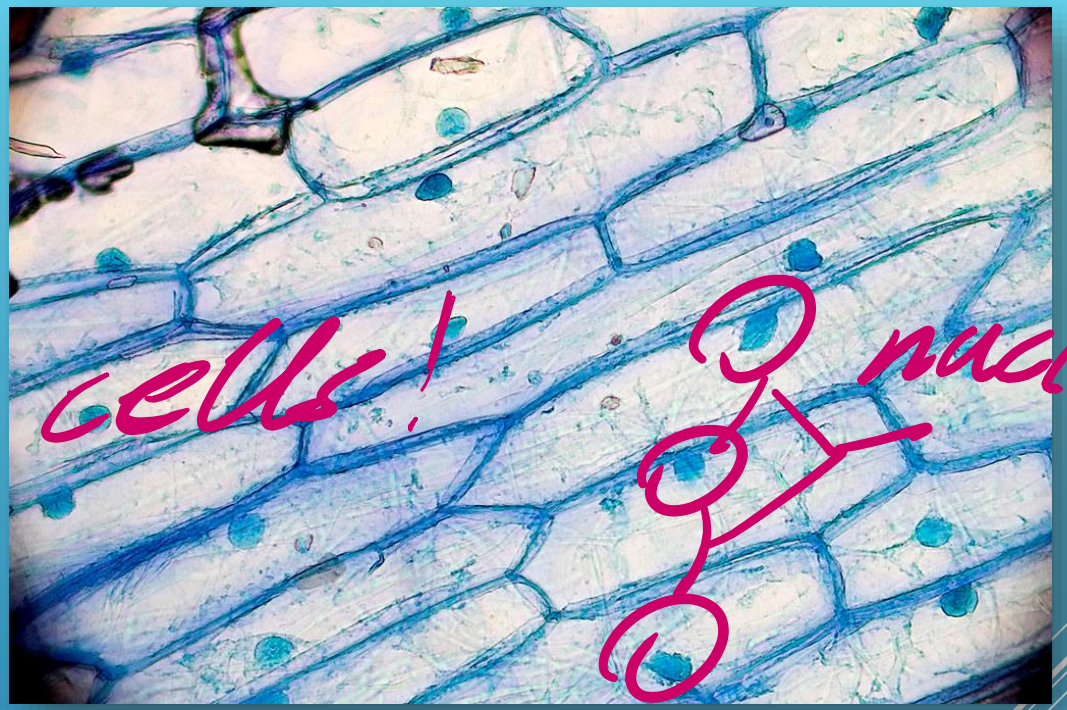
- An example of Darwinian Evolution in action
- A black-bodied phenotype of peppered moth and white-bodied peppered moth…
- The black-bodied variety was not widely known before 1811
- After the industrial revolution (lots of smoke, smog, factories burning fossil fuels), the habitats of the moths changed and became darker and covered in soot.
- The white variant became much less camouflaged by its surroundings, and predators could see them much more easily. The black variant was now better camouflaged.
- As the white moths died out, only the black moths were left to pass on their genes to the next generation

Charles Darwin



physical trait

ONION EPIDERMAL CELLS!



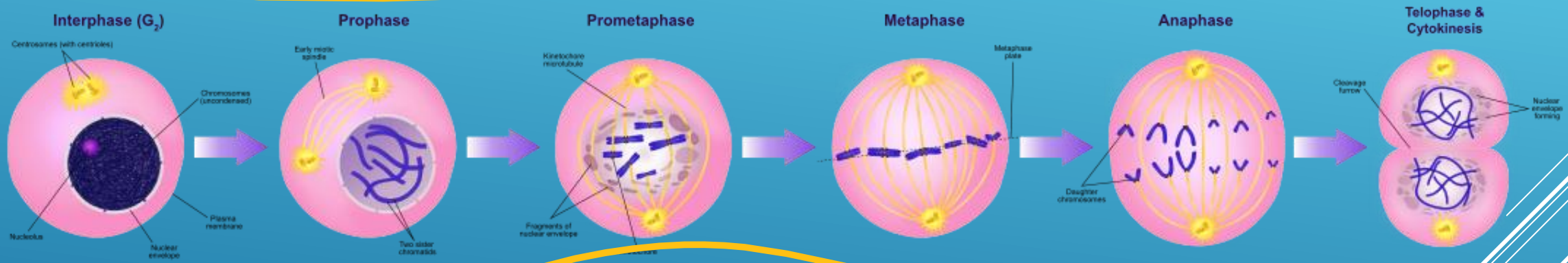
Humans also have epidermal (SKIN) cells!

- Epidermal cells stained with methylene blue
- Iodine can also be used to stain cells… you might have used this before!*

Disinfectant; catalyst → speeds up reactions

*Research! – What is a common use of iodine in everyday life?

CELLS! PROTEINS! DNA!

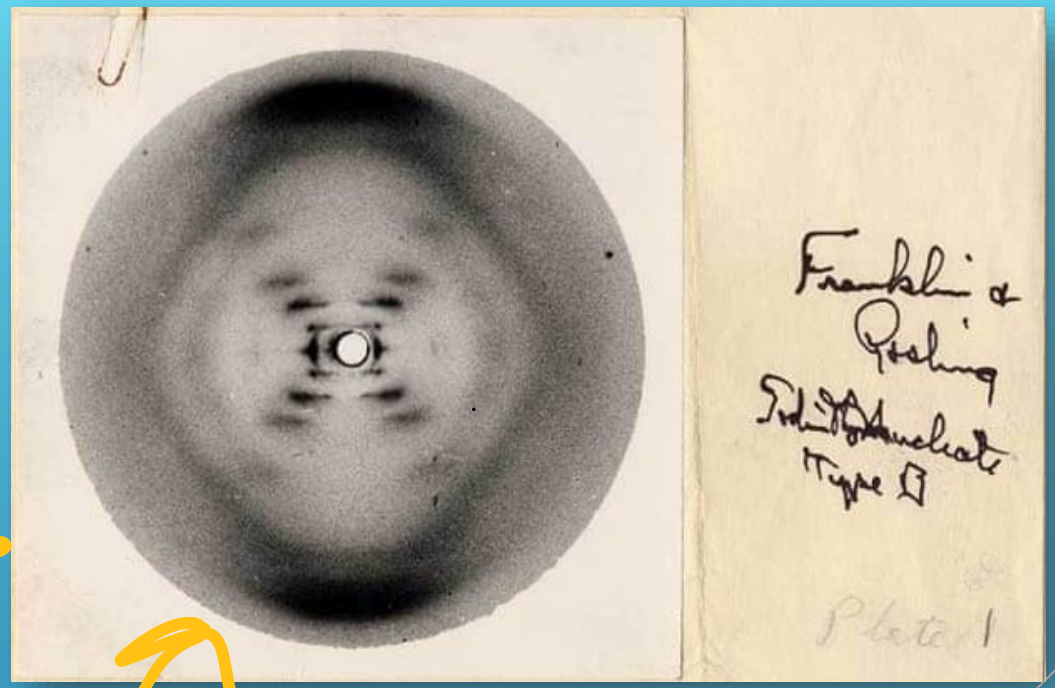


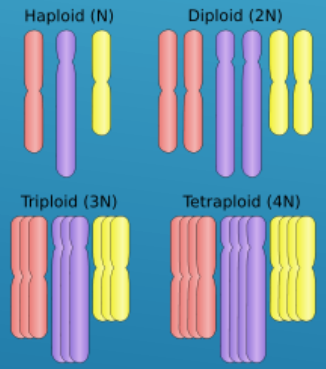
- Cellular Division - Mitosis

How cells make more of themselves

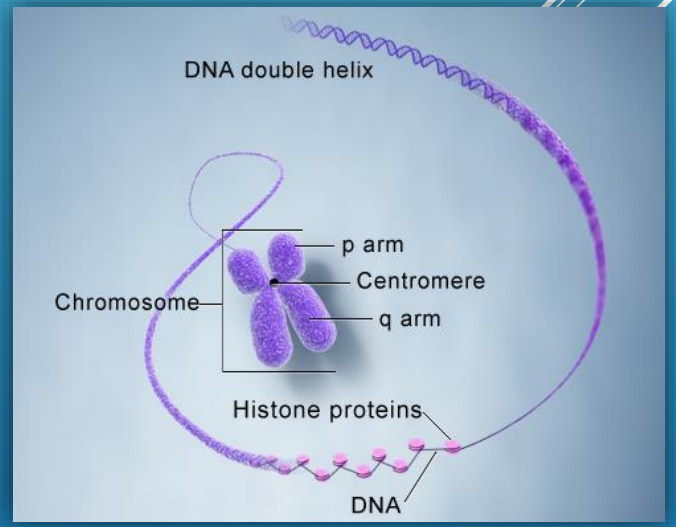
- Rosalind Franklin
- *Photo 51* – X-ray diffraction image

Photo 51 or DNA...





THE POWER OF GENETICS!



- Nancy Wexler and Huntington's Disease

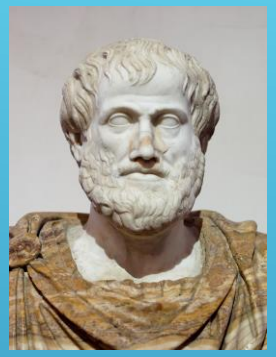
- Venezuelan Villages

PCR 'Gene Locus' = Where a gene is located

- One of first diseases linked to a single gene using modern gene-mapping methods

) Used for making lots of DNA in a lab (Polymerase Chain Reaction)

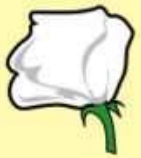
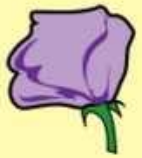
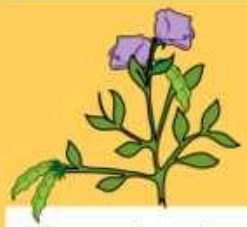
- ‘units’ or ‘factors’ of heredity…
- Aristotle = hereditary info. transmitted in the form of ‘messages’, c. 350 BC



Gregor Mendel

MENDELIAN GENETICS

Passing on genes to the next generation!

Seed		Flower	Pod		Stem	
Form	Cotyledons	Color	Form	Color	Place	Size
						
Grey & Round	Yellow	White	Full	Yellow	Axial pods, Flowers along	Long (6-7ft)
						
White & Wrinkled	Green	Violet	Constricted	Green	Terminal pods, Flowers top	Short ½ -1ft
1	2	3	4	5	6	7

- Mendel's Pea Plants and phenotypes studied... (caused by genes)

Physical Differences

WHEN DOES EVOLUTION OCCUR?

If…

- There is an abundance of shelter, food and water for the species? ✗

Lots'

or

- The species lives peacefully together with other species? ✗

or

- Resources are limited for all species in their environments? ✓

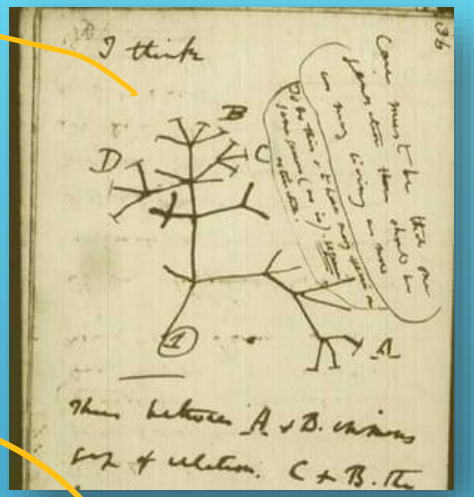
Must be competition for resources

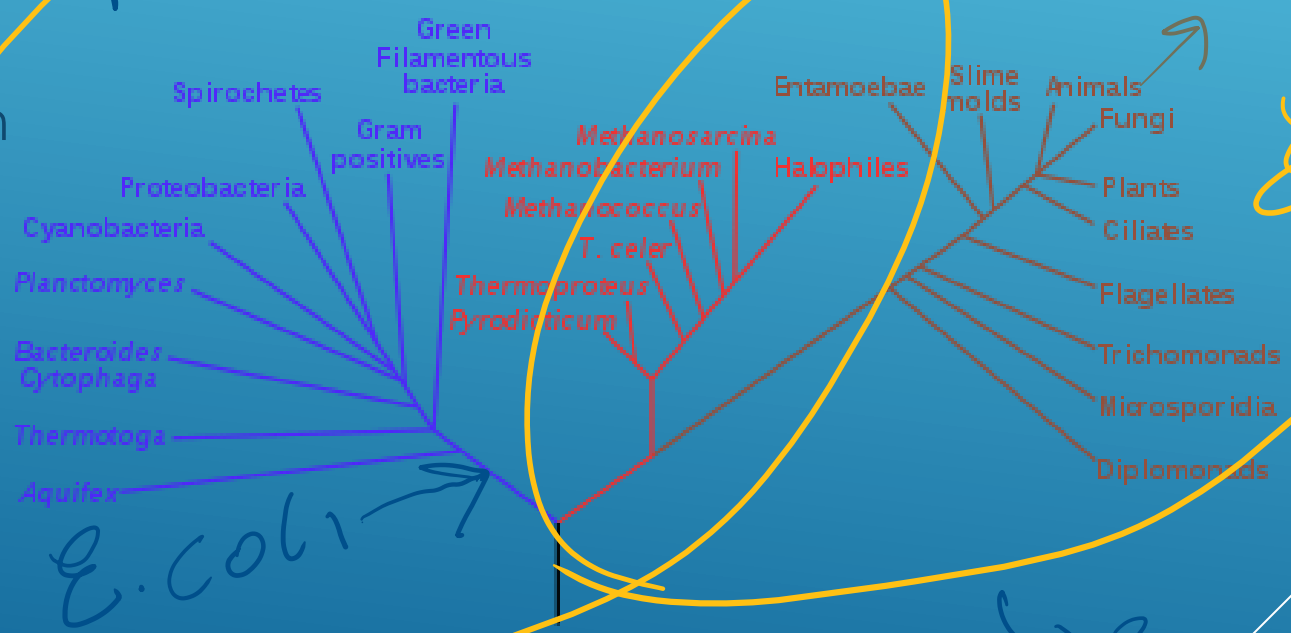
→ e.g.

EVOLUTION

Explaining the genetics of forensic science…

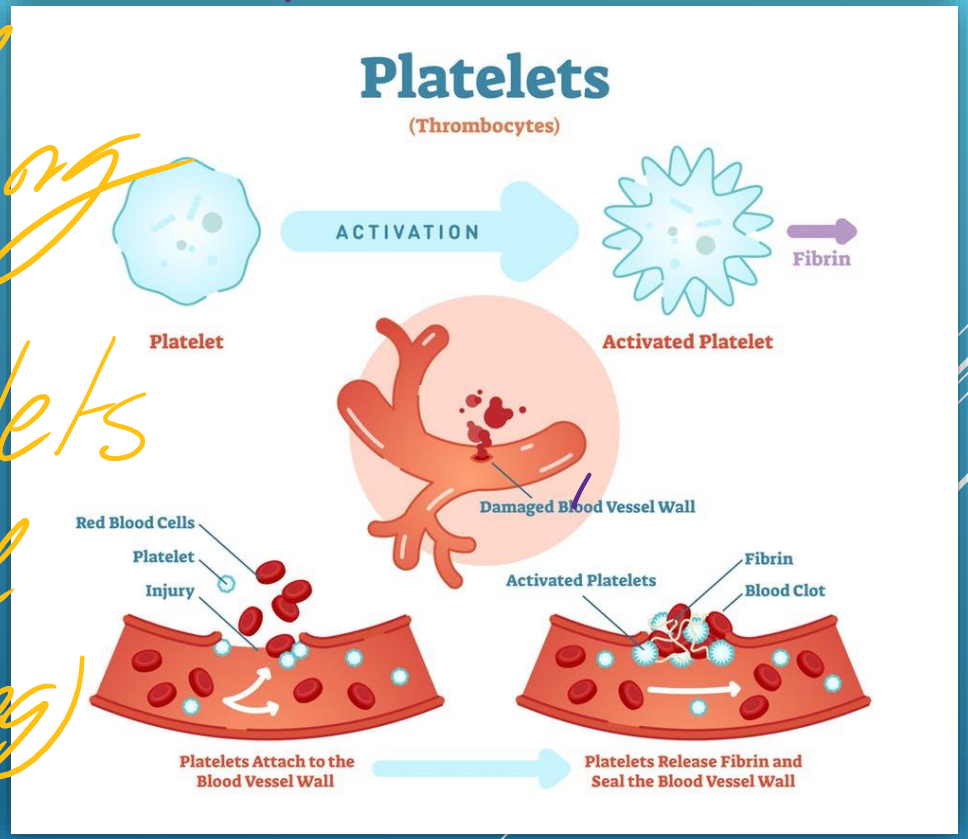
- Evolution & Adaptation
- Heredity





The phylogenetic tree…

PLATELETS & THROMBOSIS



Blood spatter analysis – coagulation; clotting factors…

WHAT MAKES UP BLOOD?

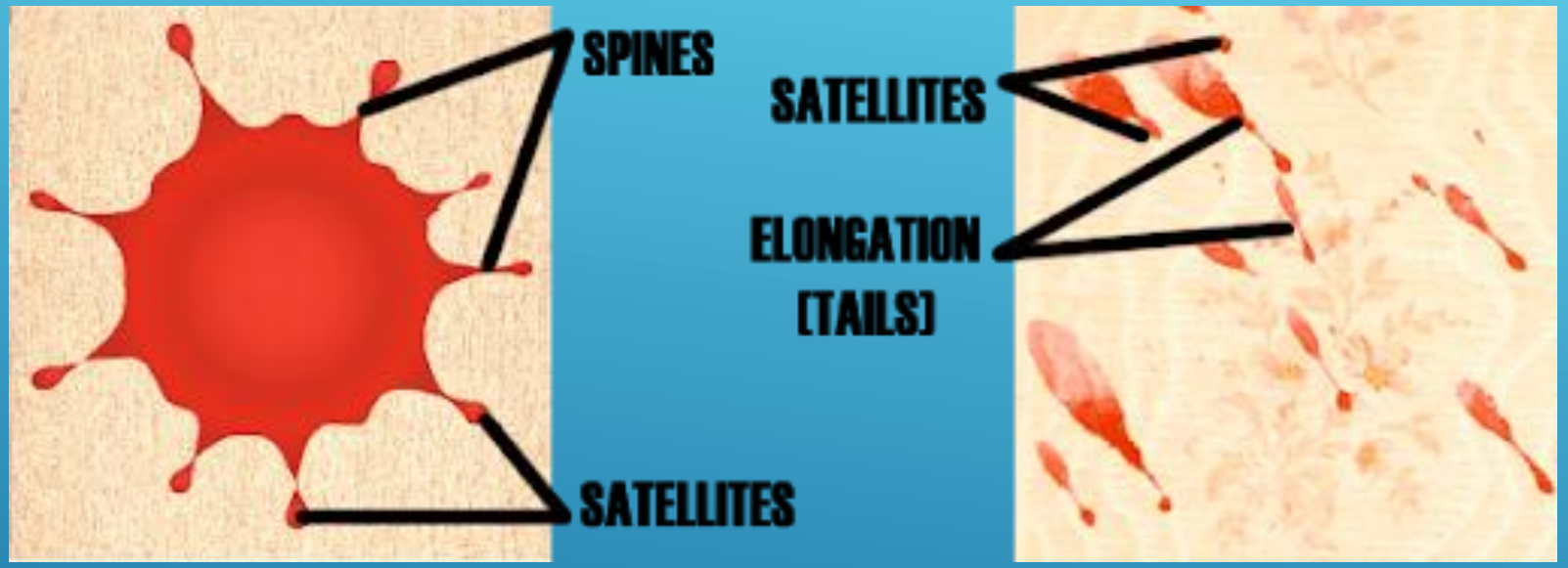
Mainly…

- Plasma (yellowish; mainly water; helps regulate body temperature)
- Red blood cells ('erythrocytes'; biconcave discs; have haemoglobin to latch on to oxygen and transport it around the body; haemoglobin contains iron, Fe)
- White blood cells ('leucocytes'; fight infection; make 'antibodies' which engage with a pathogen's 'antigens' to fight them off
- Platelets (formation of blood clots = 'thrombosis')

- Blood serum can be taken from a centrifuge – it is the blood plasma minus everything else and minus any fibrinogens → help stop bleeding

Coagulation (platelets engaged when healing) = blood changes from a liquid to a gel

REMINDER! BLOOD SPATTER ANALYSIS



- Important Factors:

Velocity; angle (elliptical? Round?); volume; location of wound; source of blood (using maths – blood droplets as projectiles); type of surface (absorbant?)

A CENTRIFUGE IN ACTION…

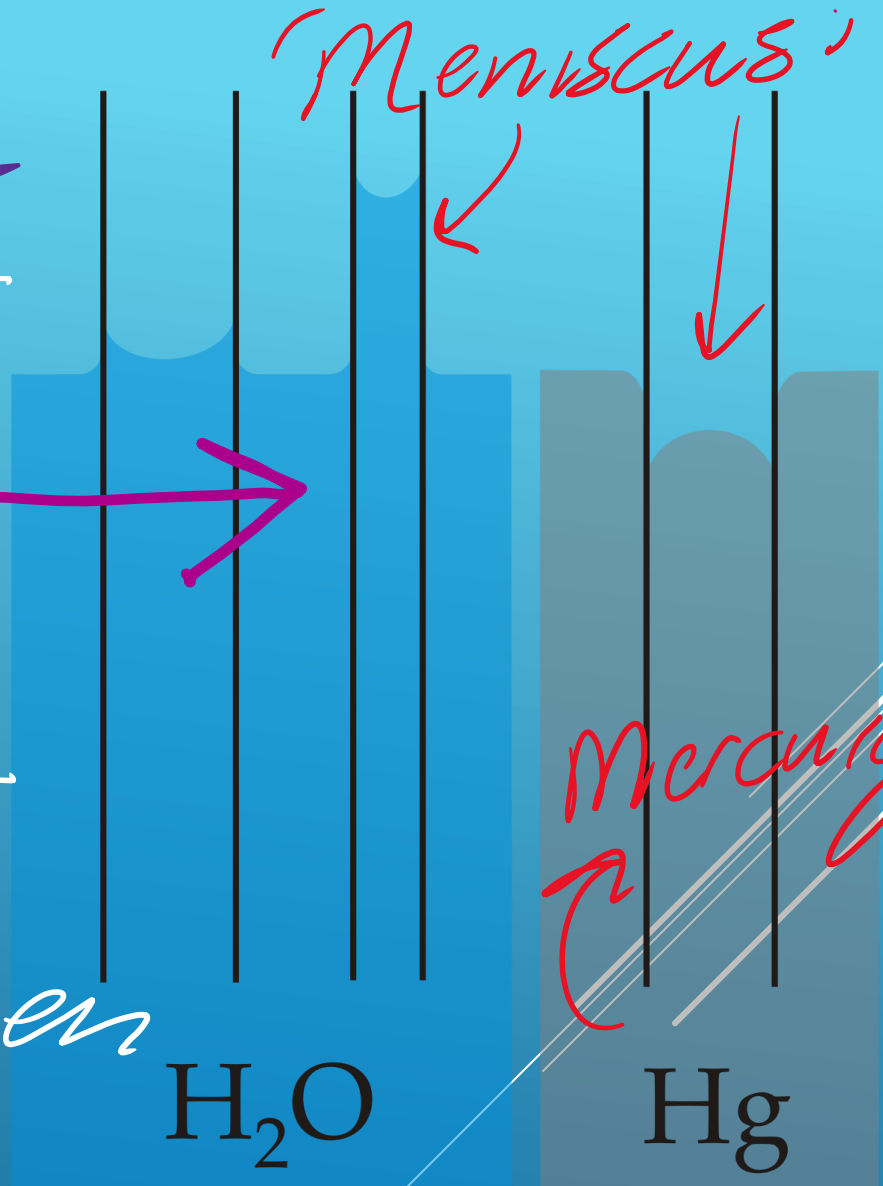
- https://www.youtube.com/watch?v=9u4azf206T0

- Piece of kit in a forensic science laboratory

- Have to be extremely careful with them – have to balance them out; if not, extreme speeds and mechanical pressures can cause them to explode!!!

Cap. Hars Action

- Major blood vessels:
  - Arteries
  - Veins
  - Capillaries



When Red Blood Cells take up Oxygen
→ change shape
(= 'conformational change')

Capillaries!!!

↳ Located in our lungs on → ALVEOLI (little air sacs)

↳ capillaries are vital for gas exchange, helping us breathe...

Pneumonia → breathing difficulties due to fluid/pus build-up in lungs (COVID-19)

ALEXANDER FLEMING…

'Innovations'?

→ Inventions
→ New Ideas

'Serendipity' in science and forensic science

→ The importance of discoveries by chance…

Discovers of penicillin (fights bacteria → an antibiotic)

MAIN POINTS RE-CAP

- DNA is super important in forensic science – it explains how each of us is different, and how material from humans left at a crime scene can be used for genetic analysis to help identify suspects, victims and others present at the scene of a crime

- Chemistry is used by forensic scientists to perform the different experiments needed to help in the work of crime-solving. Chemistry also helps us understand how biology works. As we have seen and will see more of later, physics helps us understand the mechanics of the natural world. Each of these areas blend together to help us in understanding forensic science.

- Evolution explains how our genetic differences arose, and many of these differences are important biometrics in forensic science – fingerprints, eye colour, facial features, bone structure, blood (blood groups!) etc.