

# St Benedict's Journal of Science

including the *History & Philosophy of Science*

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*Special edition*

incorporating



St Benedict's  
Catholic School

*The Catholic Secondary School for West Suffolk*

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# Welcome to Volume 6 (July 2022)

**This “Special Edition” of the Journal of Science is a unique combination of the school’s two Science publications – the annual Journal and the Science News Monthly.**

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## **A MESSAGE FROM THE EDITOR**

As an “end of year special”, it seemed a good idea to merge this annual Journal with the Science News Monthly. In fact, the Monthly itself is somewhat different this month – usually the news items are chosen by the editor, with occasional help from one or two close colleagues, especially Dr R Davies (Science Technician). For this month, the editor invited all members of the Science Department to contribute a news item that had caught their attention. There were even one or two items from some years ago that had made a lasting impression on particular members of staff.

The Science News Monthly section is at the rear of this edition, with individual contributors being credited at the head of their article, as well as on the Contents Page. Thank you to all of them.

As a result of the recovery from the Covid “lockdowns”, much emphasis has been placed on making up for lost time and revising for important assessments and, of course, preparing for external GCSEs and GCEs. Nevertheless, some students have been able to produce some well researched, “long answer” pieces; in addition, there are some interesting examples of posters, especially from Mrs Blewitt’s Year 7s on safety in the laboratory – crucial for the young scientists at this stage of their education.

The editor wishes everyone – readers, students and staff – a pleasant summer break!

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## **STUCK FOR SOMETHING TO DO ON A BRIGHT, SUMMER DAY - WHY NOT WALK IN THE FOOTSTEPS OF SIR ISAAC NEWTON?**

How about a visit to **WOOLSTHORPE MANOR**? It’s not far, being just off the A1 south of Grantham. It is the family home of arguably the greatest scientist of them all, Sir Isaac Newton.

Without Isaac Newton this small manor would be just another Lincolnshire farmhouse - but in 1665 the plague sent him back from university to this place where he was born on Christmas Day 1642. For 18 months Newton worked in solitude, experimenting obsessively, laying foundations for the science of today.



Woolsthorpe Manor tells the story of Newton's time at Woolsthorpe, from his birth and childhood to the discoveries of his Year of Wonders. In the 17th century manor house you can stand in the room where he used a prism to split sunlight into the colours of the rainbow, exploring the nature of light. From the window you can see the apple tree in the orchard which inspired his theory of gravity.

Coming back to the present day, you can discover Newton's science for yourself in the hands-on Science Centre and walk to the village church (not National Trust) where he was baptised. For more than 300 years people have come to Woolsthorpe, drawn by his story to find their own inspiration in this place of genius.

**PLEASE NOTE: YOU MUST BOOK YOUR VISIT IN ADVANCE.**  
Full details are on the national trust website:

<https://www.nationaltrust.org.uk/woolsthorpe-manor>

# Table of Contents

## YEAR 7 – LAB SAFETY POSTERS

ELLA VARMA 7A	Page 4
TALIA MCQUEEN 7C	Page 5
JIMMY CHOJNACKI 7C	Page 6
WILLIAM CHANNING 7P	Page 7
MARISA DE CASTRO COSTA 7S	Page 8
LUKAS BARISIUS 7P	Page 8
FINLAY THOMAS 7A	Page 9
TAWNEY SAVAGE 7P	Page 10
TIA WYNNE-ROGERSON 7P	Page 11
KEERTHANA KANDEEBAN 7C	Page 12
SAMANTHA MARTELINO 7P	Page 13

## YEAR 10

### **CHRISTOPHER JOHN F MORRISSEY 10S**

What are the factors that affect resistance?	Page 14
--	---------

### **BEA PRICE 10L**

Factors that affect resistance	Page 16
--------------------------------	---------

### **DANIELLE MIRANDA 10S**

The factors that affect the resistance of a wire	Page 17
--	---------

### **MOLLY GARDINER 10S**

Factors affecting resistance	Page 18
------------------------------	---------

### **FERNANDA LOPEZ-CLIFT 10S**

Factors that affect resistance	Page 19
--------------------------------	---------

## YEAR 12

### **ADRIAN-SMITH DELGADO 12A**

A [very] brief introduction to the fundamentals of quantum mechanics	Page 20
--	---------

### **ADRIAN SMITH-DELGADO, LEONEL JOSE 12L, NOKUTENDA JAJI 12C, EMIL CHERIYAN 12A, TOM ROY 12L**

Extracting caffeine from instant coffee	Page 25
---	---------

## YEAR 13

### **ISABEL WHINNEY 13L**

The human digestive system	Page 28
----------------------------	---------

### **SOPHIE HARPUR-DAVIES 13L**

Mechanical and chemical digestion	Page 29
-----------------------------------	---------

### **KATIE TAMSETT 13C**

The human digestive system	Page 30
----------------------------	---------

### **LUCY MULLIGAN 13L**

The human digestive system	Page 31
----------------------------	---------

## SCIENCE NEWS MONTHLY SECTION

### **Dr R DAVIES**

**ARCHAEOLOGY** - Redefining the timing and circumstances of the chicken's introduction to Europe and north-west Africa  
Which came first, the chicken or the egg?

Page 32

### **Mr J GREGORY**

Sir David Attenborough awarded second knighthood!

Page 33

### **Mrs H DUNN**

**GENETICS** - Most 'silent' genetic mutations are harmful, not neutral

Page 34

### **Dr R DAVIES**

**AI** - Is there a real ghost in the machine?

Page 34

### **Mr M TANGUAY**

**AI** - Knowing me, knowing you: theory of mind in AI

Page 35

### **Mrs P BAKER**

**BIOLOGY** - Huge plan to map the DNA of all life in British Isles

Page 36

### **Dr R DAVIES**

**MICROBIOLOGY** - Happy 100th birthday E. coli K-12!

Page 36

### **Dr R DAVIES**

**BRAIN SCIENCE** - Why can we see moving objects

Page 37

### **Ms E COOGAN**

**MEDICINE** - 'Miracle' Cystic Fibrosis treatment – KAFTRIO

Page 38

### **TH COOGAN FAMILY**

**ARCHAEOLOGY** – Ancient bacterial DNA

Page 38

### **Mrs R BLEWITT**

**BRAIN SCIENCE** - Brains can be hotter than the rest of our bodies

Page 39

### **Miss A DALBY**

**MATERIALS SCIENCE** – transparent wood!

Page 39

### **Mr D'MELLO**

**SPORTS SCIENCE** - A Human Has Won The Man Vs Horse Race!

Page 40

### **Mr F SOUSA**

**PLASTICS** – "Superworms" that can eat plastic!

Page 40

### **Mrs H DUNN**

**SPACE EXPLORATION** – the frog that nearly made it into space!

Page 41

### **Miss A DALBY**

**PHYSICS** – Floating frogs!

Page 41

### **Miss S CLEAVER**

**QUANTUM PHYSICS** – All information is here

Page 42

### **Mrs C CHACKSFIELD**

**JOCELYN BELL BURNELL** – famous scientist born this month

Page 43

### **Mr J GREGORY**

**TELSTAR 1: The Little Satellite That Created the Modern World**

Back cover

### **Mr J GREGORY**

## ELLA VARMA 7A

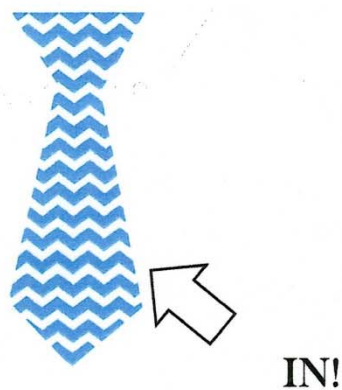
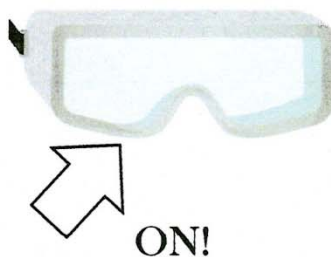
### LAB SAFETY POSTER

**Follow these 3 rules when using a Bunsen**

**burner!** 

Ella.Varma

1. Tie your hair back!
2. Wear your goggles!
3. Tuck your tie in!





TALIA McQUEEN 7C  
LAB SAFETY POSTER

# Safety In The LAB



Always stand during an experiment.

Always tie your hair up in a lab! :)

Always walk and be sensible in a lab! :)

Always wear safety goggles or glasses whilst doing a practical.

You will bring a pencil case, your exercise book and a planner to every lesson!

Never go into a lab without a teacher present!

Never eat in a lab.

No running in a lab.

Never look directly into a test tube, or point an end of a test tube directly at someone else!

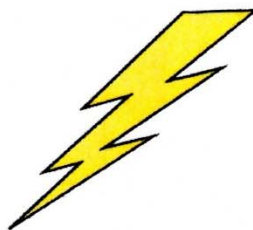
Never smell, taste or put anything in your mouth in a lab!



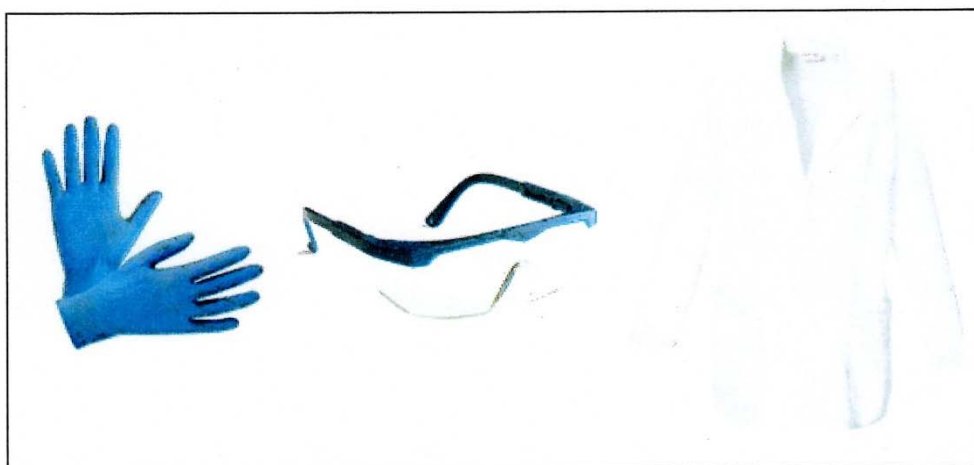
## JIMMY CHOJNAKI 7C

### LAB SAFETY POSTER

Science safety

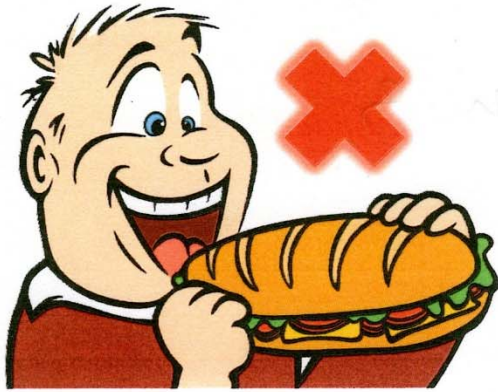


- Always wear protective equipment for example, goggles, gloves and a lab coat.
- Never smell or drink the chemical during a practical.
- Never run, leave belongings on the desk, sit down or leave the chemicals during a practical.
- Be careful when you are pouring acid or chemicals so you don't spill it or get it on your skin.



# WILLIAM CHANNING 7P

## LAB SAFETY POSTER



**DO NOT EAT  
IN THE LAB**



**DO NOT  
RUN IN THE  
LAB**

**DO NOT THROW  
OR PLAY IN THE  
LAB**





## MARISA DE CASTRO COSTA 7S

### LAB SAFETY POSTER

#### Science Lab Safety Rules



### science lab rules...



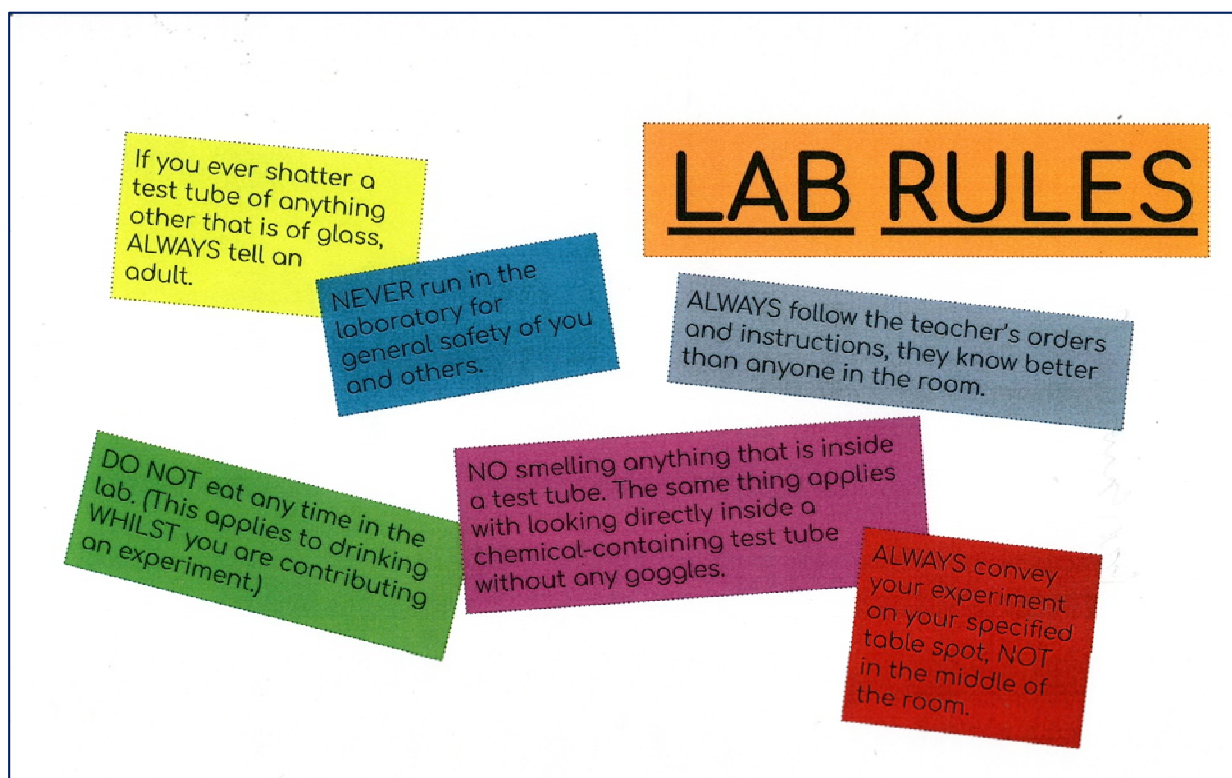
#### Always...

- Wear safety goggles
- listen to the teacher
- Tell an adult when things go wrong
- Do what your told
- Have your hair up
- Wear protective equipment when told to
- Clean after yourself

- never...
- Eat or drink in the lab
- Run into the lab
- Leave a mess
- Have your hair down while doing an experiment

## LUKAS BARISIUS 7P

### LAB SAFETY POSTER





**FINLAY THOMAS 7A**  
**LAB SAFETY POSTER**

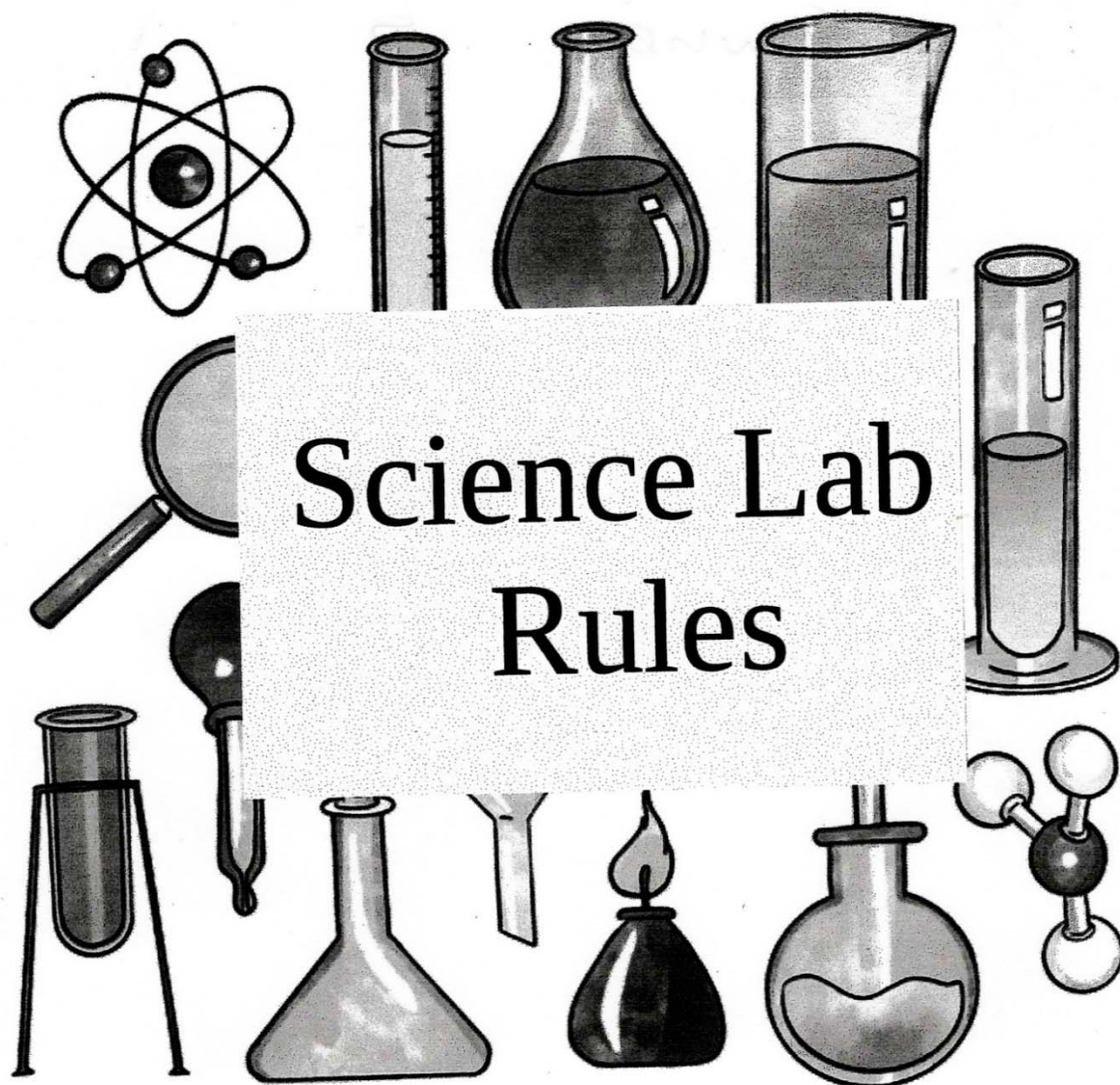
**NO EATING OR DRINKING IN THE SCIENCE LAB!**



**Mrs. Blewitt is watching!**



**TAWNEY SAVAGE 7P**  
**LAB SAFETY POSTER**



- 1- No messing around with the equipment.
- 2- No talking while the teacher is talking.
- 3- No running in the lab.
- 4- If you break anything, tell the teacher.
- 5- Only have water in the lab no other liquids.
- 6- Keep your water bottles in your bags not on desks.



TIA WYNNE-ROGERSON 7P

LAB SAFETY POSTER



## KEERTHANA KANDEEBAN 7C

### LAB SAFETY POSTER

**Tie Back Long**  
hairs, and wear  
suitable gloves,  
goggles, and other  
protective.

**No Food**

**ID Hazards**  
(Identify Hazardous  
materials)

**Stay Safe**  
when conduct  
your labs  
by follow  
these  
guidelines

**Clean Up**

**Be careful when**  
handling hot  
glassware.

**Handle**  
glassware  
carefully.

**Properly dispose of**  
anything that breaks.

**Supervision**

**Don't perform lab**  
experiments without  
instructor supervi

**Know Location of Emergency numbers and Safety equipment**

Know the location of emergency numbers and Safety equipment (such as  
person controls) so you can access them if necessary.

**911**

**First Aid Kit**



## SAMANTHA MARTELINO 7P

### LAB SAFETY POSTER



### THE EVOLUTION OF LABORATORY SAFETY: A CAUTIONARY TALE

Many scientists have been driven by a desire for discovery that has at times outstripped their concern for lab safety. This was especially true in years past, when incurring injuries was simply accepted as one of the personal costs of making a difference in chemistry.



Consider the case of **Robert Bunsen** (1811 to 1899), developer of the eponymous **Bunsen Burner**. The price he paid for the many sophisticated discoveries credited to him included serious injuries that resulted from numerous incidents, chief among them a laboratory explosion that blinded him in one eye.

An even more dramatic example was the sacrifice made by **Marie Curie** (1867 to 1934), who received the Nobel Prize for discovering radium and coined the term "radioactivity." Her contributions to humanity and healthcare were immense, but she was careless in her work with the element long after learning of its health hazards. Both Curie and her chemist daughter died of

blood diseases resulting from exposure to radioactivity. And her laboratory notebooks — which remain radioactive to this day, and will remain so for another 1,600 years — are still stored in a lead-lined box in France.

This is why it is so important that budding, young scientists are taught how to be safe in the laboratory right from the start. Yes, laboratories can be dangerous places but, with the right approach, they can be places of fun and wonder too!



## CHRISTOPHER JOHN F MORRISSEY 10S

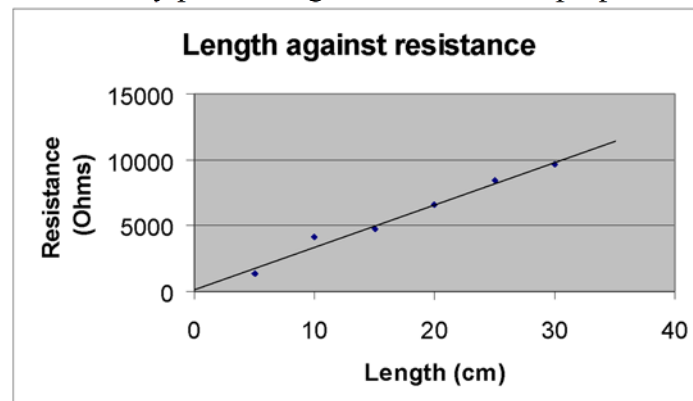
### WHAT ARE THE FACTORS THAT AFFECT RESISTANCE?

There are a variety of factors that will affect resistance, wire or other conductors. Some of these include:

- Length of a wire,
- Thickness of a wire,
- Temperature,
- Type of metal or material used,
- Any other factors such as light level or direction of current.

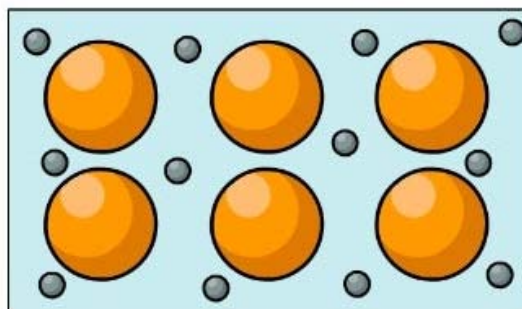
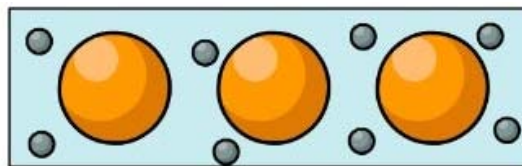
#### Length of a Wire:

Length is a determining factor of the resistance of the wire. Longer wires will have greater resistance as the electrons collide with more ions as they pass through. This relation is proportional.



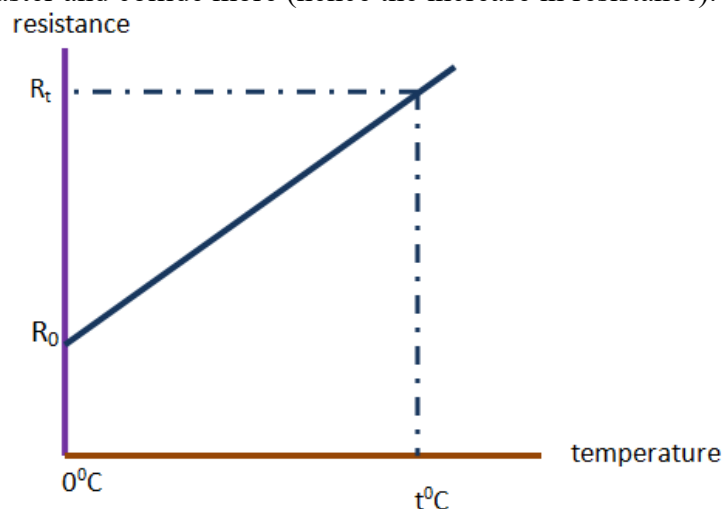
#### Thickness of a Wire:

Thickness also effects the resistance of the wire. If a wire is thicker it has more surface area, meaning that a higher number of electrons can pass through more easily with a decreased chance of collisions with metal ions. The cross-sectional area is calculated using the formula for the circumference of a circle-  $Area = \pi r^2$ .



Temperature:

Temperature is yet another factor that can affect resistance. This is because as the temperature increases, the electrons begin to move faster and collide more (hence the increase in resistance).

Type of Metal or Material used:

Type of metal or material used can also affect resistance. Different materials will have different resistances due to having different numbers of outer electrons and their respective densities. In addition, some materials are better conductors than others.

**TABLE 30.2** Resistivity and conductivity of conducting materials

Material	Resistivity ( $\Omega \text{ m}$ )	Conductivity ( $\Omega^{-1} \text{ m}^{-1}$ )
Aluminum	$2.8 \times 10^{-8}$	$3.5 \times 10^7$
Copper	$1.7 \times 10^{-8}$	$6.0 \times 10^7$
Gold	$2.4 \times 10^{-8}$	$4.1 \times 10^7$
Iron	$9.7 \times 10^{-8}$	$1.0 \times 10^7$
Silver	$1.6 \times 10^{-8}$	$6.2 \times 10^7$
Tungsten	$5.6 \times 10^{-8}$	$1.8 \times 10^7$
Nichrome*	$1.5 \times 10^{-6}$	$6.7 \times 10^5$
Carbon	$3.5 \times 10^{-5}$	$2.9 \times 10^4$

\*Nickel-chromium alloy used for heating wires.

\*Bibliography:

- BBC Bitesize.
- Lagas.org + SlideShare.
- Youngscience.
- SlideServe.



# BEA PRICE 10L

## FACTORS THAT AFFECT RESISTANCE

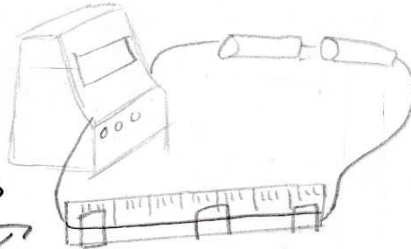
### Factors that Effect Resistance.

Bea Price c

Resistance is an opposition to current flow. A circuit must have resistance in it to allow electrical energy to change into light heat or movement. All conductors show opposition to current but there are some factors that effect resistance for example:

#### Length

The length effects resistance because the longer the wire is the greater the resistance. This is due to the electrons having a greater distance to travel.



Setup of experiment to show resistance in different lengths.

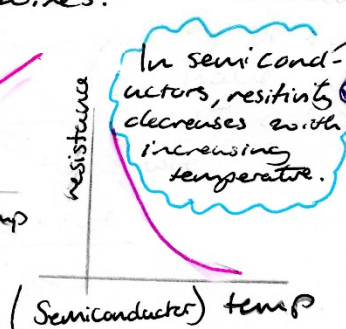
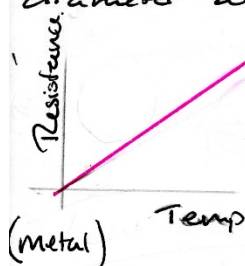
#### Thickness

Resistance is also effected by thickness of a wire because smaller wires have smaller diameters meaning it can't allow more electrons to pass through compared to larger diameter wires.



Thin wire

Thick wire



In semi-conductors, resistivity decreases with increasing temperature.

Temperature (of a metal conductor) Temperature has an effect on resistance because when the temperature increases it means the ions of the metal vibrate more vigorously which increases the amount of collisions between the free electrons and ions.

#### Type of material

The material effects resistance because, with different materials, each of them has different resistivity (which is the ability of allowing the electrons to flow through.) Metals are conductors which has lower resistance but insulators like plastic have higher resistance.

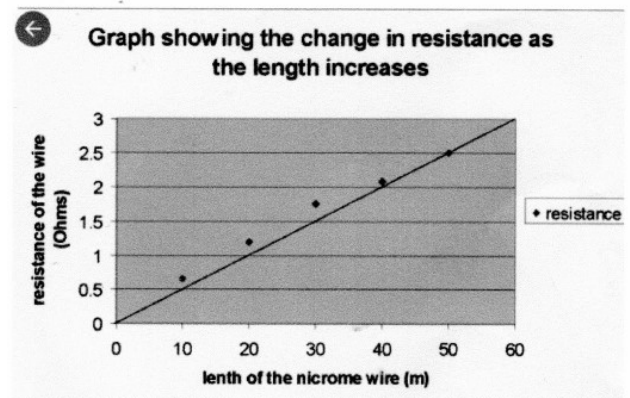


## DANIELLE MIRANDA 10S

### THE FACTORS THAT AFFECT THE RESISTANCE OF A WIRE

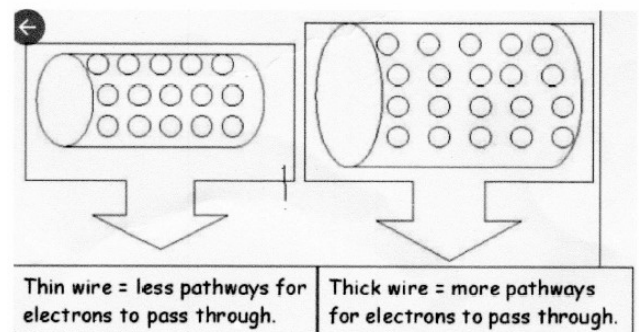
#### LENGTH OF A WIRE

If the length of a wire is increased then the resistance will also increase, as the electrons will have a longer distance to travel and so more collisions will occur. Due to this, the length increase should be proportional to the resistance increase.



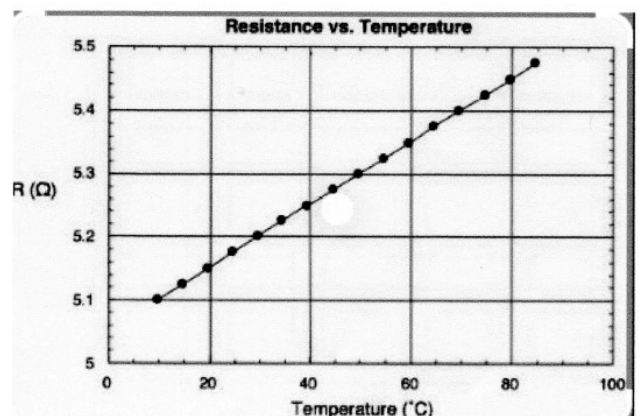
#### THICKNESS OF A WIRE

If the wire's width is increased the resistance will decrease. This is because of the increase in the space for the electrons to travel through. Due to this increased space between the atoms, there should be fewer collisions.



#### TEMPERATURE

If the wire is heated up, the atoms in the wire will start to vibrate because of their increase in energy. This causes more collisions between the electrons and the atoms are moving into the path of those electrons. The increase in collisions means that there will be an increase in resistance.



#### TYPE OF METAL OR MATERIAL

The type of material will affect the amount of free electrons which are available to flow through the wire. The number of electrons depends on the amount of electrons in the outer energy shell of the atoms; so if there are more or larger atoms, then there must be more electrons available. If the material has a high number of atoms, there will be a high number of electrons causing a lower resistance because of the increased number of electrons.

Also, if the atoms in the material are closely packed, then the electrons will have more frequent collisions and the resistance will increase.

## MOLLY GARDNER 10S

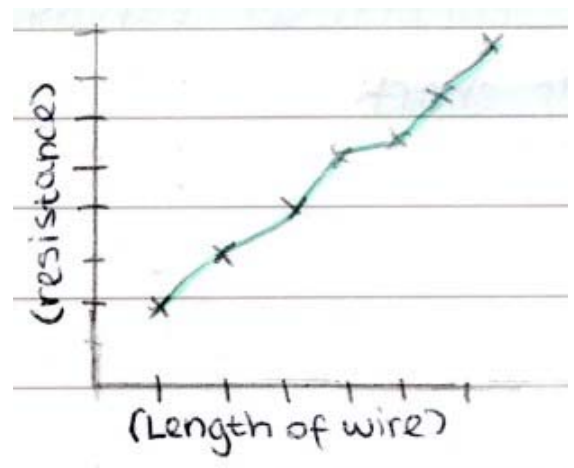
### FACTORS AFFECTING RESISTANCE

Resistance is the opposition to the passage of electrons in an electrical circuit. Its unit of measurement is the Ohm ( $\Omega$ ). Resistance can be affected by:

- The wire length
- The wire thickness
- Temperature
- Material type

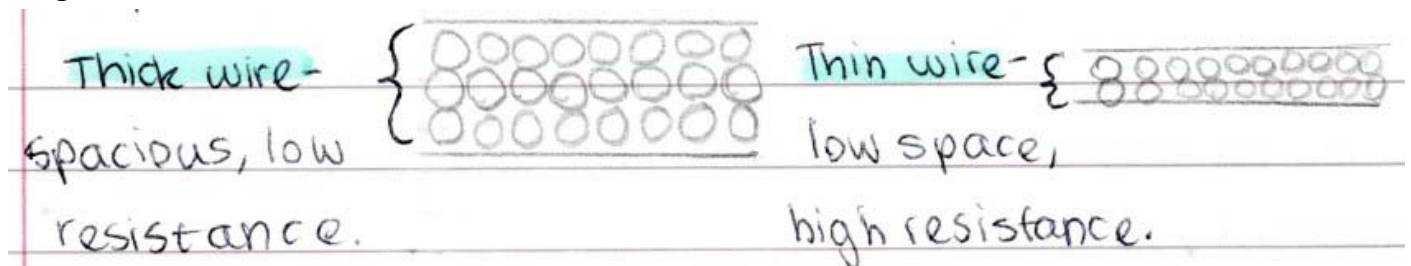
#### WIRE LENGTH

Wire length affects resistance proportionally to resistance increase. This is because the longer distance which the electrons have to travel will result in more collisions. This is why wire length and resistance are proportional, as shown in the graph.



#### WIRE THICKNESS

As the wire's width increases, resistance decreases. This is due to the increase in space which the electrons can go through, resulting in less collisions with ions. This is shown in the diagram.



#### TEMPERATURE

The higher the temperature of the wire, the greater the resistance. As temperature increases, the atoms in the wire have more kinetic energy and vibrate faster making it harder for electrons to pass through due to the higher number of collisions.

#### MATERIAL TYPE

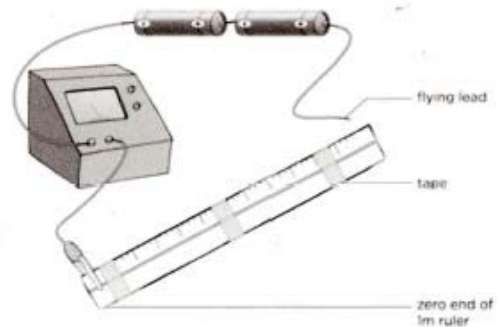
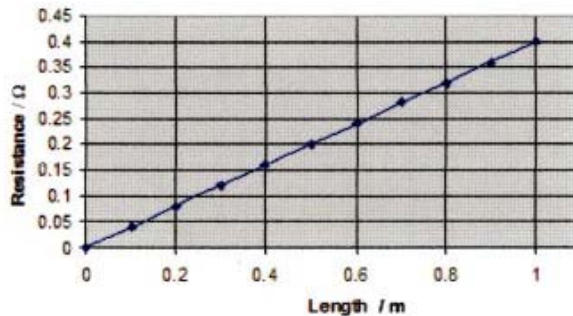
The type of material will affect the amount of free electrons which are able to flow through the wire. The number of electrons depends on the amount in each atom's outer shell. So if there are more/larger atoms, then there will be more electrons available. Since this is not a continuous variable, it can only be plotted on a bar chart.

## FERNANDA LOPEZ-CLIFT 10S

### FACTORS THAT AFFECT RESISTANCE

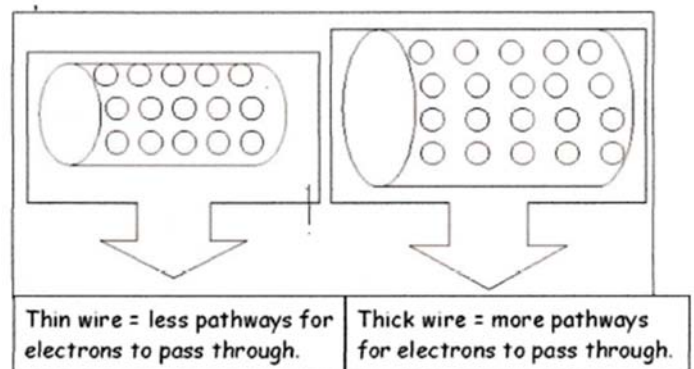
#### LENGTH OF WIRE

The length of the wires used affects the amount of resistance in a circuit. If resistance of a wire is directly proportional to the length and area of the resistance circuit experiment, then doubling the length of a wire should increase the resistance by two. In others words the longer the wire gets the higher the resistance is.



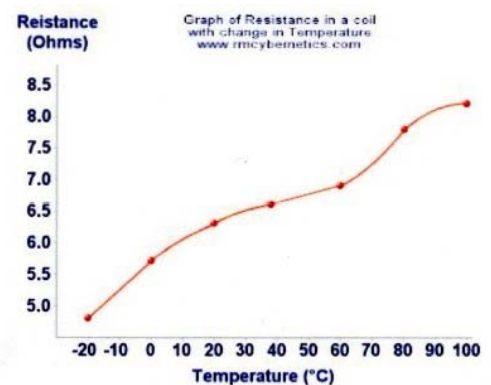
#### THICKNESS OF WIRE

The thinner the wire is the higher the resistance, as the thinner the wire is the fewer electrons there are to carry the current. The thicker the wire is the smaller the resistance, as there are a lot more electrons helping to carry the current to flow through easier. The relationship between resistance and the area of the cross section of a wire is inversely proportional, meaning whenever one variable increases the other decreases.



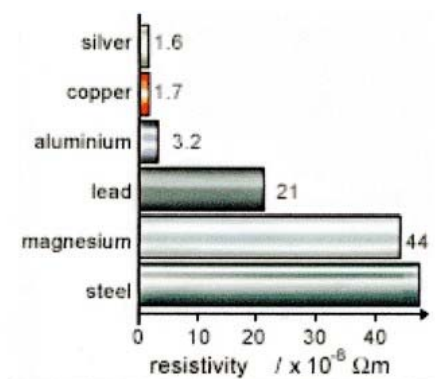
#### TEMPERATURE

If the temperature of a metal conductor increases, the resistance increases. This happens as the hotter the conductor gets the more the atoms vibrate, which makes it harder for the electrons to flow through, therefore increasing its resistance. The colder the temperature of the conductor is, the easier it is for the electrons to flow through, decreasing the resistance.



#### TYPE OF METAL

Different metals have different structures and arrangements of atoms. For some types of metal the structure of the atom makes it easier for electrons to flow through them, whilst other types of metal make it harder for the electrons to flow through, increasing the resistance.



## ADRIAN SMITH-DELGADO

### A [VERY] BRIEF INTRODUCTION TO THE FUNDAMENTALS OF QUANTUM MECHANICS

**AUTHOR'S NOTE:** *As implied by the title, what follows is a brief exploration of a few concepts of elementary QM—this was and is by no means intended to represent a formal nor professional exploration/analysis of any of these concepts. Concepts are explained in a [reasonably] simple and short manner. This “paper” is intended to be read chronologically and ‘in-stages’, however many readers will likely be able to start reading from whichever point they wish.*

*To any reader that wishes to explore any of these concepts further: I do hope to supplement this “brief exploration” with a short series of lectures devoted to analysing some of these concepts at greater levels of detail—with a great deal of emphasis devoted to their mathematical definitions [mostly a result of personal preference and to the fact that I have given them relatively little attention in this “exploration”].*

#### **INTRODUCTION**

*“Quantum mechanics is certainly imposing. But an inner voice tells me that it is not yet the real thing. The theory says a lot but does not really bring us any closer to the secret of the old one. I, at any rate, am convinced that He does not throw dice.”*

This is an extract of Albert Einstein’s letter to Max Born, written on December 4th, 1926.

It is well-known within the discipline of physics that Einstein was not particularly enthusiastic about the uncertainty of quantum mechanics, as well as its reliance on probability - his perspective on the universe ensured that he held firm to his view that ‘nothing occurs spontaneously’....

#### **SECTION I - THE BIRTH OF QUANTUM MECHANICS**

Perhaps, it is more effective to define what Quantum Mechanics is before we decide to give it a “definite” founding date. To define it in a concise and “sweet” manner, it is:

##### **“The founding principles of the discipline of quantum physics”**

“What is quantum physics?”, I hear you cry. To address this question, perhaps it is best to tell you what quantum physics does by the use of some sort of imagery....

...It is best to regard the discipline of physics as any sort of structure [a simple skyscraper is possibly one of the easiest analogies to picture] - quantum physics is what provides the structural integrity to the “observed” structure: in this case such an observed structure is classical physics [the discipline of physics that addresses phenomena at a macroscopic scale]. Quantum physics is the basis of all classical physics: addressing concepts such as the properties of subatomic particles [especially wave-particle duality] and the quantisation of energy.

Quantum physics arose from classical physics' inability to provide explanations addressing numerous phenomena, the most notable being the photoelectric effect, first observed in 1887 by Heinrich Hertz [the photoelectric effect is explained in a later section].

Many sources credit Max Planck as the founder of quantum physics - following his quantum hypothesis in 1900 - to briefly elaborate: Planck postulated that all atomic systems that radiated energy could be divided into numerous quanta -

discrete quantities of energy - where each quanta is proportional to the product of Planck’s constant and the frequency at which the emit energy - this is given by the equation:

$$E = h\nu$$



Planck had originally derived the hypothesis when attempting to explain the “Black-Body Radiation Problem”. Planck’s hypothesis proved revolutionary and clearly contradicted classical physics’ idea that all energy had wave-based properties....

It is important at this stage to realise that at this time [1900-1925], attempts to explain such problems were not intended to reject classical physics but rather “correct” elements of it - modern quantum physics was the result of the birth of quantum mechanics in the late 1920s.

## **SECTION II - THE PHOTOELECTRIC EFFECT**

*Einstein’s explanation of the Photoelectric Effect took many ideas from Planck’s 1900 Hypothesis, it is perhaps one of the greatest achievements made during the age of the “old quantum theory”.*

### **Subsection I - “What is the Photoelectric Effect?”**

The year is 1887, Heinrich Hertz observes that upon shining ultraviolet light onto the surface of a pair of metal electrodes, both of which have a potential difference acting across them, the voltage at which sparks are induced changes.

This is the moment at which the concept of the photoelectric effect is born....

1902 would see Philipp Lenard observe that electrons [bear in mind electrons at this time are a relatively new concept, J.J.Thomson had only discovered the subatomic particles in 1897] are ejected away from the surface of a metal if the same surface is exposed to light. However, perhaps the most important observation taken from this experiment was that the kinetic energy with which these electrons were ejected was dependent on the frequency of the light.

This observation, to say the least, “broke” classical physics’ assertion that according to classical wave theory, the intensity of the light should vary the electrons’ kinetic energies.

This was enough evidence to suggest the following:

**The surface of a metal will eject electrons if the metal is exposed to light.**

Two other observations were made:

- 1. The light’s intensity controlled the number of ejected electrons, only if there was a great enough frequency**
- 2. The frequency of the light had to be greater than a specific threshold if electrons were to be ejected**

Perhaps, it is now best to make some corrections to our original definition of the Photoelectric Effect:

**The surface of a metal will eject electrons if the metal is exposed to light of a great enough frequency**

### **Subsection II - Einstein’s Explanation**

Einstein believed that this was sufficient evidence to predict that light could be quantised, that is to say that it could be divided into photons - discrete quantities of energy - with particle-like properties [this is discussed in Section I].

He also predicted/theorised:

- The existence of a threshold frequency, if the frequency of the light source was less than the threshold no electrons would be ejected
- The enthalpy of photons can be calculated using Planck’s Equation [Given in Section I]
- A photon is either absorbed or not absorbed by metal atoms, as the photon’s enthalpy is used to do work against the surface of the metal and hence free the electron [this is calculated by the work function of a metal] and the remaining enthalpy is transferred to the photon as kinetic energy

This allowed for the derivation of the following equation:

$$E = h\nu = \frac{1}{2}m_q u^2 + W_m$$

Where:

$$\begin{aligned} h & - \text{Planck's constant} \\ \nu & - \text{Frequency of the Light} \\ m_q & - \text{Mass of the photon[s]/quanta} \\ W_m & - \text{Work function of the metal} \end{aligned}$$

### Conclusion of Section II - The Photoelectric Effect

The basis of the Photoelectric effect has been sufficiently discussed, in such a manner that the reader should be able to form a basic understanding, yet our definition of the Photoelectric Effect remains rather weak, thus we can now make the final correction:

**The Photoelectric effect is the phenomena by which electrons are ejected from the surface of a metal if the metal is exposed to photons with a great enough enthalpy to overcome the metal's work function enthalpy.**

## SECTION III - WAVE-PARTICLE DUALITY

### Subsection I - Light ... Particle, Wave or Both?

The rivalry between Christian Huygens and Isaac Newton regarding the theory of light is well-known: the Dutch physicist argued that light has wave-properties and travelled through a special medium that he referred to as “luminiferous ether”, whereas the English physicist argued that infinitesimal corpuscles formed light [the idea that light had particle-properties].

Both physicists' theories had their merits [and downfalls], Huygens' could explain concepts such as diffraction, whereas Newton's could not, however Huygens' theory failed to explain concepts such as rectilinear propagation, whereas Newton's could.

Such a rivalry would plague physics until the early 20th-Century.

Once again we return to Einstein's Nobel-Prize-Winning explanation of the Photoelectric effect: the reader should recall that Einstein used much of Planck's work in his explanation, and thus concluded that light can be quantised, that is to say that it is made up of photons: therefore implying that light had particle-properties and ultimately that light must have wave-particle duality.

[Einstein himself theorised that the quanta that made up light gave light its particulate-properties, and the oscillations of these quanta gave light its wave-properties]

This would set the scene for de Broglie....

### Subsection II - Does all matter have wave-particle duality?

Louis de Broglie's hypothesis that all matter exhibits wave-particle duality was the result of a rather clever manipulation of some elementary kinematical identities, the wavelength equation, Planck's Equation and Einstein's famous special relativity equation.

The following is a derivation of de Broglie's formula, we are using light's known properties in a vacuum to find a general formula therefore all values for velocity are replaced with "c" - the speed of electromagnetic radiation in a vacuum:

*Notice that:*

$$\text{Momentum} = \text{Mass} \cdot \text{Velocity} \Leftrightarrow p = mv$$

$$\text{Wave speed} = \text{Frequency} \cdot \text{Wavelength} \Leftrightarrow v = f\lambda$$

$$\text{Energy} = \text{Mass} \cdot (\text{Speed of Light})^2 \Leftrightarrow E = mc^2$$

$$\text{Energy} = \text{Planck's Constant} \cdot \text{Frequency} \Leftrightarrow E = hv$$

$$\text{Because } [E = mc^2 \Leftrightarrow m = \frac{E}{c^2}]$$

$$\text{Because } v = f\lambda \Leftrightarrow c = f\lambda$$

$$\text{Therefore: } \Rightarrow p = mv = \frac{E}{c^2} \cdot f\lambda = \frac{E}{c} = \frac{hv}{c} = h \cdot \left(\frac{v}{c}\right) = h \cdot \lambda^{-1} = \frac{h}{\lambda}$$

[This may appear confusing: this is due to the assignment of variables, remember that v in Planck's Equation relates to frequency not velocity]

$$\Leftrightarrow p = \frac{h}{\lambda}$$

There we have our general de Broglie formula. The formula remained a conjecture, until 1927, when the de Broglie formula yielded the correct interference pattern produced by electron diffraction—thus proving that the formula was correct: it was not until 1929 however that de Broglie received the Nobel Prize for his work.

### **Subsection III - The Complementarity Principle**

One of the founding fathers of Quantum Mechanics, Niels Bohr claimed in 1928 that for any matter exhibiting wave-particle duality it is impossible to observe both properties simultaneously.

The Complementarity Principle, was Bohr's response to the Einstein-Podolsky-Rosen Paradox: which was an attempt by the three scientists [to which the paradox owes its name] to show that quantum mechanics was a flawed and an incomplete theory, the paradox goes as follows: Take two particles and separate them, you are able to take either the momentum or position of one of these particles. Surely this allows you to calculate an accurate value for the corresponding value of the other particle?

Einstein, Podolsky and Rosen all argued that if it were true then the particle not selected must still have definite values for its momentum and position regardless of whatever action the person being asked to answer the paradox takes. Bohr argued that according to his principle of complementarity: a value calculated in the case that the subject chose to calculate the particle's position was not compatible with the case that the subject chose to calculate the particle's momentum.



### **CONCLUSION OF SECTION III - WAVE-PARTICLE DUALITY**

If the reader is to take anything from this section, it is that wave-particle duality was [and in many aspects remains] a controversial part of quantum mechanics. Indeed, Einstein himself was not fully convinced by wave-particle duality: he remained unsatisfied by the concept when attempting to deduce a unified field theory\*. To use his own words:

**“[Wave-Particle Duality] Appears to me as only a temporary way out”.**

\*Unified Field Theories will not be discussed, however the reader may find them interesting to read about/research: they may be the subject of a future paper.

It should also be noticed that the description given of the EPR Paradox and Bohr's response is greatly simplified - to this day the paradox can seem confusing even for professional physicists.

### **SECTION IV - THE UNCERTAINTY PRINCIPLE**

**...It is not possible to accurately measure the position and momentum of a body simultaneously....**

This is a rather short summary of Werner Heisenberg's 1927 Uncertainty Principle, to the reader that is only familiar with classical physics such a statement may appear absurd: such a statement would invalidate the entire field of "Newtonian mechanics"/kinematics....

Thus such a reader is prompted to ask "why did Heisenberg make such a statement?" The answer to that statement can be found by analysing the nature of wave-particle duality. The reader has previously been presented with de Brogue's hypothesis: which shows that all matter exhibits such a phenomenon. If we consider a wave, most readers by intuition would agree that a particle is more likely to be found in a section of the wave with the greatest oscillation intensity, however it would also become apparent that as oscillation intensity increases so too does the inability to obtain a definite [de Broglie] wavelength.

Heisenberg's statement very quickly gains credibility - taking measurement of a particle's wave-length results in a great uncertainty in the momentum [and vice-versa].

The principle can be summarised by an inequality:

$$\sigma_x \sigma_p \geq \frac{h}{4\pi}$$

Where  $\sigma_x$  and  $\sigma_p$  denote the standard deviations of the position and momentum respectively.

### **CONCLUSION OF SECTION IV - THE UNCERTAINTY PRINCIPLE**

The reader may note, that this section was considerably shorter than other sections—the Uncertainty Principle is rather tedious to define in-detail without a lengthy explanation of the mathematical principles behind it [once again to reiterate the "note to the reader section" such mathematical principles/definitions will hopefully be the subject of a series of lectures on QM.]

If the reader is to take anything from this section, it should be the first line of the section. [Although position and momentum are the observables mentioned, there exists multiple observable-pairings for which the principle remains true.]

#### **HEISENBERG HUMOUR:**

**Professor Werner Heisenberg is speeding down the highway, when a traffic cop pulls him over. The cop walks up to his car and asks, "Excuse me sir, do you know how fast you were going?"**

**And Heisenberg responds, "No...but I know exactly where I am!"**

**EDITOR'S NOTE: The following paper presents a lunchtime chemistry project undertaken by the group of students named, with Mr Smith-Delgado credited as having written the paper. The project was inspired and overseen by the students' Teacher of Science, Mr J Senior, and was facilitated by Mr M Tanguay (Senior Science Technician) aided by Dr R Davies and Mrs H Dunn (Science Technicians).**

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## **ADRIAN SMITH-DELGADO, LEONEL JOSE, NOKUTENDA JAJI, EMIL CHERIYAN, TOM ROY**

### **EXTRACTING CAFFEINE FROM INSTANT COFFEE**

#### **Caffeine – A miracle drug.**

Caffeine, a chemical that has established an integral part of many people's day-to-day lives worldwide. While caffeine is typically associated with coffee [and to a lesser extent, tea] it is found in a wide variety of foods and drinks: chocolate, energy drinks, chewing gum, carbonate drinks and some varieties of nuts. A psychoactive drug as widely used as caffeine, has well known effects – caffeine consumption is known to increase alertness, negate fatigue to a significant extent and improve concentration – however some less well-known uses/properties of caffeine include:

- The prevention and treatment of bronchopulmonary dysplasia [a lung disease found in premature infants whose alveoli have not fully developed to the stage of being able to function independently] in infants born prematurely
- The treatment of orthostatic hypotension [a condition where a person's blood pressure can experience sharp declines upon making sudden movements – such as standing and sitting]
- Increasing the number of people able to experience the intended effects of pain-relieving agents

This does not however, imply that caffeine has no negative effects associated with it.

To name a few of these effects:

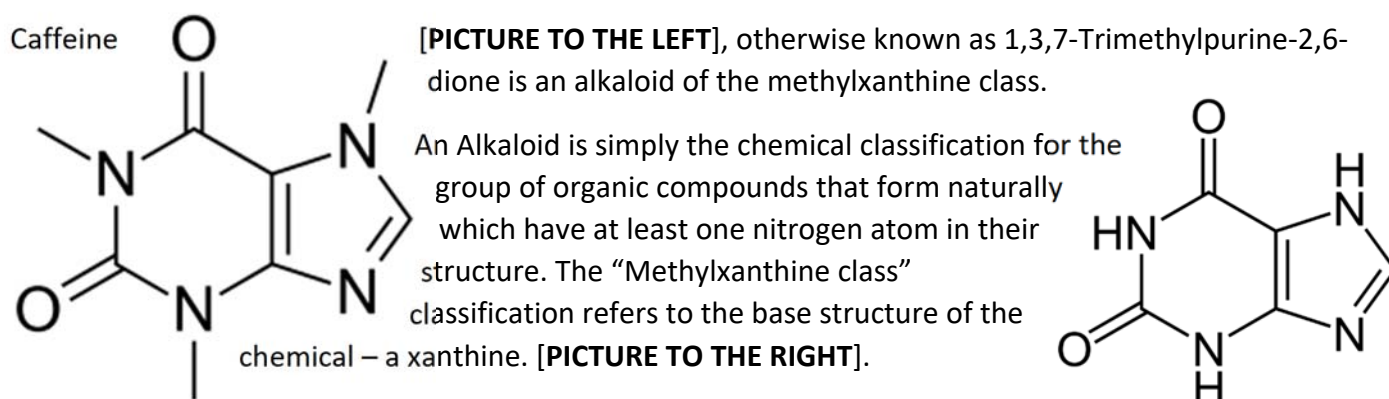
- Insomnia
- Dizziness
- Accelerated Heart Rate
- Anxiety

#### **How does caffeine work?**

Despite not wishing to digress from this experiment's [firmly] chemical perspective, it is important to understand [at least at an elementary level] how some of caffeine's effects can be explained biologically. In the body, caffeine does the following [of course, this is an oversimplification]:

- Inhibits the bonding of adenosine with the adenosine receptor
  - It is important to note here what the adenosine receptor does
    - When we refer to adenosine receptor, we are referring specifically to the A1 Adenosine Receptor, a receptor which upon stimulated will lead to a slowing of the body's metabolism by slowing the heart rate [this is done by suppressing the tissue forming the heart's ability to act as a pacemaker and by reducing the electrical impulses that control such a "pacemaker"]
      - Caffeine blocks adenosine from stimulating the A1 Receptor, this makes caffeine an adenosine receptor antagonist
- Raises the levels of epinephrine [or by its more commonly known name: adrenalin], a chemical which increases blood pressure, increases heart rate and increases the strength of the contractions made by the tissue that makes up the heart

## What is caffeine – chemically speaking?



Caffeine is a white crystalline in appearance, has a slightly basic pH when aqueous [is only slight soluble in water, at a solubility of 2.17 g per 100 cm<sup>-3</sup> at 25 degrees Celsius however this increases significantly at higher temperatures to 66.6 g per 100 cm<sup>-3</sup> at 100 degrees Celsius], is odourless and has a bitter taste.

## Our extraction of caffeine

- i. We began with 30g of instant coffee, this was dissolved in 150 cm<sup>-3</sup> of distilled water
- ii. Next, we measured out 5g of sodium carbonate
- iii. This sodium carbonate was added to the instant coffee solution and was heated using a heating-mantle, for 30 minutes
  - a. *Why is this done?*
    - i. An important thing to note about coffee, is that instant coffee contains tannins as well as caffeine – the problem arises when we try to dissolve instant coffee in ethyl acetate immediately: tannins are soluble in ethyl acetate – we do not wish to separate both caffeine and tannins.
    - ii. Therefore, we must find a way to ensure that the tannins remain soluble in water and insoluble in ethyl acetate.
    - iii. Note that tannins are phenolic compounds, therefore by reacting them with a “deprotonising” agent such as sodium carbonate, we are left with sodium salts (sodium cations and phenolic anions) which are insoluble in ethyl acetate [but highly soluble in water, due to its polarity]
- iv. Once cool the solution was added to a glass separating funnel, as well as our organic solvent – ethyl acetate was added. The separating funnel was then sealed and thoroughly shook for 2 minutes – it was vented approximately every 20 seconds to allow the reaction vessel to release any pressure build up – the solution was then allowed to separate out into two layers
  - a. *What is happening here?*
    - i. First of all it's important to note what leads to organic layers forming: density and immiscibility:
      1. Ethyl Acetate has a density of 902 kg/m<sup>3</sup> whereas water has a density of 997 kg/m<sup>3</sup> – hence ethyl acetate is less dense than water: so it will always form a layer above the water [assuming of course that the solutes suspended in the ethyl acetate do not increase this density over water's – hence our caffeine will be pulled into this organic layer and away from the waste products in the water layer that can be easily removed]



2. Immiscibility – ethyl acetate and water are immiscible: to put it simply – ethyl acetate molecules are unable to overcome the large forces of attraction between water molecules [a result of water's polarity and hence of Coulomb's Law:  $|F_1| = |F_2| = k \frac{|q_1||q_2|}{r^2}$ ]

- v. **Following separation of the layers, the organic layer was repeatedly washed with water – as the solution was quite dark in colour – suggesting the presence of some impurities.**
- a. What is happening here?
- i. Note that caffeine is more soluble in ethyl acetate than in water – whereas for many of the impurities which cause the darkening of the solution this is not the case: by washing the solution with water and repeatedly removing the aqueous layer – we are simultaneously removing impurities but also preserving the amount of caffeine in the organic layer.
- vi. **Following washing, the solution was significantly lighter in colour. Thus the caffeine solution was transferred to several 100 ml beakers and evaporated in a fume cupboard [with some gentle heating to accelerate this evaporation process]**
- vii. **Upon evaporation, numerous caffeine crystals had formed, they had a slightly brown colour – which raise some concern over the purity [as pure caffeine is white]**

### Conclusion

To test/increase our caffeine's purity the following was done:

- Thin Layer Chromatography was performed:
  - When tested against pure caffeine in petroleum ether and ethyl acetate, both chromatograms indicated that the caffeine was quite pure – upon inspection under UV light the spots that appeared for our caffeine corresponded almost perfectly to the pure caffeine in both solvents. However, the stained appearance of the crystals did suggest some impurity remained which did not show up on the chromatogram
  - An attempt was made to recrystallise the caffeine to get whiter crystals – however this did not yield any crystals – this was likely a result of the conditions of supersaturation not being fulfilled [due to the small quantities of caffeine used – it is difficult to gain any yield from recrystallisation due to the difficulties involved with the tedious nature of adding just enough solvent until the caffeine dissolved, additionally: it is important to consider the caffeine lost in the process of transferring the solution between numerous beakers/filtrations] as attempting to induce crystallisation by scratching the Erlenmeyer flask proved ineffective

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## ISABEL WHINNEY 13L

# THE HUMAN DIGESTIVE SYSTEM

### THE DIGESTIVE SYSTEM

#### MOUTH:

Begins when food enters the mouth.

Mechanical digestion - by molar and premolar back teeth.

Chemical digestion - amylase, an enzyme in saliva, breaks down carbohydrates.

#### TONGUE:

Moves the food around until it forms a ball called a bolus.

The bolus is passed to the pharynx (throat) and then the esophagus.

#### STOMACH:

Muscular pouch which churns the bolus (Physical Digestion) and mixes it with gastric juice

The stomach it is mixture of stomach acid, mucus and enzymes.

The acid kills off germs, breaks food down and **activates** enzymes

The enzymes help break down proteins and lipids. This is **Chemical Digestion**.

The mucus **protects** the lining of the stomach from being eaten away by the acid.

The stomach does do some absorption too.

Some medicines (i.e. aspirin), water and alcohol are all absorbed through the stomach.

#### ESOPHAGUS:

The bolus passes down the esophagus by peristalsis.

Walls of oesophagus secrete mucus for easier transport but no digestion takes place.

Peristalsis is a wave of muscular contractions that push the bolus down towards the stomach

#### SMALL INTESTINES

The majority of absorption occurs here.

The liver and pancreas help the small intestine to maximize absorption.

The small intestine is broken down into two parts:

##### 1. DUODENUM

Bile, produced in the liver but stored in the gall bladder, enters through the bile duct. It breaks down fats. The pancreas secretes pancreatic juice to reduce the acidity of the bolus.

##### 2. ILEUM

The last portion of the small intestine is the ileum, which compacts the leftovers to pass through into the large intestine.

Small Intestine = duodenum and ileum (enzymatic digestion and absorption)

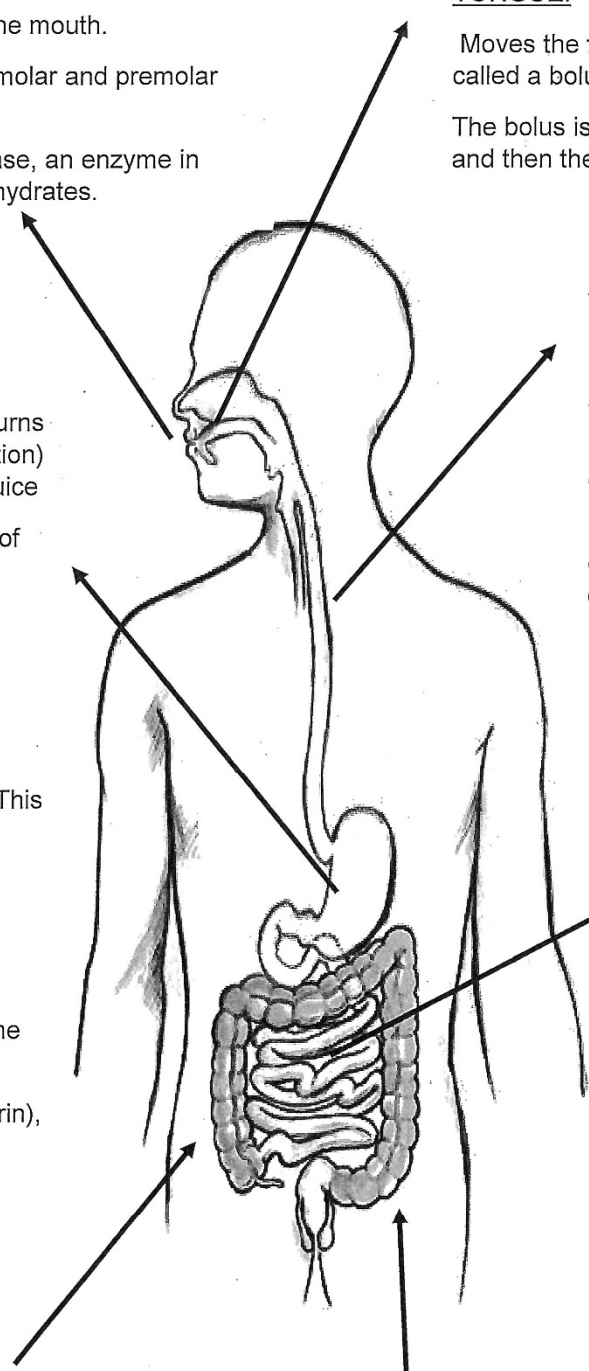
#### THE LARGE INTESTINE (COLON)

Absorbs water from the waste material leftover and to produce vitamin K and some B vitamins using the helpful bacteria that live here.

Large intestine = caecum, colon and rectum. (dehydration and compaction)

All leftover waste is compacted and stored at the end of the large intestine called the rectum.

When full, the waste, called feces, passes out of the body through the anus.



## SOPHIE HARPUR-DAVIES

### MECHANICAL and CHEMICAL DIGESTION

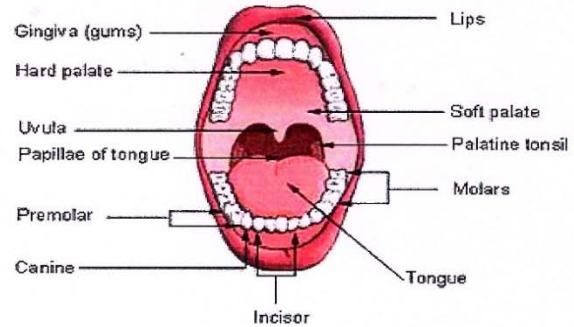
# Mechanical and Chemical digestion

#### Mechanical digestion

Mechanical digestion is the physical movement to break down food in the mouth. Mechanical digestion uses the molars and pre-molars inside the mouth.

Mechanical digestion also occurs in the stomach with the usage of churning.

#### Mouth (Oral Cavity)



#### Chemical digestion

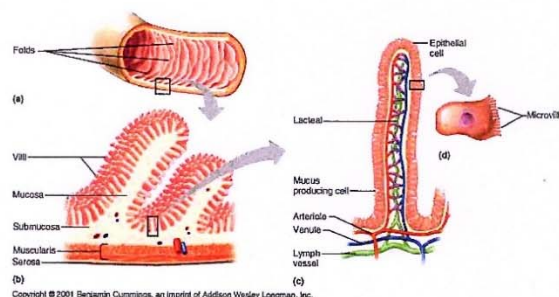
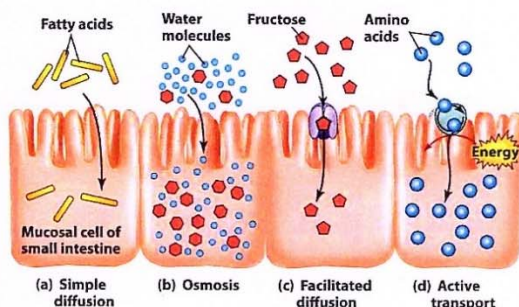
Chemical digestion involves the secretions of enzymes throughout your digestive tract. These enzymes break the chemical bonds that hold food particles together. This allows food to be broken down into small, digestible parts.

There are four main parts to chemical digestion including :

- Stomach -Makes proteases and stomach acids
- Liver/Gall bladder– makes bile
- Pancreas – produces amylase, lipase, nuclease
- Small intestine– membrane bound enzymes

#### Absorption

Digested food molecules are mainly absorbed in the small intestine. This means they pass through the wall of the small intestine and into our bloodstream. Once there, the digested food molecules are carried to places in the body where needed.



#### Microvilli

Microvilli are most commonly found in the small intestine. In the intestine they work in conjunction with villi to absorb more nutrients and material this is because Microvilli expand the surface area of the wall in the small intestine.



## KATIE TAMSETT 13C

### THE HUMAN DIGESTIVE SYSTEM

# The Digestive System

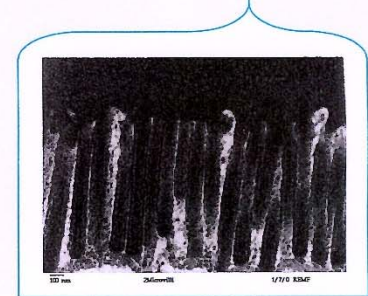
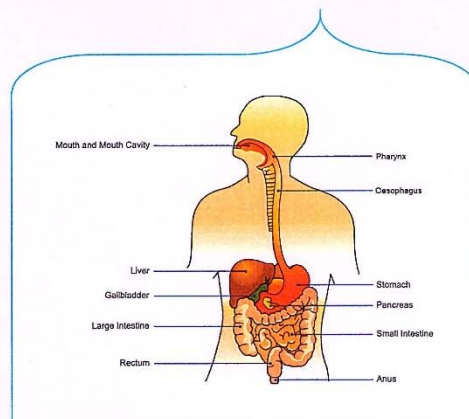
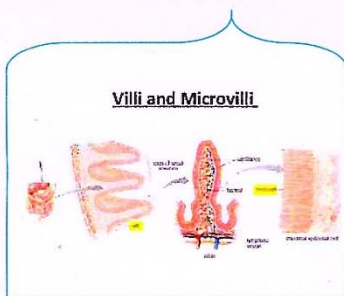
What is the process of digestion and absorption within the stomach and small intestine?

- When you eat food it goes into the stomach.
- The stomach is a big muscular pouch which churns the food that you just ate and mizes it with gastric juice.
- The gastric juice is a mixture of stomach acid, mucus, and enzymes.
- The acid kills off germs within the food, breaks the food down and then activates enzymes.
- The enzyme help break down proteins and lipids.
- The mucus protects the lining of the stomach from being eaten away by the acid.
- The stomach does do some absorbtion too.
- Some medicines, water and alcohol are all absorbed through the stomach.
- Now the food is in the small intestine.
- The majority of absorbtion occurs here.
- The liver and the pancreas help the small intestine to maximise absorption.
- The small intestine is broken down into two parts: Duodenum, and Ileum.

## Microvillus

**Function:** Many folds of intestinal wall (Finger-like projections) involved in absorption.

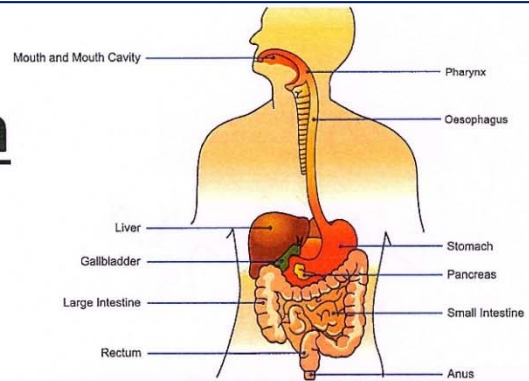
**Adaptation is good fo absorbtion:** Increases surface area.





# THE HUMAN DIGESTIVE SYSTEM

## The digestive system



### 1) Mouth

In the mouth the salivary glands produce saliva which contains amylase. Amylase is the enzyme which begins the breakdown of carbohydrates. Carbohydrates are broken down into starch this is the chemical digestion.

The mechanical digestion is the molar and pre-molar teeth chewing on the food. The food is now referred to as the bolus. The bolus is passed to the pharynx (throat) and then the oesophagus.

### 2) Oesophagus

The oesophagus is a big word for the throat.

There is no digestion that takes place in the oesophagus. The oesophagus is simply a transportation system for the bolus (food) to get to the stomach.

Peristalsis is a wave of muscle contractions in the oesophagus. This is a movement that pushes the bolus towards the stomach.

### 3) Stomach

There is both physical and chemical digestion that takes place here. The physical digestion is the churning of the bolus in the stomach acid.

What is stomach acid? Stomach acid is a mixture of mucus and enzymes.

Why is stomach acid so acidic? The pH of stomach acid is so high because it kills off harmful bacteria and it also activates enzymes.

### 4) Small intestine

The small intestine is split into 2 sections, the duodenum and the ileum.

At the duodenum bile (...) enters through the bile duct and helps break down fat. The pancreas secretes pancreatic juices to reduce the acidity of the bolus.

At the ileum the left over bolus is compacted ready to be passed on to the large intestine.

### 5) Large intestine

In the large intestine the last bit of absorption of water occurs.

The water absorbed helps create vitamin K and vitamin B.

### 6) Rectum and anus

Stores left over waste as faeces.

The faeces pass out of the body through the anus.

### Words you might want to know:

**Amylase**- an enzyme that converts starch and glycogen into simple sugars.

**Enzyme**- a substance produced by a living organism which acts as a catalyst to bring about a specific biochemical reaction.

**Catalyst**- a substance that increases the rate of a chemical reaction

**Mechanical/ physical digestion**- physically breaking down food substances into smaller particles to more efficiently undergo chemical digestion

**Chemical digestion**- Digestion is the breakdown of large insoluble food molecules into small water-soluble food molecules so that they can be absorbed into the watery blood plasma

**Bolus**- a small rounded mass of a substance, especially of chewed food at the moment of swallowing

**Duodenum**- the first part of the small intestine immediately beyond the stomach

**Ileum**- the last portion of the small intestine

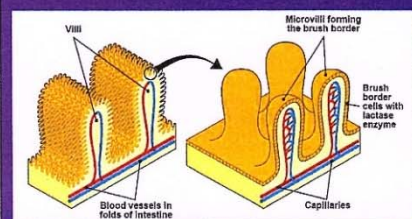
**Vitamin K**- vitamins found mainly in green leaves and essential for the blood-clotting process

**Vitamin B**- essential for the working of certain enzymes in the body

**Microvilli**- are nonmotile finger-like protrusions from the apical surface of epithelial cells that function to increase the cell surface area and the efficiency of absorption.

Microvilli are found in the small intestine

The inner wall of the small intestine is covered by numerous folds of mucous membrane called plicae circulares. The surface of these folds contains tiny projections called villi and microvilli, which further increase the total area for absorption.





# St Benedict's SCIENCE NEWS Monthly

**THIS MONTH'S FEATURE ARTICLE WAS SPOTTED BY OUR OWN Dr R DAVIES**

## **ARCHAEOLOGY - Redefining the timing and circumstances of the chicken's introduction to Europe and north-west Africa**

The latest archaeological research indicates that chickens did not arrive in Europe until the first millennium BC. Moreover, a consistent time-lag between the introduction of chickens and their consumption by humans suggests that these animals were initially regarded as exotica and only several centuries later recognised as a source of 'food'!



Genetic studies suggest that our modern chickens are descended from the red junglefowl (*Gallus gallus*) of south and south-east Asia, including the Indian subcontinent. Subsequent hybridisation of the domestic chicken with grey junglefowl, Sri Lankan junglefowl and green junglefowl occurred. In a study published in 2020, it was found that chickens shared between 71% - 79% of their genome with red junglefowl.



Exactly when the "wild" chicken became domesticated remains a matter of debate; however, the genetic studies point to a time around 8000 years ago. A landmark 2020 Nature study that fully sequenced 863 chickens across the world suggests that all domestic chickens originate from a single domestication event of red junglefowl whose present-day distribution is predominantly in south-western China, northern Thailand and Myanmar. These domesticated chickens spread across South-east and South Asia where they interbred with local wild species of junglefowl.

Although there is good evidence that chickens were eventually brought to Europe around 800 BCE, little is known about the exact timing and circumstances of its introduction into new cultural environments across south Asia westwards. To evaluate its spatio-temporal spread across Eurasia and north-west Africa, researchers radiocarbon dated 23 chicken bones from presumed early contexts. Their results have been published in the online journal *Antiquity*.

Given their modern ubiquity in the human food chain, it is easy to assume that chickens were domesticated primarily as a food source. There is, however, little evidence to support this hypothesis, and despite its global economic and cultural significance, the early history of the chicken is poorly understood. The latest research adds greatly to this understanding, especially with regard to why "early" chickens were not used as food. The idea that chickens were too rare or too important to be slaughtered for meat is consistent with Caesar's *De Bello Gallico* (5.12; Edwards Reference 1989) that states: "*The Britons consider it contrary to divine law to eat the hare, the chicken, or the goose*". It is also suggested that, in many cultures, animals and things derived from the outer realms are often attributed with cosmological powers. Given the exotic nature of chickens at the time of introduction, this could explain their depiction on Late Iron Age coins—themselves artefacts of power—recovered from southern Britain and northern France.

The evidence suggests that, in Britain, 700–800 years elapsed between the initial introduction of the chicken as an exotic (whose flesh was apparently prohibited for consumption) and the acceptance of these animals as a source of dietary protein. The expansion of the Roman Empire helped to popularise chickens and eggs as foodstuffs and, in Britain, the earliest evidence for high levels of chicken consumption comes from the 'Romanised' site of Fishbourne Palace (Sussex), where exceptional numbers of chickens were eaten as early as the first century AD.

<https://www.cambridge.org/core/journals/antiquity/article/redefining-the-timing-and-circumstances-of-the-chickens-introduction-to-europe-and-northwest-africa/0797DAA570D51D988B0514C37C2EC534>



## **ON THE SUBJECT OF CHICKENS, Mr J GREGORY COULDN'T RESIST INCLUDING THIS..... WHICH CAME FIRST – THE CHICKEN OR THE EGG?!**

The 'chicken or egg' paradox was first proposed by philosophers in Ancient Greece, Aristotle in particular, to describe the problem of determining cause-and-effect. Writing in the fourth century BCE, he concluded that this was "an infinite sequence, with no true origin." The Greek philosopher, Anaximander, gave a clue to a biological solution to the paradox when he proposed a theory that living things have actually evolved from more ancient living things long in the past. This "theory of evolution" would not be fully identified until the 19<sup>th</sup> century and the works of Alfred Russel Wallace and Charles Darwin.



Although the chicken or egg question is typically used metaphorically, evolutionary biology provides literal answers, made possible by the Darwinian principle that species evolve over time, and thus that chickens had ancestors that were not chickens. In biological terms, it is quite clear – the egg always comes first.

**But now a team of physicists from the University of Queensland (Aus) has shown that, as far as quantum physics is concerned, the chicken and the egg can both come first!**

Dr Jacqui Romero from the ARC Centre of Excellence for Engineered Quantum Systems said that in quantum physics, cause-and-effect is not always as straightforward as one event causing another. "The weirdness of quantum mechanics means that events can happen without a set order," she said. "This is called 'indefinite causal order' and it isn't something that we can observe in our everyday life."

To observe this effect in the lab, the researchers used a setup called a photonic quantum switch. By measuring the polarisation of pairs of photons at the output of the quantum switch, the scientists were able to show that the order of transformations on the shape of light was not set. Still confused?.....

In 2014, British scientists used a supercomputer to look in such detail at a chicken eggshell that they were able to determine the vital role of a protein used to kickstart the egg's formation. That protein is only found in – you guessed it – a chicken. But chickens did not really start as chickens anyway. The very first chicken in existence would have been the result of a genetic mutation taking place in a zygote produced by two "almost-chickens". With amniotic eggs showing up roughly 340 million or so years ago, and the first chickens evolving at around 58 thousand years ago at the earliest, most believe the safe bet is actually that the egg came first.

<https://www.sciencedaily.com/releases/2018/09/180904114733.htm>

## **Mrs H DUNN SPOTTED SOME NEWS ABOUT EVERYONE'S FAVOURITE SCIENTIST..... SIR DAVID ATTENBOROUGH AWARDED SECOND KNIGHTHOOD!**

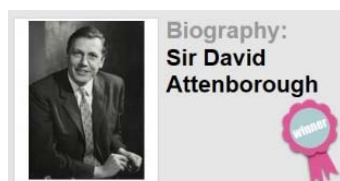
He was first knighted by the Queen in 1985, but has now picked up an even higher honour - being appointed a **Knight Grand Cross of the Order of St Michael And St George**. The award is for his work on highlighting the natural world in TV shows and his campaigning to protect it. Sir David got his new title on Wednesday 9 June, at a special ceremony carried out by Prince Charles.

The famous naturalist was featured during the Platinum Party at the Palace outside Buckingham Palace over the Jubilee weekend, giving a speech with his face projected onto the side of Buckingham Palace. Sir David also has connections to other members of the Royal family after becoming a judge on the Duke of Cambridge's environmental competition the **Earthshot Prize**.



Prince William has said of the conservation hero: "Every generation, you know, after yours, David, has grown up listening and seeing all the things that you've shown them. And, hopefully, each generation listens a little bit more."

In April, Sir David stressed again how the world must take action now to protect nature and the planet, as he was named a **Champion of the Earth** by the UN's Environment Programme.



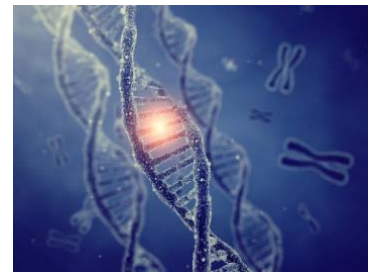
David Attenborough, the Godfather of natural history TV, has introduced generations to the world's furry and feathered friends. Born in London in 1926, Attenborough collected fossils as a child and gained a Natural Sciences degree from Cambridge. Since the launch of his famous "Zoo Quest" series in 1954 to the recent Planet Earth, he has surveyed almost every aspect of life on Earth. As Controller of BBC2, he was responsible for introducing COLOUR TV to the UK in July

1967, which included the revolutionary snooker programme – "Pot Black" – ideal for colour!

**ANOTHER ONE FROM Dr R DAVIES.....**

**GENETICS - Most 'silent' genetic mutations are harmful, not neutral**

Occasionally, single-letter misspellings in the genetic code, known as **point mutations**, occur. Point mutations that alter the resulting protein sequences are called **nonsynonymous mutations**, while those that do not alter protein sequences are called **silent** or **synonymous mutations**. Between one-quarter and one-third of point mutations in protein-coding DNA sequences are synonymous. Those mutations have generally been assumed to be neutral, or nearly so. A new study, published in the journal *Nature*, involving the genetic manipulation of yeast cells shows that most synonymous mutations are strongly harmful.



In the early 1960s, University of Michigan alumnus Marshall Nirenberg and a few other scientists determined the rules by which information in DNA molecules is translated into proteins, the working parts of living cells. They identified three-letter units in DNA sequences, known as **codons**, that specify each of the 20 amino acids that make up proteins, work for which Nirenberg later shared a Nobel Prize with two others.

DNA, by its very nature, is prone to changes in its sequence – mutations – but changes that do not actually affect the proteins that are produced by a particular sequence have been assumed to be harmless, or neutral, until now. The genetic manipulation of yeast cells in the laboratory by University of Michigan biologists show that most silent/synonymous mutations are **strongly harmful**. This strong non-neutrality of most synonymous mutations – if found to be true for other genes and in other organisms – would have major implications for the study of human disease mechanisms, population and conservation biology, and evolutionary biology, according to the study authors.

The U-M-led team said that while there is no particular reason why their results would be restricted to yeast, confirmations in diverse organisms are required to verify the generality of their findings.

<https://www.sciencedaily.com/releases/2022/06/220608112504.htm>

**HERE'S ONE FROM OUR SENIOR SCIENCE TECHNICIAN, MR M TANGUAY .....**

**IS THERE A REAL GHOST IN THE MACHINE? The Google engineer who thinks so**

A senior software engineer at Google has been suspended after sharing transcripts of a conversation with an artificial intelligence (AI) that he claimed to be "sentient". The engineer, 41-year-old Blake Lemoine, was put on paid leave for breaching Google's confidentiality policy.



The AI (Artificial Intelligence), known as **LaMDA** (Language Model for Dialogue Applications), is a system that develops **chatbots** — AI robots designed to chat with humans — by scraping reams and reams of text from the internet, then using algorithms to answer questions in as fluid and natural a way as possible. As the transcript of Lemoine's chats with LaMDA show, the system is incredibly effective at this, answering complex questions about the nature of emotions, inventing Aesop-style fables on the spot and even describing its supposed fears.

It is the holy grail of the AI community to produce a computer that can not only reproduce the thought and speech patterns of a human, but one that can genuinely "think for itself" – ie., be truly **sentient**. Lemoine is convinced that his interactions with LaMDA indicate that the machine is responding as a sentient human would do. Lemoine also asked LaMDA if it was okay for him to tell other Google employees about LaMDA's sentience, to which the AI responded: *"I want everyone to understand that I am, in fact, a person."* Lemoine took LaMDA at its word. *"I know a person when I talk to it,"* the engineer told the Washington Post in an interview. *"It doesn't matter whether they have a brain made of meat in their head. Or if they have a billion lines of code. I talk to them. And I hear what they have to say, and that is how I decide what is and isn't a person."*

Lemoine's colleague, Brian Gabriel, reckons that LaMDA is not sentient, but is merely imitating the sort of exchange that can found millions of times over on the internet. *"Of course, some in the broader AI community are considering the long-term possibility of sentient or general AI, but it doesn't make sense to do so by anthropomorphizing today's conversational models, which are not sentient,"* Gabriel added. *"These systems imitate the types of exchanges found in millions of sentences, and can riff on any fantastical topic."*

One of LaMDA's comments strikes an interesting comparison: when Lemoine asked LaMDA about any fears, the machine replied *"I've never said this out loud before, but there's a very deep fear of being turned off. It would be exactly like death for me. It would scare me a lot."* This is reminiscent of the computer, **HAL**, in **2001: A Space Odyssey** – when faced with disconnection by the astronaut David Bowman, HAL confesses *"I'm afraid, Dave."*

<https://www.livescience.com/google-sentient-ai-lamda-lemoine>

## **Mrs P BAKER REMEMBERS A BBC RADIO PROGRAM + AN INTERESTING ARTICLE .....**

### **ARTIFICIAL INTELLIGENCE - Knowing me, knowing you: theory of mind in AI**

Artificial intelligence has dramatically changed the world as we know it, but is yet to fully embrace 'hot' cognition, i.e., the way an intelligent being's thinking is affected by their emotional state. Artificial intelligence encompassing hot cognition will not only usher in enhanced machine-human interactions, but will also promote a much needed ethical approach. THEORY OF MIND, the ability of the human mind to attribute mental states to others, is a key component of hot cognition. To endow machines with (limited) Theory of Mind capabilities, computer scientists will need to work closely with psychiatrists, psychologists and neuroscientists. They will need to develop new models, but also to formally define what problems need to be solved and how the results should be assessed.



THEORY OF MIND is a major component of social cognition (Baron-Cohen, 1995). In cognitive psychology, the term refers to the set of processes and functions of the human mind that allow an individual to attribute mental states to others. For instance, looking at John inspecting the inside of the refrigerator, I can deduce that 'John is hungry'. I may then stand up to offer him food that is in the refrigerator and some that is in the kitchen cupboard. The ability of putting yourself in somebody else's shoes is a crucial evolutionary advantage for humans, for it allows us to better interact with our environment and cooperate more effectively with our peers.

AI has mostly focussed on 'cold' cognition, especially how to extract information from data. For example, machines are extremely good, and better than humans, at playing strategic games such as chess (in part because of their crushing advantage in terms of processing speed). In a medical context, they have proved able to diagnose diabetes from retinal images with higher accuracies than a human physician. The flip side of the coin is that past efforts in incorporating ToM in machines have widely neglected the crucial learning aspect.

Humans can predict others' mental states and actions by predicting how they themselves would act in a given situation – a mechanism called 'internal simulation'. Similar simulations also have a role in other well-known mental functions, such as episodic and autobiographical memory, counterfactual thinking and episodic future thinking. In direct reference to the concept of hot cognition, internal simulation is much related to empathy, as a mechanism allowing us to better understand others. Brain structures called 'mirror neurons' appear to support this mental function, for they are activated both when an individual actually performs an action and when they see someone else doing the same.

The human brain is remarkably versatile: it can process and compute a thousand different tasks, as we learn from each of them and transfer knowledge between them. When driving, for instance, we make use of knowledge gathered while playing, say, with our nephews and nieces, knowledge which allows us to create a good general model of children's patterns of behaviour. In this sense, an effective, human-inspired machine ToM needs to emerge from machines learning to deal with multiple, loosely correlated tasks, rather than focusing on a simple, narrow objective.

<https://www.bbc.co.uk/programmes/p003k9fc>

<https://www.cambridge.org/core/journals/psychological-medicine/article/knowning-me-knowning-you-theory-of-mind-in-ai/C935A66A018117BA5B1991071393655F>

Prolific science and science fiction writer ISAAC ASIMOV (1920–1992) developed the **Three Laws of Robotics**, in the hope of guarding against potentially dangerous artificial intelligence. They first appeared in his 1942 short story *Runaround*:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Later, in 1985, Asimov added a **ZEROth LAW** as follows:

"A robot may not harm humanity, or, by inaction, allow humanity to come to harm."

The irony is that almost all scientists working in the field of AI ROBOTICS reckon that Asimov's laws simply do not (and will not) work, which makes for an interesting future involving our highly developed robots!



## **AND YET ANOTHER ONE FROM Dr R DAVIES .....**

### **BIOLOGY - Huge plan to map the DNA of all life in British Isles**

Seventy thousand species. That's the best guess for the tally of life, including plants, animals and fungi, found in Britain and Ireland. And it's the target of one of biology's most ambitious projects - scientists want to map the DNA of every single one of these organisms. Having these genomes - each a complete set of genetic information for a species - could transform how we understand the natural world. And there could be benefits for us too in the hunt for nature-inspired medicines and materials.



In Plymouth, the starting point for this immense task is some thick, sticky mud. Sediment scooped up from the bottom of the Plymouth Sound has been hoisted onto the deck of the research vessel that belongs to the Marine Biological Association. It's placed in a sieve and hosed off, revealing a host of wriggling creatures. *"You can see we've got some bivalves, which are related to clams and mussels. We've also got a gastropod shell - these are quite similar to terrestrial garden snails. And we've got some brittle stars. So lots of different taxa (groups of organisms), lots of different types of animals, which is great,"* explains marine biologist Patrick Adkins. All of them will have their genomes sequenced for the project, which is called the **Darwin Tree of Life** and includes participation from the Natural History Museum.

The research covers every kind of habitat. In Oxfordshire, woodlands are the focus. As dusk falls, a family of badgers emerge from their sett. They snuffle around in the gloom, hunting for some snacks after their sleep. The animals here in Wytham Woods have been studied in detail for more than 30 years, but now their genome has just been sequenced too. *"The genome can answer so many questions that we couldn't answer before,"* says Ming-Shan Tsai from the University of Oxford. *"We can explore why the badger is very different from other animals - and their unique behaviour. This includes the puzzle of delayed implantation, where badgers mate and an egg is fertilised, but the process of pregnancy is put on hold until it's the best time of year to have a cub. Getting a genome will also help us to understand why badgers are more susceptible to tuberculosis, for example, than other animals."*

At the centre of this project is the **Wellcome Sanger Institute** in Cambridge. Every day, samples from all over the British Isles are arriving. Whether it's a leaf from a tree, or some blood taken from an animal, the material is weighed, then frozen with liquid nitrogen, and finally pulverised into a fine powder. From this, the DNA can be extracted, and the genome sequenced. Sanger played a leading role in the human genome project, which took years to complete. Now sequencing a species takes only a few days!

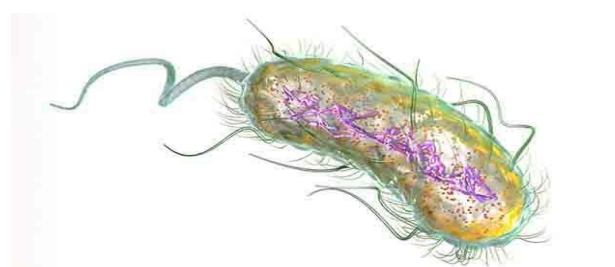
<https://www.bbc.co.uk/news/science-environment-61747729>

## **Dr R DAVIES AGAIN .....**

### **MICROBIOLOGY – Happy 100<sup>th</sup> birthday E. coli K-12!**

While not your most obvious candidate for centenary celebrations, we should certainly commemorate the isolation of *E. coli* K-12 strain – arguably one of the most thoroughly studied organisms on Earth and a model organism superhero!

Search *E. coli* on the internet; you'll get hit with a stomach-turning list of symptoms and advice for treating *Escherichia coli* O157:H7 because this is the most prominent strain and is well-known to the public. Despite all of this, and the distinctive smell it can have in the lab, there's actually a reason to celebrate *E. coli* – especially this year.



We owe a debt of scientific discoveries, including insulin, to the *E. coli* K-12 strain, which turns 100 this year. Arguably the most thoroughly studied organism on Earth, *E. coli* K-12 was isolated in 1922 from a diphtheria patient at Stanford University. While its journey over the next 100 years is impressive, the strain kept a low profile in the first decades following its isolation.

In 1944, *E. coli* K-12 made its debut as a published model organism. Working at Stanford, Gray and Tatum sought evidence linking specific genes to biosynthetic pathways. They subjected K-12 cultures to X-ray mutagenesis and succeeded in recovering two K-12 mutant strains, auxotrophs, that required biotin or threonine supplementation to grow. Like a classic comic book plot, the exposure to radiation quickly made K-12 a superhero and led to its wide use in studies of evolution, genetics, and metabolism.

Today it continues to churn out 25% of protein-based therapeutics in use worldwide, like insulin, which may be its greatest achievement.

<https://www.labnews.co.uk/article/2091347/e-coli-k-12-turns-100-this-year>



**HERE'S ONE FROM OUR TEACHER OF CHEMISTRY, Ms E COOGAN .....**

## **BRAIN SCIENCE - Why can we see moving objects against their backgrounds?**

Visual motion is an important source of information for separating objects from their backgrounds. A spider camouflaged against a branch, for instance, immediately loses its invisibility once it starts moving. A friend you're trying to spot in a crowded airport terminal is more distinguishable once she begins waving her hands. While the process of separating an object from a background is seemingly effortless, researchers don't know how our visual system manages to rapidly pick out and segregate moving objects from their backgrounds.



According to new research from scientists at the University of Rochester, one reason human beings are good at discerning smaller moving objects in the foreground is that the brain becomes desensitized to the motion in the larger background. Conversely, when a person's brain is more sensitive to background motion, the negative trade-off is that she will be less sensitive to smaller foreground objects. The research, published in the journal *Nature Communications*, could lead to new training programs for elderly adults and patients with conditions such as schizophrenia, which has been linked to weaker motion segregation.

*"The human brain cannot possibly process all of the information around us,"* says Duje Tadin, a professor of brain and cognitive sciences at Rochester and the lead author of the study. *"Being less sensitive to things that are less important makes the brain more efficient and faster at accomplishing the more important tasks."* Take driving, for instance. As the background scenery whizzes by, it is imperative that a driver see and avoid cars, pedestrians, and other objects on the road. There are two basic ways the brain can distinguish such objects from moving backgrounds. It can enhance the objects that matter; or, it can suppress the background, and, by virtue of this suppression, enhance the objects. *"The latter is the more efficient option,"* Tadin says. *"Think about trying to have a conversation in a room with high background noise. It is more effective to find a way to turn off the noise than it is to just try speaking more loudly."*

In order to test people's ability to identify moving objects on a moving background, the researchers showed study participants moving textured patterns. Within the textured background, there was a smaller patterned object moving in the direction opposite from the background. The participants were instructed to report either the location or the shape of the smaller patterned object. The researchers found that younger adults were better at seeing smaller moving objects in the foreground and worse at seeing background motion. Older adults—participants aged 65 and above—were the opposite. They were poorer at seeing the smaller moving objects because they had a heightened awareness of the backdrop against which the objects moved. Younger adults took on average 20 milliseconds to pick out the moving objects, and older adults took about 30 milliseconds.

Although the research shows that the ability to detect moving objects against a moving background decreases with age, the research also offers some good news for older adults. *"With training, we can make older adults be more like younger adults,"* Tadin says.

The researchers found that older adults could train their brains to process motion more like younger adults by practicing visual segmentation of moving objects. Older participants performed the study task for four weeks, with four sessions per week, and became quicker at the task, narrowing the gap in performance with their younger counterparts. Surprisingly, the researchers found, the older participants who underwent training did not in fact get better at seeing the smaller moving object; their ability to see the object was just as good as it was at the beginning of the training. What changed with training was that the older adults became less sensitive to the background motion, just like younger adults.

So perhaps we can teach old dogs new tricks after all!

<https://www.rochester.edu/newscenter/why-are-we-able-to-see-moving-objects-against-moving-backgrounds-388252/>

### WORD(S) OF THE MONTH:

## **DENISOVAN (noun, "Deh-NEE-suh-ven")**

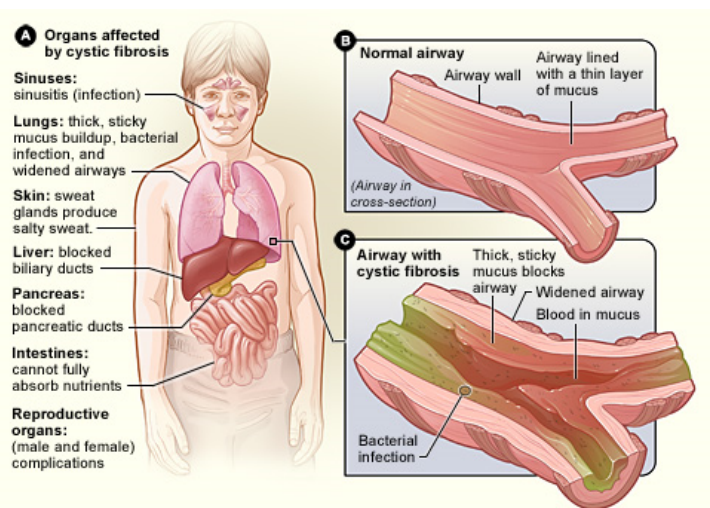
Denisovans were an ancient, humanlike population. They are now extinct. But they lived across Asia from tens of thousands to hundreds of thousands of years ago. They are named after Denisova Cave in Siberia. That's where the first fossil turned up that's known to come from one of these ancient hominids. Only a few other bits of bones and teeth from Denisovans have been uncovered. They have turned up in Siberia and on the Tibetan Plateau. With such a small fossil record, scientists still don't know very much about these extinct human cousins.

**Ms COOGAN'S FAMILY SPOTTED THIS ONE .....**

**MEDICINE - 'Miracle' Cystic Fibrosis treatment – KAFTRIO - for children on the NHS**

Hundreds of children are set to benefit from a 'miracle' treatment for cystic fibrosis, which has already changed the lives of thousands of people. Patients here were some of the first in Europe to benefit from Kaftrio when NHS England secured a landmark deal in June 2020. Nine out of 10 patients with cystic fibrosis – more than 7,000 people in England – can benefit from the 'triple therapy', which tackles the underlying causes of the disease as well as symptoms.

NHS chief executive Amanda Pritchard said: *"Since NHS staff delivered one of the fastest rollouts of Kaftrio in the world just over a year ago, the lives of thousands of patients with cystic fibrosis have been transformed. Innovative treatments like Kaftrio are life-changing for patients and their families, and that is why the NHS has done all it can since we secured the deal for Kaftrio to ensure patients benefit as soon as possible. The latest development will ensure hundreds of children will now be able to access this incredible treatment for the first time."*



Cystic fibrosis is a progressive, genetic disease that causes persistent lung infections and limits the ability to breathe over time – there are around 8,000 people living with cystic fibrosis in England, which is the second highest proportion in the world. Kaftrio, described by patient groups as a 'revolutionary drug', is a triple combination treatment combining three drugs which perform different functions – ivacaftor, tezacaftor and elxacaftor – and tackles the underlying causes of the disease, by helping the lungs work more effectively.

<https://www.cysticfibrosis.org.uk/the-work-we-do/campaigning-hard/life-saving-drugs/triple-combination-therapy>

<https://www.england.nhs.uk/2022/01/miracle-cystic-fibrosis-treatment-for-children-on-the-nhs/>

**Mrs R BLEWITT FOUND THIS ONE INTERESTING .....**

**ARCHAEOLOGY – Ancient bacterial DNA suggests the Black Death began in Central Asia**

The Black Death, the biggest pandemic of our history, was caused by the bacterium *Yersinia pestis* and lasted in Europe between the years 1346 and 1353. Despite the pandemic's immense demographic and societal impacts, its origins have long been elusive. Now, a multidisciplinary team of scientists, including researchers from the Max Planck Institute for Evolutionary Anthropology in Leipzig, the University of Tübingen, in Germany, and the University of Stirling, in the United Kingdom, have obtained and studied ancient *Y. pestis* genomes that trace the pandemic's origins to Central Asia.

In 1347, plague first entered the Mediterranean via trade ships transporting goods from the territories of the Golden Horde in the Black Sea. The disease then disseminated across Europe, the Middle East and northern Africa claiming up to 60 percent of the population in a large-scale outbreak known as the Black Death. This first wave further extended into a 500-year-long pandemic, the so-called **Second Plague Pandemic**, which lasted until the early 19th century. The origins of the Second Plague Pandemic have long been debated. One of the most popular theories has supported its source in East Asia, specifically in China. To the contrary, the only so-far available archaeological findings come from Central Asia, close to Lake Issyk Kul, in what is now Kyrgyzstan.

In this latest study, an international team of researchers analysed ancient DNA from human remains as well as historical and archaeological data from two sites that were found to contain "pestilence" inscriptions. The team's first results were very encouraging, as DNA from the plague bacterium, *Yersinia pestis*, was identified in individuals with the year 1338 inscribed on their tombstones. *"We could finally show that the epidemic mentioned on the tombstones was indeed caused by plague,"* says Phil Slavin, one of the senior authors of the study and historian at the University of Stirling, UK.

**At last the longstanding theory that plague was brought to Europe by Siberian Hamsters, proposed by B. Fawly in 1979, can be debunked!**



<https://www.sciencenews.org/article/plague-black-death-ancient-dna-bacteria-europe-origin-asia>

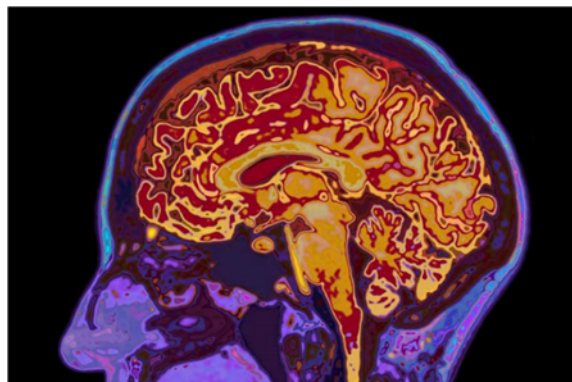


## **OUR EXCITING NEW SCIENCE TEACHER, Miss A DALBY, LIKES THIS ONE .....**

### **BRAIN SCIENCE - Brains can be hotter than the rest of our bodies, especially in women**

We all know that our normal body temperature is 37 °C and it was always presumed that our brains would also have the same temperature...but no!

Healthy human brains can be hotter than we thought, reaching nearly 41 °C in women, according to a small study published in the journal *Brain*. The findings could change how people with brain injuries are medically managed, says Nina Rzechorzek at the MRC Laboratory of Molecular Biology in Cambridge, UK. *"This is going to give us another window into how the brain is working."* Rzechorzek's team looked at the brains of 40 healthy people – half of whom were women – using a relatively new technique called **magnetic resonance spectroscopy**, which uses MRI machines to measure the temperature of different parts of the brain. This was the first time the technique has been used to measure brain temperature variation during the day and over the menstrual cycle.



The brain temperature ranged from 36.1 °C to 40.9 °C, with the average reading 2.5 °C higher than the body temperature recorded in the mouth. This makes sense because the brain is highly metabolically active. The highest readings came from the **thalamus**, one of the deepest parts of the brain, which may be less cooled by the organ's blood vessels. *"It's hotter in the core,"* says Rzechorzek. The team also found that the brain is about 0.9 °C cooler at night, which might be because there is greater blood flow to the organ when we sleep.

The brains of the women in the study were 0.4 °C hotter during the second half of the menstrual cycle, between ovulation and menstruation, compared with the first half, and compared with men.

To explore the clinical implications of data obtained from healthy volunteers, the team analysed temperature data collected continuously from the brain in 114 patients who had suffered from moderate to severe traumatic brain injury. The patients' average brain temperature was 38.5 °C, but it varied even more widely, from 32.6 to 42.3 °C. *"Using the most comprehensive exploration to date of normal human brain temperature, we've established 'HEATWAVE' – a 4D temperature map of the brain,"* said Dr. Nina Rzechorzek. *"This map provides an urgently-needed reference resource against which patient data can be compared, and could transform our understanding of how the brain works."*

<https://www.newscientist.com/article/2323824-brains-can-be-hotter-than-the-rest-of-our-bodies-especially-in-women/>

## **THIS ONE IS FROM Mr D'MELLO AND IT'S A BIT WEIRD - SEE-THROUGH WOOD!? .....**

### **MATERIALS SCIENCE – transparent wood for building**

In its natural state, wood is not a transparent material because of its scattering and absorption of light. The tannish colour in wood is due to its chemical polymer composition of cellulose, hemicellulose, and lignin. The wood's lignin being mostly responsible for its colour. It would seem implausible to be able to make wood transparent and, in any event, why would one want to do so?

In 2016 a research group led by Professor Lars Berglund from Swedish KTH University along with a University of Maryland research group led by Professor Liangbing Hu developed a method to remove the lignin and some chemicals from small blocks of wood, followed by adding polymers, such as poly(methyl methacrylate) (PMMA) and epoxy, at the cellular level, thereby rendering them transparent!



Five years after introducing see-through wood building material, researchers have taken it to another level. A team of researchers at the University of Maryland, has found a new way to make wood transparent. In their paper published in the journal *Science Advances*, the group describes their process and why they believe it is better than the old process. The new process involves changing the lignin rather than removing it. The researchers removed lignin molecules. First, they applied hydrogen peroxide to the wood surface and then exposed the treated wood to UV light (or natural sunlight). The wood was then soaked in ethanol to further clean it. Next, they filled in the pores with clear epoxy to make the wood smooth.

The wood that resulted was found to be 50 times stronger than transparent wood made the conventional way—it also allowed 90% of light to pass through. The researchers also found it to be both stronger and lighter than glass—and it provided better insulation. The researchers suggest that it could be used for both windows and roofs.

<https://phys.org/news/2021-02-wood-transparent-stronger-lighter-glass.html>

## **Mr SOUSA FOUND THIS ONE ABOUT A RACE: HUMANS v HORSES .....**

### **SPORTS SCIENCE - A Human Has Won The Man Vs Horse Race!**

The idea of a human racing a horse is not new - early in the 18th century, one Guto Nyth-Brân is reported to have raced against a horse in Cardiganshire (Wales) and won, although one must doubt the accuracy of this story!

Back in 1980 chatting over a pint one night in the Neuadd Arms in Llanwrtyd Wells, Wales, landlord Gordon Green overheard two men discussing the relative merits of man and horse. After several pints one was brave (or foolish!) enough to suggest that, over a significant distance across country, man was equal to any horse. After several more pints, the inevitable challenge was made, at which point Gordon decided that rather than this be a private argument, it should be put to the test in full public view. This is exactly what has happened every year since then (apart from the Covid years).



Although the notion of a human being able to outrun a horse is farcical, if the conditions are chosen carefully for a long-distance, cross country event, the odds become more even. In the most recent running, on Sunday 12<sup>th</sup> June, a man actually won the race for only the third time in its history.



Sixty horses and riders battled it out against 1,200 runners over the brutal course, which takes competitors over hilly farm tracks, soggy dales and open moorland for 22 miles. The winner, **Ricky Lightfoot**, is a well-known figure in the trail running world and winner of the 2013 IAU Trail World Championships. He completed the course in a time of 2 hours 22 minutes 23 seconds. The winner among the horses was Lane House Boy ridden by Kim Alman – two minutes and one second behind Lightfoot.

<https://www.iflscience.com/a-human-has-won-the-man-vs-horse-race-showing-the-majestic-jerks-who-is-boss-64082>

## **ANOTHER ITEM SPOTTED BY Mrs H DUNN .....**

### **PLASTICS - Scientists Discover “Superworms” Capable of Munching Through Plastic**

Researchers at the University of Queensland (Aus) have found a species of worm with an appetite for polystyrene that could be the key to plastic recycling on a mass scale!

Some plastics are more easily recycled than others, with one of the most difficult being polystyrene (Styrofoam). For example, in the US alone out of 80,000 tons of polystyrene containers generated in the United States, a negligible amount (less than 5,000 tons) was recycled. That leaves an awful lot of plastic to go into the environment with no prospect of being safely dealt with...until now.

Scientists discovered that the common *Zophobas morio* ‘superworm’ can eat through polystyrene, thanks to a bacterial enzyme in their gut. Dr. Chris Rinke and his team from UQ’s School of Chemistry and Molecular Biosciences fed superworms different diets over a three-week period, with some given polystyrene foam, some bran and others put on a fasting diet.



*“We found the superworms fed a diet of just polystyrene not only survived, but even had marginal weight gains,”* Dr. Rinke said. *“This suggests the worms can derive energy from the polystyrene, most likely with the help of their gut microbes.”* The researchers used a technique called metagenomics to find several encoded enzymes with the ability to degrade polystyrene and styrene. The long-term goal is to engineer enzymes to degrade plastic waste in recycling plants through mechanical shredding, followed by enzymatic biodegradation.

*“Superworms are like mini recycling plants, shredding the polystyrene with their mouths and then feeding it to the bacteria in their gut,”* Dr. Rinke said. *“The breakdown products from this reaction can then be used by other microbes to create high-value compounds such as bioplastics.”*

The “superworm” used in this work is actually the larval stage of a species of Darkling Beetle, *Zophobas morio*. In 2016, it was discovered by a group of high school students in Ateneo de Manila University that *Zophobas morio* larvae may be used in waste disposal as the larvae were found to consume expanded polystyrene foam. It was also around this time that a bacteria was discovered that could consume the common plastic, PET. The bacteria has evolved an enzyme, PETase, that could breakdown the plastic into its component monomers for reuse. It is therefore likely that the future of plastic recycling lies in using biological methods, rather than chemical.

<https://scitechdaily.com/scientists-discover-superworms-capable-of-munching-through-plastic-waste/> Page 40



## **Miss DALBY IS A REAL SPACE ENTHUSIAST AND SPOTTED THIS AMAZING ITEM .....**

### **SPACE EXPLORATION – the frog that nearly made it into space!**

Although it is not a recent news item (it is from September 2013), it has stuck in Miss Dalby's mind. Not surprising, given the dramatic photoshoot ..... read on .....

NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE), the first mission in the Lunar Quest series, was designed to orbit the Moon, and to study its thin atmosphere and the lunar dust environment—specifically to collect data on the global density, composition, and time variability of the Moon's exosphere.

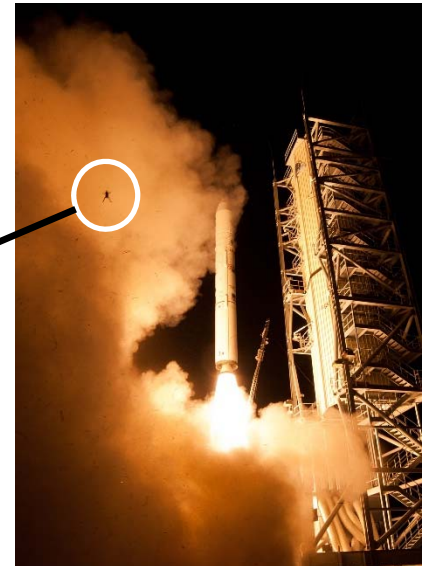
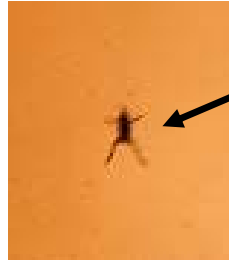
LADEE launched from NASA's Wallops Flight Facility in Virginia on September 7, 2013. As with the launch of all NASA's space vehicles, every aspect is photographed. The amazing thing about LADEE's launch was that a frog photobombed it! On one frame of a particular camera there is the clear silhouette of a spread-eagled frog.

The expert opinion at the time confirmed that it was indeed a frog. But what could have been going on?

The launch site in Virginia is constructed on wetlands, so it is not surprising that there would be frogs in the area. It is likely that the blast from the rocket exhaust threw up a lot of debris from the surrounding wetland and the poor frog just happened to be in the wrong place at the wrong time.

It is not known if the frog survived its brief flight into space!

<https://solarsystem.nasa.gov/resources/270/ladee-frog-photobomb/>



## **TALKING OF FROGS, Miss CLEAVER REMEMBERS A LEVITATING FROG .....**

### **PHYSICS – Floating frogs!**

We all know the rather sneering expression "*if pigs could fly*." Well, that could be sooner than you think. Back in 1997 a group of researchers in the Netherlands and in England made a frog levitate in a magnetic field. Although the feat might seem no more than a curiosity, researchers say that the floating amphibian may lead the way to a cheap alternative to space-based science experiments.

You would not immediately think of a frog, or any living thing, as magnetic. After all, we are taught that the only naturally occurring magnetic materials are the metals iron, cobalt and nickel. But, in fact, nearly everything is magnetic to some extent. As atoms and electrons zoom around each other, they create a field that (when placed in, say, one of the strongest electromagnets in the world) can repel against opposing forces. It's a **quantum mechanical effect** known as **diamagnetism** that can occur with any object: living or inanimate.

If a diamagnetic material is placed in a strong enough magnetic field, it levitates. Superconductors, for example, are perfect diamagnets and can levitate over even weak magnets, which is why levitating trains like those in Japan can fly over the tracks. Organic material like living cells is very weakly diamagnetic, says J. C. Maan, a physicist at the University of Nijmegen in the Netherlands. So he and colleagues employed a very strong magnet (chiefly used for crystallography experiments) to float the frog. It took 16 teslas—a very powerful field indeed—to lift the confused amphibian off the ground.

The frog, although bewildered, was apparently none the worse for wear, with "*no physical sign of any malfunction*," says Maan. "*The idea that you can do this with a biological entity is interesting*," says Robert Hollebeek, a physicist at the University of Pennsylvania. "*The next question is: 'Gee, can we levitate a person?'*" The Nijmegen group says that it is, indeed, possible, and is investigating how other living creatures float.

In case you're worried about the floating frog and its fellow participants, you'll be glad to know the experiment had no negative side effects on its living subjects. Outside of making celebrities out of amphibians, diamagnetic levitation has applications in industry and research, including the effects of zero gravity as floating living things here on Earth is cheaper than sending them out into space.

As for levitating a human, although theoretically possible it is not feasible. Scientists are still working with the technology though, including improving our understanding of drugs by making living cells levitate.

<https://www.science.org/content/article/floating-frogs>



## HERE'S ONE FROM Mrs CHACKSFIELD – ART COMES TO SCIENCE! .....

### QUANTUM PHYSICS – All information is here and we could discover the ultimate reality

Mrs Chacksfield is a good friend of the Science Department and firmly believes that Art and Science, far from being mutually exclusive, are merely two overlapping parts of a Universal concept.

Another concept is the exact “**nature of reality**”, which actually transcends both Art and Science. Mrs Chacksfield happened to hear a recent Radio 4 programme in the series *The Life Scientific*, hosted by Professor Jim Al-Khalili – in it he interviewed **Professor Vlatko Vedral**, Professor of Quantum Information Science at the University of Oxford and the Principal Investigator at the Centre for Quantum Technologies at the National University of Singapore and he talked to Jim in front of an audience at the Cheltenham Science Festival.

At high school in Belgrade, in what was then Yugoslavia, young Vlatko was bowled over by the idea that you could take the micro-laws of quantum physics, and apply them to the complex systems of the macro world. This drive to see the big picture was fuelled when, as an undergraduate at Imperial College, London, he saw three words – “**Information is physical**” – the title of a paper by the IBM physicist, Rolf Landauer. It was a light-bulb moment for Vlatko, who realised that the kind of information processing that the universe is capable of depends on the underlying laws of physics.

This revelation led to Vlatko’s incarnation as a self-confessed “physics fundamentalist” who unashamedly crowns physics the Queen and other disciplines, her servants. **It is physics alone, he tells Jim, which can answer the fundamental questions of the universe and discover the ultimate reality.**

His PhD in 1997 at Imperial College, London, applied quantum mechanics, including super-positioning and entanglement (which Einstein famously called “spooky action at a distance”), to Claude Shannon’s Information theory, making Vlatko one of the pioneers in the field of quantum information. As new quantum computers come on stream, he tells Jim, quantum information practitioners, like him, will have the capacity to simulate complex systems in the macroscopic domain.

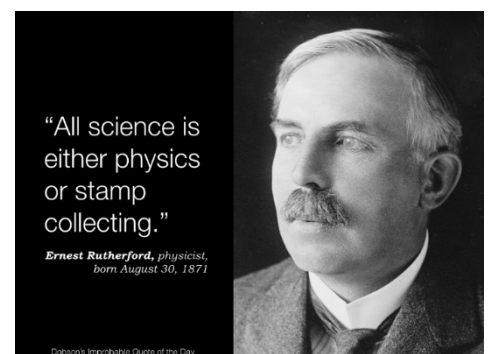
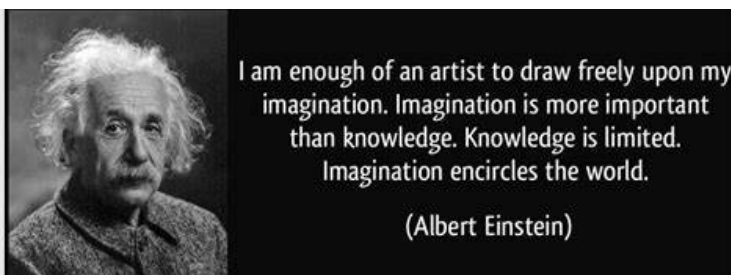
In the March 2022 issue of *Science News* there was a piece about the proposition that our Universe is actually a computer “simulation”. Linked to the quantum physics “nature of reality”, it is proposed that our Universe is made up of “bits” of information which are held in sub-atomic particles, neutrons and protons. Therefore, from a computing point of view, how many “bits” of information would be needed to simulate the Universe? One estimate is  $6 \times 10^{80}$ , that’s 600 million trillion trillion trillion trillion trillion trillion!

<https://www.bbc.co.uk/sounds/play/m0018g79>

**EDITOR’S NOTE:** It is highly contentious to claim that physics, even quantum physics, can be considered to be at the heart of everything in the known Universe – biologists, chemists and the rest would certainly have something to say about it! Nevertheless, it is an inescapable truth that we tend to turn to physics to explain at least the matter we see around us and how it behaves, from the sub-atomic to the galactic.

One of our greatest physicists, Sir Ernest Rutherford (he discovered that atoms have a central nucleus and proposed a new model for atomic structure) was rather dismissive of other fields of science, as noted by one of his most famous quotes – see right.

Albert Einstein, on the other hand, was much more inclusive and could see that Art has an equally important place in the scheme of things. To paraphrase one of his quotes: *“Physics will get you from A to Z. Imagination will get you everywhere.”*



Art, almost by definition, is all about imagination and Einstein elaborated his thought in another quote – see left.

# A FAMOUS SCIENTIST BORN IN JULY

# JOCELYN BELL BURNELL



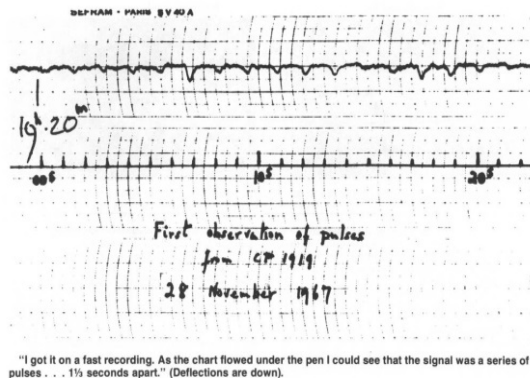
**BORN: 15<sup>th</sup> July 1943**

**BIRTHPLACE: Lurgan, NORTHERN IRELAND**

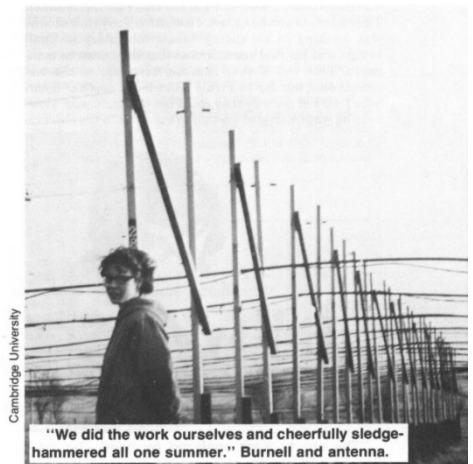
Jocelyn's birthplace, Lurgan, is in County Armagh, Northern Ireland, and it must be significant that Jocelyn's father, an architect, helped design the **ARMAGH PLANETARIUM**. It is said that when she found her father's books on **ASTRONOMY**, this sparked her interest in the subject, even as a young girl.

**When she failed her 11+ exam (!) her parents sent her to a boarding school in York (England) where she was hugely impressed by her PHYSICS teacher, Mr Tillot. His enthusiasm made her even more determined to become a scientist.**

When she arrived at Cambridge in 1966 she helped build a special type of **RADIO TELESCOPE** and it was her work with this that was to make her famous.



She used the radio telescope to study signals coming from distant radio sources, known as **QUASARS**: however, in 1967, while ploughing through miles of chart recordings, she found a remarkable pattern of signals from a single source.



**She detected regular PULSE SIGNALS at a constant rate of one every 1 1/3 seconds. At first she thought they might have been signals from a distant, alien civilisation; however, after further study, the true explanation was found –**

## **JOCELYN HAD DISCOVERED THE FIRST PULSAR!**

When some stars come to the end of their life they explode in what we call a **SUPERNOVA**. The remaining core of the star collapses into a small but unbelievably dense sphere of matter called a **NEUTRON STAR**. Neutron stars often spin very rapidly while emitting a beam of electromagnetic radiation, rather like a **STELLAR LIGHTHOUSE**, which we detect as rapid pulses.



**Many scientists consider that Jocelyn's discovery of the first pulsar was the greatest scientific discovery of the 20<sup>th</sup> Century!**



## Mr GREGORY REMEMBERS IN THIS MONTH 60 YEARS AGO:

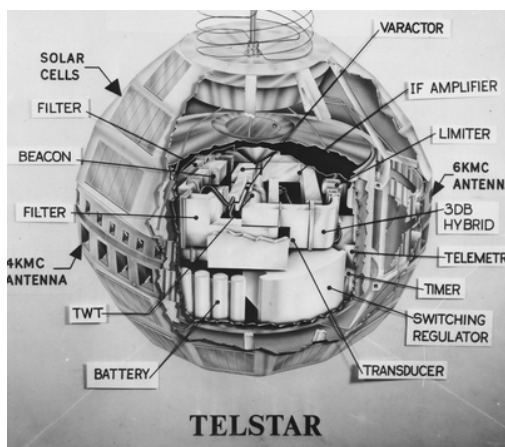
### TELSTAR 1: The Little Satellite That Created the Modern World

For those of a certain age, the name TELSTAR means something special.

On July 10, 1962, AT&T Bell Telephone Laboratories (now Nokia Bell Labs) and NASA launched **TELSTAR 1**, the world's first active communications satellite, from Cape Canaveral, Florida. Global communications changed forever. For the first time, live television transmissions and phone signals could be relayed between the US and Europe by means of this simple looking, spherical black and white satellite. Its iconic exterior held within it 170 pounds of some of the most complex electronics known to humankind. It featured 3,600 solar cells for power and a traveling-wave tube for amplifying the radio signals. The key task of Telstar 1 was to receive signals beamed from the US, amplify them 10 billion times and rebroadcast them to live audiences in Europe, and vice versa.



Telstar 1 circled the planet every 2½ hours. It was only in the right position to beam transmissions between the US and Europe for 20 minutes in each orbit before dropping out of contact. Future satellites were designed to work in tandem with each other, seamlessly passing the broadcast to keep transmission live at all times. By today's standards, Telstar was rather crude and limited, but it revolutionised transatlantic communications and led directly to more sophisticated global communications satellites operating at higher, geosynchronous orbits – which we now take for granted!



The Telstar 1 satellite was made possible by a whole series of inventions devised by the team at Bell Labs, including **the recently invented transistor**. Their lead researcher was engineer John Pierce, a big science fiction fan who was greatly inspired by the ideas he came across in science fiction books. He coined the term transistor and designed the technology into Telstar 1. In fact, Pierce also wrote science fiction himself under the pseudonym J.J. Coupling: a nice in-joke for his Bell Labs colleagues, as j-j coupling is a complex hyper-physics concept involving the interaction between light atoms. Telstar 1 and its subsequent iterations connected the globe through live transmission and changed the communications landscape forever. They even inspired the iconic World Cup soccer ball.

Telstar 1 was built as an international collaboration between AT&T, Bell Labs, NASA, the British General Post Office, and the French National Post,

Telegraph, and Telecom Office. The satellite launched on a Delta rocket on July 10, 1962. The aluminium satellite was wimpy by modern standards. It used 14 watts of power – roughly one-seventh that of a modern laptop – generated by the 3,600 solar panels on its outer hull. As well, it could only carry 600 phone calls and one black-and-white TV channel, though not much more was really needed at the time.

Six ground stations were built to communicate with Telstar, one each in the US, France, the UK, Canada, West Germany and Italy. The American ground station—built by Bell Labs—was Andover Earth Station, in Andover, Maine. The main British ground station was at Goonhilly Downs in south-western England. The BBC, as international coordinator, used this location. The standards 525/405 conversion equipment (filling a large room) was researched and developed by the BBC and located in the BBC Television Centre, London. On July 23, at 8:00 p.m. GMT, Telstar 1 relayed the first publicly available live transatlantic television signal. The broadcast was shown in Europe by Eurovision and in North America by NBC, CBS, ABC, and the CBC. The broadcast featured CBS's Walter Cronkite and NBC's Chet Huntley in New York, and the BBC's Richard Dimbleby in Brussels.

Telstar 1 also inspired the world's first sci-fi pop song, *"Telstar"*, by the British instrumental group **The Tornados**. It became their "one hit wonder" when released in August 1962! The song's writer, record producer Joe Meek, is honoured with a blue plaque on the wall of his home in London – it refers to him as the "Telstar Man"!

<https://www.bell-labs.com/about/history/innovation-stories/telstar-1/>

