

# Antiseptics

## What is it?

In the early 19<sup>th</sup> Century, there were no facilities in hospitals for cleaning patient's wounds or doctors' hands; it was also considered unnecessary for the surgeon to wash his hands before operating. The death rate in hospitals was very high as operations lead to infection.

In 1861, a new surgeon, named Lister, was appointed at the Glasgow Royal Infirmary. He was put in charge of a new surgical building that was built in an attempt to reduce the number of deaths due to sepsis. Lister experimented with ways to stop the rotting of wounds by exposing them to a chemical solution called carbolic acid or phenol. He began to test the results of spraying phenol onto surgical incisions, instruments and dressings, and found that wounds were much less likely to develop sepsis. Lister insisted that surgeons wear gloves whilst operating, and scrub their hands in phenol before and after operations. He also concluded from his tests that the handles of medical instruments should not be made from materials like wood that could encourage bacterial growth.



An operation being performed using Lister's Carbolic Acid chemical solution.

## Why was it important *then*?

Between 1861 and 1865, 45-50% of Lister's amputation patients died from sepsis. This was typical of the time. Prior to Lister's research, only risky amputations were undertaken but with the use of antiseptics, operations inside the body became possible.

## Why is it important *now*?

The use of antiseptics for patient preparation before surgery and for the operating team 'scrub' is now part of routine surgical technique.

Antiseptics not only continue to be part of modern clinical practice, but will also play an increasingly important role in surgery and wound care as resistance to antibiotics increases.

## Who invented it?

*Lord Joseph Lister (1827 - 1912)*



Lister (1827-1912) was an English surgeon, working in Scotland, who promoted the idea of sterile surgery to prevent infection. He is considered the 'father of modern antiseptics'.



## Did you know?

In 1879 Listerine mouthwash was named after Lister for his pioneering work in antiseptics.

Find out more about surgical procedures that would not be possible without the development of antiseptics! Catch a show at our 'Science in the Dock' exhibit on Floor 2 of the Science Mall at Glasgow Science Centre.

# Carbon Dioxide



## Scottish Inventions and Discoveries



### Why was it important *then*?

Long before its existence was confirmed; scientists had been able to observe the effects of carbon dioxide. CO<sub>2</sub> is linked with many processes such as breathing and burning and the advances made by Black's work allowed scientists to further increase their knowledge of many other gases.

### What is it?

At Edinburgh University in the 1750's, Scottish chemist and physicist Joseph Black studied the properties of what he called 'fixed air' or carbon dioxide. He experimented with the gas and found that it was not breathable and could not support a flame or animal life. He was the first person to isolate carbon dioxide as a pure compound and this was a very important step in chemistry, as until then, people believed that air was an element. Black proved, however, that air was made up of different elements.

Black proved in 1756 that carbon dioxide was present in the atmosphere and that it could form other compounds. His experiments helped him discover that carbon dioxide is released when things are burned and also when animals breathe out.



To find out more about the role of CO<sub>2</sub> in our atmosphere, catch a show at Glasgow Science Centre's Climate Change Theatre.

### Why is it important *now*?

Carbon dioxide is used today for a wide range of applications such as fire extinguishers, refrigeration and lasers.

The discovery of carbon dioxide also allowed scientists to establish its role in the atmosphere, and it has been found that CO<sub>2</sub> is a greenhouse gas. Human activities such as burning fossil fuels and cutting down large areas of trees have contributed to the increase of carbon dioxide in the atmosphere. The delicate balance of gases in the atmosphere has been upset by a 35% increase in carbon dioxide since the industrial revolution, and could be contributing to global warming.

### Who discovered it?

*Joseph Black (1728 - 1799)*



Black was born in Bordeaux, France to Scottish parents, and spent most of his life studying in Scotland. The first person to isolate carbon dioxide and to examine its properties, he also made important discoveries about heat capacity and latent heat.

### Did you know?

The expression to be a 'guinea pig', meaning to be the subject of an experiment, was derived from an early experiment involving carbon dioxide. The French scientist Pierre Laplace used a guinea pig to demonstrate that the oxygen we inhale is used to form the carbon dioxide produced when we exhale.

# Animal Cloning



Dolly and one of her lambs

## Did you know?

It is widely rumoured that Dolly was named after Dolly Parton, the country and western singer. This is because the donor cell used to create Dolly was taken from a mammary gland!

## Scottish Inventions and Discoveries



## Why was it important then?

The cell used as the donor for the cloning of Dolly was taken from a mammary gland. The birth of a healthy Dolly proved that a cell taken from a specific body part could recreate a whole individual.

## What is it?

Cloning is the process of creating a genetically identical copy of a plant or animal. Born on July 5<sup>th</sup> 1996, Dolly the Sheep was the first animal to be cloned from an adult cell rather than from an embryo. She was not the first animal to be cloned (other sheep, cows and frogs had all been cloned before) but it was the first time this particular process was used.

The process of cloning is based around the ability of cells to reproduce themselves (e.g. when you cut yourself, new skin grows). To produce Dolly, scientists used the nucleus of a cell taken from the udder of a 6-year-old sheep. They then reprogrammed the cell to stop it growing. The next step involved injecting the nucleus into a separate, unfertilized egg cell that has its nucleus removed. The cells were then fused together using electrical pulses.

Scientists had attempted the process 277 times before Dolly became the only lamb successfully born via this method. The world's media was fascinated by Dolly's birth and she became famous around the globe.

## Why is it important now?

The research that led to Dolly's creation also highlighted the fact that the potential uses of cloning are wide and varied - from developing more resilient crops or livestock to creating genetically modified pigs to act as organ donors.

The future of cloning is still considered to be highly controversial however. In particular the idea of human cloning raises many ethical issues.

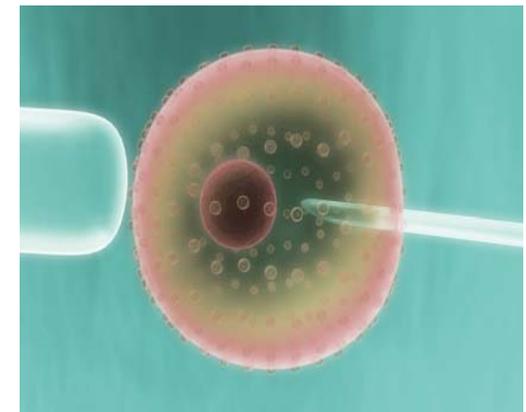
## Who invented it?

### *The Roslin Institute*

The Roslin Institute is a government research facility based in Roslin, Midlothian. Many Scientists contributed to the work resulting in the creation of Dolly; notably Sir Ian Wilmut, Keith Campbell and their colleagues.



Find out more about Dolly by catching a show at our 'Science in the Dock' exhibit on Floor 2 of the Science Mall at Glasgow Science Centre.



# Fingerprinting

## What is it?

Fingerprints are composed of tiny ridges on the tips of fingers that form distinct patterns. Each of these ridges is made up of pores that are attached to sweat glands. It's because of this sweat that whenever we touch things we leave our fingerprint pattern behind.



Skin ridges on hand.

Fingerprint patterns fall into one of three different groups - loop, whorl or arch. When matching or identifying fingerprint patterns, scientists study the position, size, number and detail of each pattern.

These patterns are formed before a baby is even born. How fast the baby grows and how much it moves around inside the womb determines the features of its fingerprints. This means that even identical twins don't have the same fingerprints. Since no two people have the same fingerprints, they are a great form of identification. Other methods of identification may change over time - such as weight, height, hair colour etc., but a person's fingerprints always stay the same.

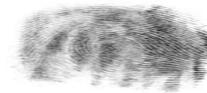
## Who discovered it?

*Henry Faulds (1843 - 1930)*



Born in Beith, Ayrshire, Henry Faulds studied maths at Glasgow University before going on to become a doctor. He later became a medical missionary and travelled to Japan. It was whilst in Japan that Faulds first came upon the idea of using the uniqueness of fingerprints to solve crime. While looking at his own fingerprints together with those of his friends, Faulds noticed that no two appeared to be the same. A theft at the hospital where Faulds was based gave him an opportunity to test his theory and as a result the culprit was successfully apprehended.

In later life, Faulds became involved in a bitter argument with William Herschel over the discovery and development of the use of fingerprints. Still, to this day, it is not clear where the credit should lie. Francis Galton is credited with the classification of finger print patterns however. He developed his classification system in the 1890s and it is still in use today.



## Why was it important then?

The uniqueness of fingerprints allowed investigators to prove the presence of a suspect at the scene of a crime. This was a major advancement in the field we now call forensic investigation.

## Why is it important now?

Today, there are many different techniques used in the process of forensic identification. Fingerprinting is, however, still very much a part of modern forensic investigation.

## Did you know?

There is a one in 64 billion chance that your fingerprints will match someone else's.

Each of your fingers has a print different to the others. In fact, palmprints and toeprints are also unique and can be analysed in a similar way to fingerprints.



Take a close up look at your own fingerprints by using the 'microscope' on the Clyde Explorer on Floor 1 of the Science Mall at Glasgow Science Centre.

# Lemmings

## Computer Game

### What is it?

Lemmings is a puzzle based computer game inspired by a quirky rodent known as the lemming. Often mistakenly thought to be committing suicide, lemmings can sometimes be seen in large groups, throwing themselves from cliffs into the ocean (in fact, when witnessed jumping from cliffs, lemmings are actually in the process of migrating and refuse to let any obstacle, even cliffs or oceans, get in their way). The game consists of many different scenes and levels. Lots of tiny lemmings drop from a trapdoor in the roof of each level and begin to blindly follow each other around. The aim of the game is to safely guide the tiny lemmings through each level.

Originally released in 1991 for the Commodore Amiga computer system, Lemmings was extremely popular and later became available in many formats including for the Playstation3 and Nintendo DS. It's estimated that more than 15,000,000 million copies of the original Lemmings game have been sold worldwide.

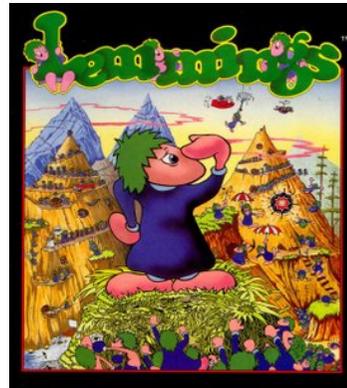
### Who invented it?

#### *Rockstar North (formerly DMA Design)*



Edinburgh based Rockstar North is a computer game development company. Formerly known as DMA Design, the company was founded in Dundee in 1988 by Mike Daily, Dave Jones, Steve Hammond and Russell Kay.

The company has produced many successful titles along with the Lemmings series of games including Body Harvest and the highly acclaimed Grand Theft Auto series of games.



### Why was it important then?

Lemmings became one of the most popular computer games of the early 1990s. It captured the public's imagination and was one of the first games with an appeal to a wide audience rather than simply to the 'hard-core computer geek'.

### Why is it important now?

No longer simply undertaking the obvious role of entertainment, computer games now perform a variety of roles in our society. From education and training to making sales or weather predictions and even to helping combat obesity (Wii Fit), today's computer games continue to evolve and impact our lives in a multitude of different ways. And thanks to the developers of DMA design and the success of Lemmings, Scotland continues to be at the forefront of this exciting scientific field.

If you're a fan of computer games, have a go at some of the games available on our website!

[www.glasgowsciencecentre.org/games.aspx](http://www.glasgowsciencecentre.org/games.aspx)

### Did you know?

The first ever degree course in computer game technology was offered in Scotland. The BSc in Games Programming and the BA in Games Creativity and Artwork at the University of Abertay in Dundee, were the first of their kind anywhere in the world. Today, the University of Abertay is an international leader in the field of gaming technology and development.

# Penicillin: The First Antibiotic

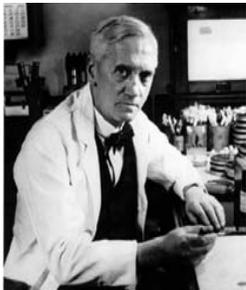
## What is it?

During World War I, a Pharmacologist named Fleming served in a battlefield hospital on the front line in France. Whilst there, he saw many soldiers dying from infection and so, upon returning to London, he decided to find a way to better antiseptics.

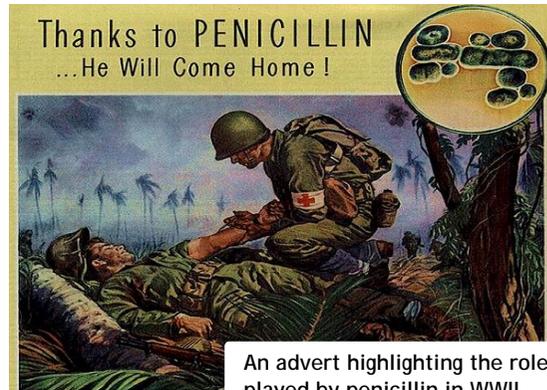
Whilst conducting routine research in 1928, Fleming noticed that mould had formed by accident on a culture plate and that the mould had created a bacteria-free circle all around it. He had found the world's first antibiotic, penicillin. He found it to be strongly antibacterial but non-toxic to animals and humans, however, Fleming was not able to isolate the active substance in large enough quantities for it to be produced as a drug.

## Who invented it?

*Sir Alexander Fleming (1881-1955)*



Born in Lochfield, Ayrshire, Sir Alexander Fleming was a Biologist and Pharmacologist. The discovery of penicillin won him the Nobel Prize in 1945 along with Florey and Chain.



## Scottish Inventions and Discoveries

### Why was it important then?

Fleming's work encouraged other scientists to do further research, and it was Oxford Biochemists Florey and Chain amongst others that harnessed penicillin's full potential as a life-saving drug. Once it was ready for medical use, the drug was used exclusively for wounded soldiers in World War II and was called the 'miracle drug' as it saved thousands of soldier's lives.

### Why is it important now?

Penicillin, along with many other antibiotics, is still very much in use today. Many common diseases or simple injuries are no longer considered life threatening. However, scientists continue to develop new forms of antibiotics to help fight new types of infection.

### Did you know?

Florey's development of penicillin peaked at the beginning of World War II, and there was concern that the team's research could be stolen by invading German forces. They smeared mould into the lining of their lab coats, so that in the event of an invasion, all evidence of their work could be destroyed without losing the key substance.

Check out our online game 'Epidemic Emergency' - see if you can stem the spread of the virus!  
[www.glasgowsciencecentre.org/epidemicemergency.aspx](http://www.glasgowsciencecentre.org/epidemicemergency.aspx)



# Colour Photography



## What is it?

In 1855 Scottish scientist, James Clerk Maxwell discovered that white light is made up of a spectrum of colours, and that all the colours we see in nature are combinations of the primary colours, red, blue and yellow. This amazing discovery led to the creation of the first ever colour photograph.

It was discovered that colour photographs could be taken using red, blue and green filters. The process involved taking the same photograph of a tartan ribbon three times; each time with a different coloured filter on the lens. After developing the photographs, each image was projected through the coloured filter with which it was taken, and the images overlapped to create a full colour image.

## Who invented it?

*James Clerk Maxwell (1831-1879)*



Born in Edinburgh, James Clerk Maxwell was a Scottish mathematician and theoretical physicist considered to have had an impact on physics as great as Isaac Newton and Albert Einstein.

## Did you know?

Maxwell is also known for proving the rings of Saturn are made of small particles, not liquid as thought by many astronomers. However, his most important discovery, and one of the greatest finds in scientific history, was his discovery that light is a wave form.

## Why was it important then?

Seeing colour photographs is something we take for granted. Prior to the invention of colour photography, the only way we could reproduce images in colour was through paintings or drawings.

With the invention of colour photography, people the world over could marvel at the colours of sights such as mountains, oceans and even countries they had never visited. Colour photographs sparked the public's imagination and also provided a more detailed picture of the world.

## Why is it important now?

Modern electronic communication may not exist without Maxwell's work developing the colour photo. His theories have been used to develop items such as mobile phones, TVs and x-ray machines.



See the results of combining red, blue and green light by checking out our 'Coloured Shadows' exhibit on Floor 1 of the Science Mall at Glasgow Science Centre.

# Speedo Swimwear



Speedo Swimwear at the 1924 Paris Olympics

## What is it?

The Speedo brand was born when a company called 'MacRae Hosiery' began to produce swimwear in addition to their underwear lines. The 'racerback' costume, proved to be a hit with athletes. In 1955, Speedo began using nylon in their fabrics to improve the quality of the swimwear.

Speedo's latest fabric technology, 'FastSkin' has drawn inspiration from nature's fastest swimmer: the shark. FastSkin reduces the amount of drag in water by copying the biological skin characteristics of shark's skin, and allows swimmers to swim faster than ever. By designing a fabric that imitates v-shaped skin ridges in shark's skin, FastSkin allows swimmers to cut through the water with greater ease than regular swimwear. The suit is also designed by using the world's only 3D swimsuit pattern, which engineers the suit, to cope with every possible body movement.

## Why was it important then?

Speedo's figure-hugging designs were the first items of swimwear designed specifically for competitive swimming rather than simply for beachwear. This new kind of swimwear enabled swimmers to swim faster than ever before.

## Why is it important now?

Speedo Swimwear is well known for being at the forefront of swimwear technology, and has been popular with athletes for decades.

Today, Speedo is arguably the best swimwear manufacturer in the world. With an impressive track record of world first technologies and sponsored athletes, Speedo is a front-runner in swimwear technology.

## Who invented it?

*Alexander MacRae (1888-1938)*



Alexander MacRae was born in Kyle of Lochalsh and emigrated to Sydney in Australia in 1910. In 1914 Alexander set up a knitwear factory, where he later began producing swimwear that is now the world's most technologically advanced.

## Did you know?

It has been reported that Speedo offered Michael Phelps a \$1 million bonus to attempt to match Mark Spitz's record Olympic haul of 7 gold medals in 1972. Phelps won 8 gold medals at the 2008 Olympics in Beijing, making him the world record holder for the most golds won at a single Olympics.

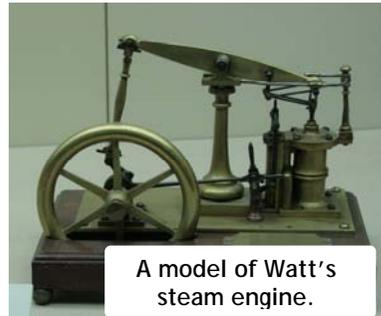


The FastSkin Suit

## Did you know?

Speedo's latest line of competitive swimwear, FastSkin LZR Racer has proved itself to be the world's fastest swimwear, as between April and August 2008, 71 swimming World Records had been broken in the LZR Racer.

# The Separate Condenser: The Improved Steam Engine



A model of Watt's steam engine.

## Did you know?

The unit of power, the Watt, is named in recognition of the importance of James Watt's contribution to the development of the steam engine. Watt was also the first person to use the term 'horsepower' when discussing the power of an engine.

## What is it?

Often when we hear the term 'steam engine' we think of a locomotive or steam train. However, the engine that heats water to generate power was around long before the locomotive.

Steam engines work on the basic principal that when heated, water turns to a vapour known as steam. The volume of water expands as it turns to steam inside the boiler, creating a high pressure. The expansion of steam pushes pistons whilst something called a slide valve opens and shuts two steam ports (or openings) alternately, creating a simple up-and-down motion.

The separate condenser is an extra cylinder that keeps the condensing steam separate from the water. This avoids wasting fuel by no longer having to heat *and* cool the cylinder with each stroke. The invention of the separate condenser meant that the cylinder could remain hot and that greatly increased the steam engine's fuel efficiency.

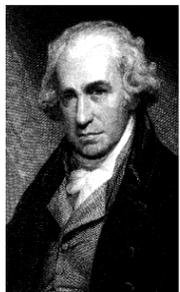
## Why was it important then?

Before the industrial revolution of the late 18<sup>th</sup> century life was tough - processes such as manufacturing and farming involved lots of heavy labour. With no 'machines' to help, many simple activities that we take for granted today, took a long time to complete.

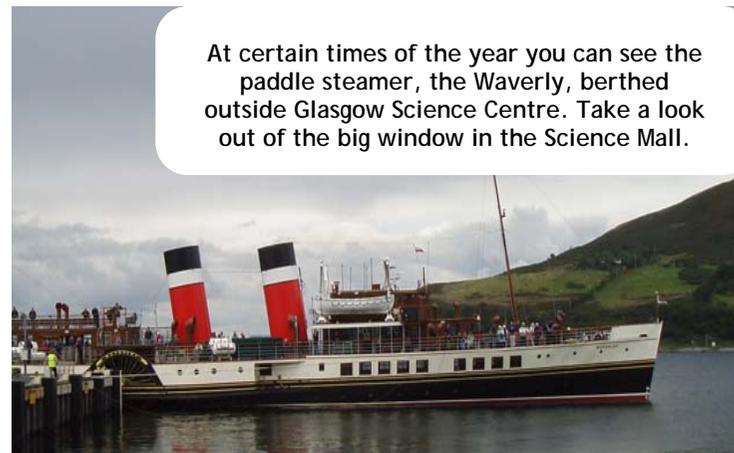
There were many different types of machinery using steam engines before Watt's improvement. The new design however, converted a machine of limited use into one of efficiency and multiple applications such as powering machinery in factories and mills and cultivating farmland. That, in turn, sparked the industrial revolution. It was also very important in the development of later forms of transportation such as the locomotive and paddle steamers.

## Who invented it?

*James Watt (1736 - 1819)*



Born in Greenock, James Watt was the son of a wealthy shipbuilder. A mathematical instrument maker by trade, Watt's design for the separate condenser won awards and he became a wealthy man. He retired at the age of 63 and devoted his time to researching further ideas such as the rotary engine and the steam indicator.



At certain times of the year you can see the paddle steamer, the Waverly, berthed outside Glasgow Science Centre. Take a look out of the big window in the Science Mall.

## Why is it important now?

Watt's improvements to the steam engine were only the beginning, leading to the later development of the steam turbine, which is still very much in use today. In fact, the majority of the electricity supplied to our home from the national grid, is still generated using steam turbine plants.

# The Telephone

## What is it?

Invented in the 1830s by Samuel Morse, the telegraph system revolutionised communication. The system worked by sending pulses of electrical current through wire. Morse also designed a code of long and short pulses of electric current representing different letters. This meant that messages could be

transmitted across vast distances. In fact, cable was laid across the Atlantic Ocean enabling communication between Europe and the USA.

Whilst working on improvements to the telegraph system, one scientist, Alexander Graham Bell, stumbled upon an amazing discovery - sound could be transmitted along a wire. Armed with this discovery, Bell eventually managed, on March 10<sup>th</sup> 1876, to transmit the first spoken message along a wire. The message, between Bell and his assistant Watson, travelled from one room to another and said "Mr. Watson. Come here. I want to see you." The system worked by changing voices into electrical currents at one end, at the receiver, and back again at the other.

This amazing new method of communication was named the telephone and that simple sentence, sent from one room to another, became the first message ever to be spoken over the telephone.



## Why was it important then?

The invention of the telephone brought the ability to have two-way conversations in real-time, across vast distances. Telephone communication was far more efficient and easier to use than the pre-existing telegraph system.

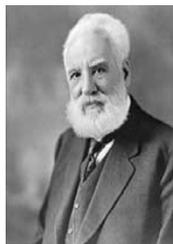
The telephone also allowed for the communication of subtle sound cues and tones associated with speech (i.e. tone of voice easily affects meaning which can be hard to detect when written).

## Why is it important now?

Today it's possible to communicate around the world instantaneously. From news stories and important information to conversations with friends around the world, the telephone is still one of our major forms of communication. Without it, our lives would be very different.

## Who invented it?

*Alexander Graham Bell (1847- 1922)*



Born in Edinburgh, Bell emigrated to Canada and eventually the USA. His father, grandfather and brother were all in the business of elocution and speech and his mother and wife were both deaf. This aspect of his personal life profoundly influenced his work - he became a professor of vocal physiology and concentrated his research in the areas of hearing and speech.



Find out more about how sound travels by having a conversation via the 'Whispering Dishes' on Floor 1 of the Science Mall at Glasgow Science Centre.

## Did you know?

Although the telephone is arguably the most famous of Bell's inventions, later in life he felt that the telephone actually prevented him from concentrating on his scientific work. As a result, he refused to have a telephone in his office!

# Television

## What is it?

The first working model able to transmit moving images was constructed from a second-hand electric motor, a hatbox, a darning needle, a biscuit tin and a bicycle lamp. The system, known as the 'Baird Televisor', consisted of a camera and a television. Both the camera and the television contained a rotating disc with spirals of holes (or lenses). As a beam of light passed through the lenses, the object or subject of the picture was scanned. The camera's spinning disc broke up the picture into light and dark dots. The light and dark dots were then sent to the television where its spinning disc rebuilt the picture.

The first moving image, which was of a ventriloquist's dummy named Stooky Bill, was created in a lab in 1925. The first public demonstration of the device took place in an attic in London on January 27<sup>th</sup> 1926.

This mechanical form of T.V. became obsolete as a new, electronic television system was developed. That same electronic form of T.V. is still in use today although in the last decade there have been many new improvements. HDTV, Plasma screens, mobile T.V., digital and satellite technologies and interactive television are just some of the current developments in the evolution of the television.



## Why was it important then?

Telephone communications allow us to transmit sounds across vast distances via telephone lines. Prior to the invention of Television, the idea of transmitting images in a similar manner, known as 'seeing by wireless', fascinated many people.

## Why is it important now?

It's estimated that the average person in the UK watches 25 hours of television per week. Television plays a large role in the culture of today's society. While it's mainly thought of as a form of entertainment, the television also acts as a key method for expanding our knowledge of the world.

In addition, television is a powerful tool used by those who want to influence a large number of people such as businesses and politicians.

## Who invented it?

*John Logie Baird (1888 -1946)*



The son of a clergyman, John Logie Baird was born in Helensburgh. From a very early age he was fascinated by how things worked and went on to develop not only the television but also many other inventions. He was however plagued with ill health throughout his life and died at the young age of 57.

## Did you know?

By the age of 13 John Logie Baird had constructed a telephone exchange connecting his bedroom to that of his friends across the street.

Test out a working model of John Logie Baird's first television on Floor 2 of the Science Mall at Glasgow Science Centre.



# The Pelamis Wave Energy Converter



The Pelamis Wave Energy Converter in the Firth of Fourth.

## What is it?

The Pelamis Wave Energy Converter harnesses the power of the ocean's surface waves and uses that energy to generate electricity. The converter consists of a series of red, snake-like machines, which bob on the surface of the ocean. Longer than a football pitch, each machine measures 140m! Each 'snake' is divided into sections and as the waves push and pull the sections resist the movement of the waves and in turn push in hydraulic rams that drive motors.

A prototype of the Pelamis Wave Energy Converter was launched in 2004 in the North Sea off the coast of Orkney. It was the first time energy generated from ocean waves was directly supplied to the national grid. In September 2008, the first full scale commercial wave farm, Aguçadoura, opened off the northern coast of Portugal. There are also plans to open wave farms off the coast of England and the USA.

The idea of capturing the power of waves is not a new idea however. In fact, there have been wave power experiments for many years - there were experiments happening off the coast of California as far back as 1890! The Pelamis Wave Energy Converter is however, the first such machine working on a commercial scale.

## Who invented it?

### *The Pelamis Wave Power Company*

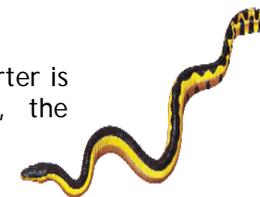


Set up in 1998, Pelamis Wave Power is an Edinburgh based company set up with the specific purpose of developing the Pelamis Wave Energy Converter.

The company was founded by Dr Richard Yemm, Dr Dave Pizer and Dr Chris Retzler.

## Did you know?

The Pelamis Wave Energy Converter is named after Pelamis Platurus, the Yellow Bellied Sea Snake!



Check out another method of converting movement to electricity; try 'The Tower of Power' on floor three of the Science Mall at Glasgow Science Centre.

## Why is it important?

Our 21<sup>st</sup> century lifestyle depends upon our ability to generate electricity. Currently, the vast majority of our electricity is produced by the burning of fossil fuels such as coal, oil and natural gas. Unfortunately, once these fossil fuels are gone, they cannot be immediately replaced. Therefore, if we want to sustain our current way of life, we must develop new, renewable energy sources.

The Pelamis Wave Energy Converter provides a way of harnessing large amounts of energy from the power of the ocean waves. In fact, each machine can provide enough power to meet the annual electricity demand of about 500 homes.

Renewable energy sources are also far kinder to the environment than fossil fuels. Renewables do not release CO<sub>2</sub> into the atmosphere and hence do not contribute to the problem of global warming. Unlike other forms of renewable energy sources (e.g. wind farms) the Pelamis Wave Energy Converter also has a minimal impact on its immediate environment.

