CONTENTS

SCIENTISTS
PHYSICS AND CHEMISTRY

By Harry Jivenmukta

ARCHIMEDES 287-212 BC

Archimedes was born in the city of Syracuse, in the Greek colony of Sicily. His father was an astronomer called Phidias. Phidias was wealthy enough to send his son to school in Alexandria, a famous centre for learning.

After he finished school, Archimedes returned to Syracuse where he became famous as a mathematician, scientist and inventor. He wrote many papers on his discoveries and inventions, nine of which still survive. Archimedes is said to have discovered the Archimedes Screw which was used for removing excess water from the holds of ships. However, he may have used an idea of the Egyptians who used a similar device to raise water from wells. Archimedes also discovered the principle by which a lever works and showed that with a ‘first class’ lever, you could lift a load using only half the effort. Archimedes also discovered the relationship between the diameter and circumference of a circle. He found out how to calculate the volume and surface area of a sphere and to make mathematical calculations on the stars and planets from his own observatory.

His best known discovery was said to have been made in his bath! Here he discovered that an object immersed in water becomes lighter by the amount of water it displaces. He was so excited by this discovery that he is said to have rushed naked through the city, waving his arms and shouting, “Eureka!” (I’ve found it) “Eureka!”

Like all excellent scientists, Archimedes found a way to use this discovery. King Hieron II had given a quantity of gold to a local craftsman to make him a new crown. By ascertaining the volume of water displaced by the original amount of gold and comparing it with the displacement caused by the crown, Archimedes was able to prove that the craftsman had been cheating the king. The king was pleased with Archimedes and the craftsman didn’t live long enough to cheat anyone else!

Archimedes was famous throughout the known world, but it did not save him from a violent death. When the Romans invaded Sicily, the Roman General gave strict orders for him not to be harmed. Unfortunately, a zealous soldier, seeing an old man scratching figures in the sand, ran him through with his spear. He did not realise that he had killed the most famous scientist of the ancient world.

Activity.

1. Find Syracuse and Alexandria on a map of the Mediterranean area.
2. Why do you think that the Romans invaded Sicily?

GALILEI 1564-1642

Galileo Galilei was born in Pisa, in Italy. His father was a well known musician. When Galileo was very young, his father moved the family to Florence. Galileo went to the local church school in a nearby monastery.

When he was seventeen he returned to Pisa to study medicine at the university. One day, he went to a lecture in geometry instead of to the one in medicine that he should have attended. He was enthralled and continued to neglect medicine in favour of mathematics and science in which he later made many important discoveries.

He made his first discovery while sitting in church. Instead of concentrating on the service, he watched a swinging lamp and saw that regardless of the length of the swing, the time that it took to oscillate was always exactly the same. This led to the use of pendulums to regulate clocks.

He published many other papers and became well known. He was offered and accepted teaching jobs at different universities at different times. These positions earned him a living and allowed him sufficient time to pursue his own interests and experiments.

Up to now, everyone had assumed that a heavy object would fall faster than a lighter one. Galileo proved them wrong when he climbed to the top of the Leaning Tower of Pisa and dropped a small rock and a lighter object over the rail. Both landed at the same time.

Galileo learned of the ideas of Copernicus. He agreed with him but kept quiet about it so as not to anger the Church or University authorities. In 1609, Galileo built himself a telescope which was able to magnify objects to x30. With it, he was able to see that the surface of the moon was rough, that the Milky Way was a system of stars, the planet Jupiter had its own moons and Saturn had its own rings.

Publishing his findings caused quite a stir. Galileo was invited to Rome to demonstrate his discoveries to the Pope. He was so well received that he felt confident enough to state that his observations of sunspots proved that Copernicus was correct. This caused a furore. Scientists and mathematicians denounced him and his ideas. Galileo pleaded with the Pope and his advisors, and although they privately agreed with him, his ideas were labelled false and wrong. The Church feared that his ideas would undermine the authority of the Church.

Galileo was ordered to keep his ideas to himself. He went into retirement, but still continued with his observations and developing both his and the ideas of Copernicus. Eventually, Galileo was allowed to write a paper on the ideas of Copernicus providing he came to the conclusion decided upon by the Pope and his advisors!

Galileo's papers were finally published in 1642. The pope was furious. Galileo had written the right conclusion but his writing made Galileo's opinions very obvious. Galileo was forced to stand trial on a charge of heresy. He was found guilty and made to recite a public apology and renounce his own beliefs in favour of those of the Church. He was also placed under permanent house arrest in Florence. Eight years later, blind and suffering from a fever, Galileo died at the age of seventy-eight.

BOYLE 1627-1691

Robert Boyle was the fourteenth child of a family living in Lismore in Ireland. His parents were wealthy and Robert was sent to school in England when he was only eight years old. He left Eton College at thirteen and went on tour around Europe with a tutor.

He returned right in the middle of the Civil War, in 1644. He managed to avoid most of the troubles by going to live with his sister in Dorset. It was in Dorset that he met Samuel Hartlib who introduced Robert to a life-long interest in scientific experiments.

Ten years later, when the country was stable again, Robert moved to Oxford where all the apparatus he needed was available. He employed a young scientist, Robert Hooke as his assistant and together they designed an air pump which was to help Boyle in his experiments on air and gases.

In 1661, Robert published a law of science which is still called, ‘Boyle’s Law’. This law stated that ‘at a constant temperature, the volume of a gas is inversely proportional to the pressure’.

Later, he went on to challenge ancient and Church beliefs when he stated that, ‘all natural phenomena are explained by the motion and organisation of primary particles’. Other scientists and the Church leaders all disputed this statement, and to avoid too much antagonism and trouble, he went to live with a sister in London. He continued his experiments in London and received many visits from other famous scientists. One of his achievements during this period was to discover how to tell the difference between an acid and an alkali.

Robert was a deeply religious man. He was a Protestant and gave religious lectures as well as writing many religious pamphlets. He died in 1691 at the age of sixty-four. In his will, he left money to pay for religious lectures which are still given in London.

Activity: Air is needed for Combustion.

1. Refer to the experiment on the next page.

2. Using the knowledge you have gained, how would you extinguish a chip-pan fire, or the clothes of a person on fire? Give reasons for your response.

3. Have a class ‘brainstorming’ session, or make a class ‘concept map’ on all the facts that everyone knows about the properties of air.

Activity.

There is a fascinating experiment you can do, if you are careful, to show that air is needed for combustion.

You will need:

a shallow bowl or glass dish

a small lump of Plasticine

a candle (max 6cm)

a glass jam jar

a few matches

1 Fix the Plasticine to the centre of the bottom of the bowl.

2 Fix the candle firmly into the Plasticine so that it stands upright.

3 Pour some water into the bowl up to the level of the top of the Plasticine

4 Light the candle.

5 Place the jam jar over the burning candle, resting its edge in the bowl.

6 Watch and see what happens.

7 What did happen? Can you explain it?

8 Write down what you did, what happened and why.

9 Make a sketch of your experiment.

NEWTON 1643-1727

Isaac Newton was born in the tiny village of Woolsthorpe, in Lincolnshire. He was such a sickly baby that he was not expected to live beyond his first birthday. His father was a yeoman farmer and his mother was the daughter of an innkeeper. Isaac's father died when he was two years old and his mother married again.

Isaac hated his stepfather so bitterly that he even tried to burn his parent's bed while they were still in it! The troubles between his stepfather and this angry little boy ended when Isaac was sent away to school in nearby Grantham. From there he went to Trinity College in

Cambridge.

Isaac achieved his degree in 1665 just before the Great Plague struck the country and the university was closed. Forced to work at home, Isaac began to experiment with light, colour and optics. With a prism in a darkened room he proved that white was a blend of all the colours of a rainbow.

He also worked on the mathematics of circular motion and the movements of the moon and planets. It was during this period that he is supposed to have seen an apple falling as he sat under a tree which led him to postulate the Theory of Gravity. Two years later Isaac returned to the newly re-opened university as a professor and began lecturing on his discoveries about colour and optics.

This caused immediate problems for Isaac. His ideas and discoveries angered Robert Hooke, the premier scientist in the field of optics at that time. Hooke criticised Isaac, and Isaac responded just as angrily, thus beginning one of the best known feuds in the scientific world.

In 1675, Isaac published papers on colours and optics. Hooke was furious. He claimed that Isaac had stolen his theories. There followed a series of letters in which both men politely insulted one another. Then Isaac's mother died and with the scientific world dividing its loyalties between Hooke and Isaac, the stress forced Isaac to retire to the country. Before leaving, Isaac also published a paper on what came to be known as 'Newton's Rings' - the concentric rings which appear in the air between a lens and a flat sheet of glass.

In semi-retirement, Newton began working on his great book, 'Philosophiae Naturalis Principia Mathematica', known as the 'Principia'. In it he included some of the theories postulated by other scientists as well as his own. Again Hooke was angered and he accused Isaac of stealing his work. Newton took his revenge by deleting every mention of Hooke and his work from the book! A fate which also befell other scientists who angered Isaac and sided with Hooke.

In 1696, as a way of rewarding Isaac for his ability and work, he was awarded the honorary position of Warden of the Mint with a salary of two thousand pounds a year, (worth about two hundred thousand pounds today). Instead of merely dealing with the mundane matters as he was supposed to, Isaac took a more active role and infuriated everyone. He even wanted perpetrators hanged for very minor offences! As he grew older, Isaac became increasingly more difficult to get on with. He was extremely rude and unpleasant to anyone who argued or disagreed with him, but however much people disliked him, everyone agreed that he was one of the finest scientists the world had ever known. The man who first managed to weigh the sun through calculation, died old and embittered at the age of eighty-eight.

Activities: The Properties of Air.

The weight of an object (not its mass) is measured in 'Newtons'; e.g. an apple is about 1/3N, and a bicycle about 36N.

1. You will need two balloons, string, rod or dowell and a pin.

2. Blow up both balloons to the same size - measure their girths to check. Tie one at each end of the rod and suspend the rod so that the balloons are level.

3. Prick and burst one balloon. Note what happens.

4. From this, what can you state about a property of air?

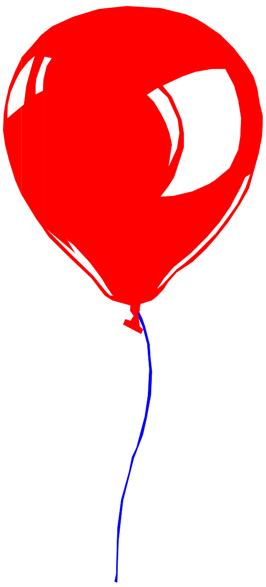
5. Next you will need, a large glass bowl of water, a clear beaker, or jar and a drinking straw.

6. Lay the beaker or jar in the bowl of water. When the beaker is full of water, stand it upright and carefully insert your straw under the edge of the beaker.

7. Blow into your straw. Note what happens.

8. What is taking up the space that was previously filled with water?

9. Form a hypothesis on this property of air.



LAVOISIER 1743-1794

Antoine-Lauret Lavoisier is often called the, 'father of modern chemistry'. He was born in Paris. His father was wealthy and worked for the French Government. Antoine had an excellent education, studying mathematics, astronomy, botany and chemistry.

Science was his great interest, but he did as his father asked and went to study law at university. He then neglected his law studies and turned to science. He wrote an essay on, 'The Best Method Of Lighting A Town' which won him the Gold Medal from the French Academy of Sciences. He followed this with papers on, 'The Composition Of Gypsum', 'Thunder' and the 'Aurora Borealis'.

He was a versatile man with a wide range of scientific interests. He went on a 'geological' journey around France which resulted in a mineralogical map of France and an analysis of France's water from various sources.

However, he needed money to continue with all his studies, so he became a tax collector. Not long after this, his wealthy father followed the custom of wealthy families of that time, and bought him the title of a count.

As his fame grew, he progressed from being a tax-collector to the Director of Gunpowder Administration. He was a humane administrator and stopped the routine searching of people's homes for the saltpetre needed to make gunpowder. He had the main gunpowder arsenal moved to Paris, which also gave him access to excellent laboratory facilities. Antoine worked steadily and investigated the process of fermentation, the ratio of gases involved in inhalation and exhalation, the cyclical patterns of plant and animal life and the theory that there are only three states of matter: liquid, solid and gas.

In spite of his title, Lavoisier was a liberal thinker and reformer and had taken no part in the planning of the French revolution or the 'terror' which was to come. This, however, did not save him. The Terror brought Jean-Paul Marat to power. Jean-Paul criticised Antoine and had him, and the other administrators of the arsenal, put on trial.

Antoine was found guilty and was sent to the guillotine in 1794. The body of this great French scientist was thrown to rot in a common grave. He was fifty-one years old.

Activity.

It is not difficult to experiment with fermentation in a similar way to that of Lavoisier.

WHENEVER YOU USE CHEMICALS MAKE SURE YOU KEEP YOUR HANDS WELL AWAY FROM YOUR MOUTH, NOSE AND EYES. MAKE SURE YOU WASH YOUR HANDS THOROUGHLY WHEN YOU HAVE FINISHED.

1 You need some limewater. To make limewater you need a large jam or coffee jar and some calcium oxide, (slaked lime). Be careful not to get any of it on your skin. Fill the jar with 500ml of water. Take 1 teaspoon full of calcium oxide and stir it into the water. Allow the solution to stand until the cloudiness has cleared. Fix an almost airtight cover on your jar with foil, and secure it with string or an elastic band.

2 While this solution of limewater is standing, prepare the next part of your equipment. You will need a small quantity of active yeast, some sugar, warm water, and a small glass jar. You will also need two flexible drinking straws. Mix a teaspoon of yeast, and one of sugar, with a little warm water and keep it warm. Cover the jar with foil as you did with the other jar. Make sure the yeast is active and bubbling.

3 Take the limewater jar and pierce the foil with one of the straws. Blow through the straw until the solution becomes cloudy. Carbon dioxide which you have exhaled into the solution turns the limewater opaque, (cloudy). Using the other straw pierce the yeast jar's lid and place the other end of the straw into the hole you made in the limewater jar's lid. Leave both jars to stand.

4 What do you observe? Write down what happens.

5 Try and think of a reason for what you have observed and write it down.

DALTON 1766-1844 9

John Dalton was born in Eaglesfield in Cumberland. He was the younger son of a Quaker weaver. Quakers were a Christian religious sect known for their honesty, serenity and system of 'listening' in church services. John remained a righteous Quaker all his life.

He was a good student at school and responsible enough to be left in charge of the local Quaker primary school when he was just twelve years old. When he was grown up he became a teacher. He tutored his brother and taught mathematics and science in the Presbyterian New College in Manchester. However, John still found the time to pursue his own interests. In Kendal, he kept a diary of the daily climatic conditions in the Lake District. He wrote about the 'Aurora' displays and concluded that they were associated with the Earth's magnetism.

He also investigated the workings and accuracy of barometers, thermometers and hygrometers. His climatic investigations included studies on the formation of clouds, precipitation, evaporation and atmospheric moisture. He was the first scientist to confirm that precipitation is caused by an increasingly cold atmosphere. He promulgated the scientific law that states that; 'the total pressure of a mixture of gases equals the sum of the pressures of the gases in the mixture, each gas acting independently.'

He also claimed that; 'all elements are composed of tiny, indestructible particles called atoms ... which are all alike and have the same atomic weight.' We now know that atoms can be split, but John had made important statements in what was to become atomic theory.

Both John and his older brother were colour blind, and John is well known for his investigations into this defect. John was a respected but lonely man when he died in 1844 at the age of seventy eight, but the greatest tragedy was that all his meticulous notes and observations were destroyed in a bombing raid during World War II.

Activity: Instruments and Daltonism.

1. What do these instruments measure: a. barometer b. thermometer c. hygrometer d. hydrometer?

2. Draw a sketch showing the physical features of your area. Show how the rain cycle is likely to operate there. Use the direction of the prevailing winds and information of the rainfall during the wettest month to help you.

3. Erect a rain gauge and keep accurate records of the rainfall in your area for a year! Dalton kept them for six years before he began to make predictions.

4. Ask a local optician if they could possible spare the time to come and talk to the class about Daltonism. You might like to undergo some simple tests.

DAVY 1778-1829

Humphry Davy was born on his parent's small estate near Penzance in Cornwall. He enjoyed school but wasn't serious about his studies; he far preferred exploring the moors, wandering along Cornish beaches, fishing and hunting. He wrote poetry, sketched anything that caught his fancy and collected specimens of rock.

Humphry was going to become a doctor until he met Davies Gilbert, the scientist. Gilbert showed Humphry his laboratory and allowed him to use his library. Humphry changed his mind and decided to become a scientist like his mentor.

As soon as he gained access to a small laboratory of his own, Humphry began experimenting. In order to learn, he first tried out many of the experiments undertaken by other scientists before embarking on the investigation of his own ideas.

Humphry studied heat, light, electricity and the effect of gases on the human body. Never one to avoid risks, Humphry had already tried inhaling nitrous oxide or laughing gas to disprove the idea that this gas could carry and spread diseases. He almost died after inhaling a mixture of hydrogen and carbon dioxide, or water-gas. His published account and meticulous results quickly made him famous. He received gifts of money to buy more equipment from many well known and wealthy people. He became so famous that he received the 'Napoloen Prize for Science' from Napoleon himself in Paris, in spite of the fact that Britain and France were at war! Humphry is best known for saving the lives of hundreds of miners by inventing the Davy Safety Lamp. The greatest danger in coal mines is the presence of an explosive gas called 'firedamp'. Firedamp was hard to detect and quick to explode when it came in contact with the lamps that the miners had been using. Humphry's lamp was completely sealed and could not be ignited by the gas.

In 1820, Humphry was made President of the Royal Society and began his study of the corrosion of the metal plates on ship's hulls by saltwater. He worked on this and other projects until he became ill in 1827. Two years later he suffered a stroke and died in Geneva when he was only fifty-one years old.

Sir Humphry Davy was involved in scientific investigation in many areas of science but his main interest seemed to have been chemistry. Among the first things a scientist learns in chemistry is whether any substance, mixed in water, dissolves or is held in temporary suspension.

You will need several small glass vials or jars with lids, and a variety of different substances form your kitchen store cupboard at home. Don't forget to ask permission first!

1 Make a list of the substances you intend to use, and write them in a chart form as below.

2 Fill each jar about 2/3 full, with water.

3 Place one teaspoon of each substance in each jar. Shake each jar for 10 seconds.

4 Leave the jars to stand for five minutes.

5 Observe the results and enter them on your chart.

6 Write a report on the conclusions you can draw from the results.

COLD WATER

SUBSTANCE	DISSOLVES	SUSPENSION	SINKS	OTHER

HOT WATER

SUBSTANCE	DISSOLVES	SUSPENSION	SINKS	OTHER

FARADAY 1791-1867

Michael Faraday was born in Yorkshire. He had two brothers and two sisters. His father, a poor blacksmith, decided to move his family to London when Michael was still very young.

His father expected his oldest son to take over the smithy from him. The other two boys were sent to day school to give them enough education to avoid having to earn a living down the mines or in a factory.

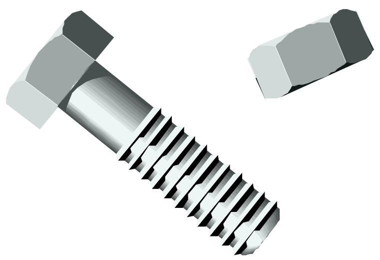
When he left school at thirteen, Michael obtained a job as an errand boy to a bookseller. Michael was diligent in his work and showed so much intelligence and interest in the books that Mr. Riebau, the bookseller, took him on as an apprentice without charging the usual fee. Michael stayed there for seven years and became a highly skilled bookbinder.

In his spare time, Michael read the books. He read everything he could and he copied down passages of scientific material which interested him. He was particularly interested in the very new subject of electricity. Mr. Riebau, and his brothers, who were earning more money than Michael, helped him to pay for tickets to attend scientific lectures and meet many of the scientists involved.

At one of these lectures he met Sir Humphry Davy, the foremost scientist of his time. Sir Humphry was very impressed by Michael and invited him to become his assistant. When Sir Humphry travelled abroad, Michael went with him and met many well known European scientists including M. Ampere from France and M. Volta from Italy.

Michael's work as Sir Humphry's assistant became well known in its own right, and when he returned to England, he was offered the position as Superintendent of the Apparatus at the Royal Institute (for science). At last, Michael had the use of a superb laboratory for his own work. In 1831, Michael discovered that the movement of a conductor of electricity through a magnetic field created an electric current. This discovery led to the invention of many useful tools and machines. Michael developed into an excellent lecturer and his Christmas lectures on the chemical history of the candle were soon famous and tickets were much sought after. Towards the end of his life he was awarded many honours including a knighthood.

The appointment that he enjoyed most was that of Scientific Adviser of Lighthouses which allowed him to visit all the lighthouses around the coast and give advice on the best use of lenses and oil-lamps. Just as Volta and Ampere gave their names to measurements of electricity, a 'farad' is a unit of electrical capacity.



Activity.

You can experiment in a way similar to that of Sir Michael Farady. Make an electromagnet. You will need and iron nut and bolt, (at least 5cm long), a 4 metre length of wire, (PVC coated), and a 1.5 volt battery.

1 Thread the nut onto the bolt leaving the end exposed for several millimetres.

2 Wrap a layer of masking tape around the bolt between the head and the nut.

3 Leaving at least 10 cm of wire free at one end, wind the wire around the bolt tightly from the head of the bolt to the nut.

4 Cover the wire with another layer of masking tape.

5 Wind on another layer of wire, going in the same direction.

6 Continue in this manner until your reach the end of the wire. Remember to leave enough wire free to reach the battery connection.

7 Connect both ends of the wire to the battery connections and check if it works on metal objects. Find out how much the magnet can lift.

PASTEUR 1822-1895

Louis Pasteur was born in the French Village of Arbois. His father was a tanner and even though they were very poor, his father insisted that Louis went to the local village school where he did so well that he went on to school in Paris and to the Sorbonne university.

He studied chemistry and soon proved so able that when he had finished his degree he was appointed Professor at the University of Lille. At Lille he addressed the problem of the unequal fermentation of sugar beet whereby some bubbled and gurgled happily and in other vats, the beet turned into a grey, viscous soup! Louis took samples from the good and bad vats and immediately saw the difference. In the good vats were buds of yeast actively reproducing themselves, while in the bad vats there was no yeast activity and the liquid was full of tiny rod-like organisms which he knew were bacteria. Louis told the farmers his findings and persuaded them to clean all the vats very thoroughly between each batch. This investigation was important because it made Louis realise that bacteria could be critical in many industries.

One of the most valuable results of Louis' work was the prevention of milk souring so quickly in warm, sunny weather. He found that if milk was heated to a temperature high enough to kill the bacteria, but not so high as to give it the boiled-milk taste, and kept there for fifteen minutes, the bacteria would die and the the milk would keep fresh for several days longer. This process was called ‘pasteurisation’ and is still in use today.

Louis also believed that different types of bacteria were disease causing agents in both animals and humans. He discovered that the bacteria from chickens who had died, when injected in tiny quantities into healthy chickens, allowed the healthy chickens to build up antibodies to the bacteria and remain healthy, (like Jenner and cowpox).

In 1881, Louis was able to prove his theories by injecting sheep and saving them from dying of anthrax. Even more amazing to people of that time, he was able to save a boy’s life with an injection after the boy had been bitten by a dog with rabies. This type of injection is now known as inoculation and has become the most important way of preventing and controlling disease. Louis’ greatness was acknowledged by thousands of people who sent donations for the building of the Pasteur Institute in Paris where scientists continue the search for disease producing bacteria. Louis died in 1895 at the age of seventy-three.

Activity: Yeast. Yeast is a fascinating substance that is used in bread, beer and some wine-making. In active yeast, you can see the budding form of reproduction very easily.

1. You will need: some yeast from a chemist or baker’s shop, sugar warm water and a microscope.

2. Mix together a cup of warm to hot water with a teaspoon of sugar. Stir until the sugar is dissolved, but do not let it get too cool.

3. Mix in your yeast, stir well. It could bubble and froth slightly.

4. Place a droplet of the mixture on a clean slide and cover with a cover-slip.

5. Examine the slide under a microscope. Draw and describe what you see.

MAXWELL 1831-1879

James Clark Maxwell was an only child. His father was a lawyer in Edinburgh; his mother died when he eight years old. He was educated at home by a tutor, who thought he was a very slow learner, until he was ten when he went to Edinburgh Academy. He published his first scientific paper while still at school! This paper was on the subject of constructing an ellipse using thread and pins. Following school, he went to Edinburgh University as well as Cambridge where he soon gained the reputation for being an outstanding student. He won prizes for original research. He also wrote an essay on his observations of the rings surrounding Saturn and predicted their composition. His theories have recently been verified by the 'Voyager' space probe, over a century later!

James was interested in the properties of colour and tested the theory that there are only three primary colours - red, yellow and blue. He also demonstrated the possibilities of colour photography. By passing a light through special filters he separated out the primary colours and then combined them in differing amounts to produce the shades seen by the human eye.

In 1860, James became a Professor at King's College in London and began working on what was to be his main area of research. He was fascinated with the properties of light. He investigated the speed of light and found that there was a relationship with electro-magnetic and electro-static units of electricity. He discovered that the amount of energy in electro-magnetic waves depended on their wave-length. Maxwell believed that waves of energy could project outwards and this theory was proved correct when Heinrich Hertz made a spark jump from one piece of apparatus to another, and then by Marconi, who constructed the first radio.

In 1865, James retired to his Scottish estate and began writing his great book, 'Treatise on Electricity and Magnetism'. Six years later he was elected to be the new Cavendish Professor at Cambridge. It was James who designed the world famous Cavendish Laboratory. James died in 1879 and was buried in a simple ceremony in the village of Parton, near his home in Scotland. He was only forty-eight years old.

Activity; you can see colours just as Maxwell did if you make some Maxwell disks.

1 Cut out circles of cardboard and mark them in three equal parts. Colour each part differently, one red, one yellow and one blue. Fix them to a surface with a pin or nail and spin them quickly. What can you see?

2 Make another disk and colour it with variations of the same colour, e.g. yellow, orange and lemon. What can you see?

3 What effect is there if you leave one portion white, then leave two white?

4 Try this experiment again but this time make the blank portions black. What can you see? Write a report on your findings.

BECQUEREL 1852-1908

Henri Antoine Becquerel was born in Paris. His father and grandfather were both scientists and that is all he ever heard about as a youngster. He went to the Louis Le Grand Lycee and later went on to the Ecole Polytechnique, a French Institute of Technology. After spending two years there, he went to study engineering, especially bridges and road building, at the Ecole des Ponts et Chausees.

Meanwhile, Henri also pursued his own scientific interests. He became an acknowledged expert on phosphorescence and on the properties of uranium. He was elected to the Academy of Sciences in 1889 and was able to spend more time on his own investigations. He studied radiation and the spectra made by different crystals under infrared radiation, He tried to find the relationship between the absorption of light and the emission of phosphorescence in some compounds. This work led him towards his greatest discovery.

He found that all substances emit radiation and the amount emitted differs with the substance. Henri's work, which was to have far reaching consequences, was largely overshadowed by the amazing work of Roentgen, Hertz and the Curies. It wasn't until some time later that other scientists recognised the value of Henri's work.

In 1901, he was working with Marie and Paul Curie when an unusual incident occurred. Henri was given a vial of the precious radium which he put into a coat pocket for later use. To his surprise, the radium burnt a hole in his coat. Until then, none of the properties of radium had been thoroughly investigated. It was an incredible thing to have happened for a substance to have burned a hole in material whilst still secure inside a glass vial. This incident led scientists towards investigating the properties and dangers of radium and its use in the treatment of carcinomas.

In 1903, Henri with the Curies received the Nobel Prize for Physics and Henri was elected to the presidency of the French Academy of Sciences. Henri left the bustle of Paris and moved to Le Croisic where he died in 1908 at the age of fifty-six. One has to wonder if he was another possible victim of the substance that he had investigated at length.

Activity: Substance Change. There is a simple experiment that you can do to show how light from the rays of the sun can change a substance.

1. You need, a day when the sun will shine for several hours, coloured paper, and a variety of objects that will lie flat on the paper and prevent any breeze blowing everything away!

2. Place your paper flat in a sunny position. Place the articles on the paper and leave them for several hours.

3. Lift your articles from the paper. What did you find?

4. Write up what you did and what you found. Give a reason for what happened.

PLANCK 1858-1949

Maximillian Karl Ernst Ludwig Planck was born in Kiel in North Germany. His father was the Professor of Law at the university in Kiel. When Max was nine, the family moved to Berlin so that his father could take up a new appointment.

Max shone at school, doing particularly well in music and on the piano, but in spite of his talent, he decided to study physics at university. His university studies were very successful and he became a lecturer at the University of Munich and Professor of Physics at Berlin University in 1889.

In 1900, Max made his most important contribution to modern physics when he formulated what is now known as the Quantum Theory. A quantum is the name given to a definite amount of something which generally cannot be divided. Originally, scientists considered the atom as a quantum until they managed to split it through fission and produce the 'atom' bomb, or nuclear explosion. Scientists used to believe that light waves radiated from a source in a continual stream, but Max's Quantum Theory states that light should be regarded as a 'stream of small bunches of energy that move through space in straight lines'. Each of these bunches act as if they are a small particle or separate quanta of material.

In 1905, Einstein supported Max's theory by stating that 'light must be composed of energy particles' which he called 'photons'. Similarly, Planck supported Einstein when he published his Theory of Relativity.

Max was elected to the Prussian (German) Academy of Sciences in 1912 and continued to work on problems associated with light, energy and radiation. He investigated the differences in energy given off in the radiation of different types of light. he found that a quantum of red light carried less energy than a quantum of ultra-violet light because it has a lower frequency of radiation. Max was awarded the Nobel Prize for Physics in 1918 for his work on his Quantum Theory.

During World War II, Max showed where his sympathies lay by trying to persuade Hitler to change his policies against the Jews, gypsies and mentally impaired. His younger son was found guilty of involvement in a plot to kill Hitler and was executed.

After the end of the war, Max, with his family, moved to Gottingen in Sweden where he died in 1947 at the age of ninety-one.

Activity.

Max Planck worked on the energy released or radiated from different types of light. You can find out some facts about different colours quite easily.

1 Cut out at least ten pieces of card about 10cm x 20cm.

2 Stick a different colour onto each board. Use paint colour charts or similar to get a wide range of colours.

3 Use different shades of colours; e.g. light and dark blue, red, pink, orange, yellow etc.

4 With a friend, sit about 100 metres apart.

5 One of you should hold up the cards in turn and the other should try to identify the colour. Write down the results but do not discuss them yet.

6 Change around and let the other person try to identify the colours.

7 Try the same experiment sitting about 200 metres apart.

8 What did you find? Were any colours difficult to identify? Can you explain why?

9 Can you think of examples in your everyday life where it would be important to use this information?

10 Which is the most dangerous colour to use? Why?

11 Which is the safest colour? Why?

12 Write up your experiment and the results.

Marie Curie was born Manya Sklodovska in the city of Warsaw in Poland. Although her parents were not wealthy, they were both teachers and provided Marie with an excellent education. From the beginning it was obvious that Marie was clever, she taught herself to read before she was four years old.

When Marie was grown up, she started her career as a teacher in a country area, giving lessons to the children of rich families. She then returned to teach in Warsaw where she was able to use a tiny, ill-equipped laboratory and her study of chemistry began. As she worked, she also saved every penny that she could. She intended to save enough to be able to work and study in Paris.

When she had enough, she went to live with her sister in Paris. She changed her name to Marie and registered at the Sorbonne University. Life for Marie was far from easy when she discovered that her knowledge of French was insufficient for studying science and that the science she had learned in Poland was of no use to her in Paris. She had to put in many hours of extra work to overcome these difficulties and become accepted in the Science faculty. Living with her sister made this almost impossible, so she rented a tiny attic of her own where, half-starved and often cold, she worked long hours into the night. In the end her struggles were worthwhile when she topped her class in all subjects.

In 1895 she married Paul Curie, another scientist and they were able to work together in a small laboratory. Marie felt the need for further study, so she decided to study the work of Henri Becquerel for a second degree. Henri had discovered that material containing uranium gave off rays like X-rays. Marie set about investigating the properties of these rays. She chose to work with a substance called pitchblende because it contained considerable quantities of uranium.

Quickly, she discovered that pitchblende gave off more rays than expected from the quantity of uranium it contained. What was causing the extra radiation? She concluded that there must be another radiating element present. To prove her theory she had to isolate this other element. It took four years of meticulous investigation for the pitchblende to give off the faint glow of the isolated, new element. Marie called this new element, ‘radium’. But no one knew how dangerous this element was until Marie and Paul discovered that their hands were covered in burns and dreadful sores after handling it. They wondered if this new element which acted on healthy skin could be used to act against cancerous growths as well.

When they published their results and theories, they were inundated with offers to purchase their rights to the discovery; they could have become instant millionaires! Instead they gave their knowledge away for the benefit of mankind. Together with Becquerel, Marie and Paul were awarded the Nobel Prize for Chemistry in 1903. Their triumph was spoilt with the tragic death of Paul who was killed in a road accident. Marie took Paul’s place at the University and continued working. She received a second Nobel Prize in 1911, the only person to have achieved two Nobel Prizes. She continued working until her failing eyesight forced her to retire in 1927. She died in 1934, of a strange malaise which we now call radiation sickness. She was a victim of her own discovery, but her discovery has also helped millions of people to recover from cancer, or at least to prolong their lives.

Activity.

It is too dangerous for you to experiment with radium. You can experiment how to eliminate substances from soil in the same way that Curie did with pitchblende.

1 Half fill a small bucket with ordinary soil from your garden.

2 Find its mass by weighing it. Remember to subtract the weight of the container.

3 Spread the soil out on a newspaper and leave it to dry out for a few days.

4 Weigh the soil again and note the difference.

5 Sift the soil and count the particles left in the sieve. Categorise them.

6 Describe the different particles in each group.

7 Describe the material that passed through the sieve.

8 Weigh the particles and the soils separately. Work out what the proportion of soil to other particles is.

9 Replace the sieved soil into the bucket and add quantities of water.

10 What happens to the soil? Stir the soil and record the changes.

11 Allow the soil to settle and see what happens.

12 Test the water for acidity or alkalinity using litmus paper.

13 Place a drop of the mixture on a microscope slide and examine it under a microscope. What can you see?

14 Write up a report on the whole exercise.

BOHR 1885-1962

Niels Bohr was born in Copenhagen in Denmark. He was the elder son of Christian Bohr, a well known professor of physiology. His mother was the daughter of a wealthy Jewish banker.

Niels worked hard at school and passed difficult exams to get into university where he studied science. While still at the University of Copenhagen, his investigations into the use of water jets to determine surface tension in liquids won him a scientific Gold Medal.

In 1912, Niels went to Manchester to work with Ernest Rutherford on the study of atoms. Niels was able to improve Rutherford's model of atomic structure by combining it with Max Planck's ideas of energy as quanta in the Quantum Theory. After more investigation, Niels promulgated the theory that every atom had its own 'fingerprint' in the form of a spectra of colour by which it became visible. For example, the hydrogen atom has a spectrum of one red line, one blue line and one bluish-green line. Niels said that each line of colour represented a release of energy when the single electron in the hydrogen atom jumps from its inner to its outer orbit.

Later in the same year, Niels returned to Denmark. He continued to study and work throughout World War I without interruption because Denmark remained a neutral country and wasn't involved in the fighting. His aim at this time was to replace the old theories of electro-dynamics and mechanics with the new Quantum Theory in a way that would encompass all the known ideas in atomic science. During this period, he continued to lecture students and publish his own theories. He received many accolades and honours including the Nobel Prize for Physics in 1922. With the prize money he bought a house in the country where he could relax and read and write the poetry he loved.

During World War II, Denmark was occupied by the Germans in 1940. Niels and his family remained in Copenhagen and did their best to continue normally. By 1943, the situation had deteriorated. The Germans were rounding up Danish Jews and shipping them to concentration camps. With a Jewish mother, Niels and his family were in terrible danger. One dark night, Niels and some of his family were secretly spirited away from under the noses of the Germans. Danish resistance fighters took them in a small fishing boat across the sea to neutral Sweden. A few days later, a British Mosquito bomber landed in Sweden and took Niels and his son Aage, who was also a scientist, back to Britain. Some months later, they were flown to America to work on the atomic bomb at Los Alamos.

The scientists working on the bomb realised that they were producing something terrible if it ever got into the wrong, or irresponsible hands. The politicians were arguing about the secrecy of the product, while some felt it would be better if everyone knew about it in an 'open world' policy. Niels argued for the open world policy, but his group was not successful and secrecy reigned. After the war, Niels persisted in his beliefs and in 1955 he chaired the First International Conference on the Peaceful Uses of Atomic Energy. He went on working and trying to persuade people until the day he died in 1962 at the age of seventy-seven.

Activity.

Niels Bohr first won recognition for his work on surface tension. There are simple experiments you can try to illustrate how surface tension works.

You need a large shallow bowl, a fine sewing needle, a small piece of tissue paper, some talcum powder, a drop of detergent, a drop of cooking oil, some soap, salt and water.

1 Make sure the bowl is really clean.

2 Fill it with water and leave it to settle.

3 Try to float the needle on the water. If you cannot manage this place a small piece of tissue paper on the water first. Eventually the tissue paper should sink to the bottom. If it does not you can gently push it down.

4 Why does the needle continue to float?

5 Fill the clean bowl gain.

6 Gently sprinkle some talcum powder on the surface.

7 Add a drop of oil from one edge and see what happens. Why does it happen?

8 Using fresh water try it again this time using the detergent and then the soap. What is the result in each case?

9 What happens when you use a pinch of salt?

10 Write up the experiment and results. Write why the reactions happened.

Lise Meitner, the daughter of a lawyer, was born in Vienna. As a young girl, Lise enjoyed parties and took part in all the activities that were usual for girls at that time. She did well at school but did not go to university until she was twenty-two. She studied hard and gained both her degree and doctorate within five years.

Lise specialised in physics and went to Berlin, to work with Max Planck, in 1907. She later went to work with Otto Hahn, a physical chemist. Lise continued to excel in her work and was granted academic positions unusual for a woman in those days. Much of her work was concerned with investigating the radioactive properties of a wide range of substances. In 1932, Hahn and Lise began to experiment with neutron bombardment, starting with the effect such bombardment would have on uranium.

Hitler came to power in 1933. Lise, as an eminent Jewish scientist, was in great danger. She remained fairly safe until the Nazis annexed her native Austria in 1938, but after that she was in grave peril. Quietly and unobtrusively, she prepared to leave. As soon as she was ready, she fled to Sweden where she joined her nephew, Otto Frisch. Because Sweden remained neutral, Lise was able to keep in contact with Otto Hahn.

Otto Hahn, wrote and told Lise the results of their bombarding experiments. The uranium, when bombarded, had produced lighter elements and barium in particular. This result thrilled Lise and she called the process, ‘nuclear fission’.

The next experiments concerned the control of the bombardment, so that nuclear fission could also be controlled.

News of Lise’s achievements reached Niels Bohr, who realised the possible consequences of nuclear fission. Otto Hahn was still in Germany, and if their work was put under the control of the Nazis, the result could be disastrous for the allies and the whole world. Luckily, President Roosevelt took the matter very seriously and he instigated the Manhatten Project in a race to beat the Germans in acquiring the atom bomb. After the war, Lise became a Swedish citizen but she lived the later years of her life in England. Like Marie Curie, Lise had overcome many prejudices and had achieved fame and many honours. She died in Cambridge just before her ninetieth birthday.

Activity: Using Energy. The propulsion of rockets requires immense thrusts of energy, just as nuclear fission requires powerful bombardment.

1. Work in small groups in an area which can be cleaned up easily.

2. Each group needs a bottle with a fitting cork, some vinegar, baking soda and pencils.

3. Wrap two teaspoonfuls of baking soda in a tissue and place it at the base of the inside of the bottle. Add 75ml of vinegar and place the cork in firmly but not too tight.

4. Wait for the cork to ‘pop’ and watch what happens.

5. You may have to adjust the fuel amounts and the inserted pressure of the cork to obtain a good propulsion.

6. Write up your experiment and include illustrations. A group competition to produce the best propulsion can be fun and interesting.

EINSTEIN 1879-1955

Albert Einstein was born in Ulm in Germany. He was very slow to develop, not beginning to talk until he was three years old and his school record was dismal. He hated the strict regime of German schools and he failed to achieve a place at university. Albert managed to gain a place at the Swiss Polytechnic in Zurich, but the qualification he finally achieved was still insufficient to allow him to go on to a university. Disappointed, he became a teacher of mathematics. Then he obtained a position in the Berne Patents Office. This gave him enough money to live fairly comfortably so he married and took out Swiss citizenship. He also continued studying and finally achieved his Doctorate from Zurich University following the publishing of several papers on the properties of light.

Einstein then went on to produce his most famous investigation which resulted in the 'Theory of Relativity' After several moves between Germany and Switzerland, Einstein ended up in Germany at the outbreak of World War I. He had taken his wife back to Switzerland for safety, but the long separation finally broke up the marriage altogether. He hated the military attitude of many German people and turned more and more towards the Jewish Faith.

In 1919, Albert's Theory of Relativity was proved by British scientists when they found his projected measurements about an eclipse to be correct. In 1921, Albert was awarded the Nobel Prize for Physics for a lesser known piece of work. In 1933, when Hitler succeeded in gaining power, Albert renounced his German citizenship and he was quietly smuggled out of Germany by some friends who feared for his life. Albert arrived in Belgium and from there he went to America.

In 1939, he met Niels Bohr who told him that Lise Meitner, in Germany, had managed to split the uranium atom. The consequences of the Germans being able to split the atom and produce an atomic bomb before the allies could were enormous. The two of them wrote of their fears to President Roosevelt who took the danger seriously. The outcome was the Manhatten Project, the gathering of atomic scientists at Los Alamos and the production of the atomic bomb. Albert was not part of the Manhatten Project.

After the bomb had been dropped on Hiroshima, he was horrified and joined those scientists who were bitterly opposed to the further development of this horrific weapon of mass destruction. He died in Princeton at the age of seventy-six; the most revered scientist of our time.

Activity: Energy.

1. Identify the sources of energy used by man.

2. Make a chart listing a. place where power\energy is produced b. the energy source, or fuel used in each place.

3. Make a chart estimating in hours, or part of an hour, that each energy source is used in own home, e.g. cooker (gas) = 17 hours per week.

4. Construct two different energy chains from source to final user. Use either sketched and labelled illustrations, or flow charts; e.g. coal furnace, steam turbine, generator, light bulb.

Enrico Fermi was born in Rome, the youngest of three children. His father worked on the railways but Enrico took after his mother who had been an excellent student before she married. Enrico's school results were so good that he missed out most of the Italian in between stage and went straight to a tertiary college associated with the University of Pisa.

Enrico achieved his degrees and doctorate in four years. He left Italy for Denmark and continued his studies under Max Born at the University of Gottingen. He published many papers on physics which were so impressive that he was offered a position as Professor of Theoretical Physics at the University of Rome when he was only twenty-five years old.

Apart from lecturing, Enrico continued with his own investigations into a statistical method for predicting the characteristics of electrons. He stayed in Rome for nine years and became the youngest scientist ever to be elected to the Royal Academy of Rome. He continued his experiments and even achieved atomic fissions without realising the importance of what he had done.

When Mussolini came to power and the king was forced to abdicate, Fermi realised that the outlook was bleak. He hated the Fascists, but sensibly kept his views to himself. Then in 1938, when Enrico was awarded the Nobel Prize for Physics, he and his family saw their chance to escape. Taking as little luggage as possible to avoid rousing the suspicions of the Fascists, they travelled to Stockholm to receive Enrico's prize. They never returned to Italy; instead they made their way to America where they met Niels Bohr. Niels told Enrico of his fears about the German scientists achieving nuclear fission and producing an atomic bomb before the Allies managed it.

After it was set up, Enrico joined the Manhatten Project at Los Alamos. His task was to produce a controlled self-sustaining nuclear chain-reaction.

The first nuclear device was tested in the desert near Los Alamos, in New Mexico, on July 16th 1945. The next device exploded was the first atomic bomb set off over Hiroshima. In 1944, Enrico was granted citizenship of the United States of America. He was awarded many honours from both Britain and America. He died in 1954 at the age of fifty-three.

Activity: Atomic Research.

1. Make sketch maps to show: a. Japan, Tokyo, Hiroshima, Nagasaki; b. Los Alamos, New Mexico, Chicago, Washington DC.

2. Find as many statistics you can on the destruction of both Hiroshima and Nagasaki.

3. Find out as many other scientists as possible who worked on the Manhatten Project.

4. What is radiation sickness? Name an earlier, famous scientist who probably died from this sickness.

5. What happened at Chernobyl in 1986? Write as much as you can about it.

6. Where is Three Mile Island and what happened there?

7. Have a class discussion on the advantages and disadvantages of nuclear power stations. What is your own opinion?