Name:

Junior Science

Metals and Materials

Downloadable Resource

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Marvellous Magnificent Molybdenum

Shiny silver flakes of molybdenite ore on quartz.

Molybdenum is number 42 on the Periodic Table and is usually an unheard of element. It is pronounced "MOL-IB-DEN-UM". Symbol Mo. Despite its **anonymity**, an average person in America will use 13 kg of Molybdenum per year. You might well ask how something you've never heard of could be so useful.

The name 'molybdenum' comes from the Greek word for lead which is 'molybdos' because the two elements look very alike and are both soft, grey, oily solids. It is so important that without molybdenum in our cells we would die. There are small proteins in our cells called **enzymes** that break down and make a whole range of different compounds. One set of enzymes responsible for dealing with sulfite compounds uses molybdenum and if a human is **deficient** in molybdenum these enzymes don't work and people become allergic to sulfites. Not only this, it is good for our teeth, skin and hair and helps us to release energy from our food. We get this element from the food we eat and things such as beans, peas, rice, liver and kidney are all high in molybdenum. However, while we couldn't live without molybdenum, that's not the only way we use it every day.

From your TV to wind turbines, hospital equipment, light bulbs and even the **reflective** orange pigments on traffic cones, all contain molybdenum. It is mined from **ore**. It isn't found in its pure form as it reacts with other elements too readily and instead it is found as the compound mineral **molybdenite** where it is combined with sulfur. It is found deep underground in **igneous rocks**[1] in some parts of the USA (mainly Colorado), Canada, Chile, China, Mexico, Peru, Russia and Mongolia. The largest producing molybdenum mine is located in Colorado, USA.

The rock containing molybdenite is blasted using explosives. The rock only contains a small amount of molybdenite which has to go through a long process of **extraction**. In fact one tonne of rock only gives up to 1.8 kg of molybdenum. The blasted pieces are taken to a crusher where they are broken down into even smaller bits. These are then taken to grinding mills where they are pounded and **pulverised** until the particles are the size of sand. Once mixed with water, a **slurry** is made which is piped onto the next stage of extraction, the **flotation**. This is where chemicals are added that make the molybdenite become **hydrophobic** (water hating) so it tries to get away from the water it has been mixed with, causing it to float on the surface. Air is then pumped in to make bubbles which the molybdenum sticks to get it farther away from the water. These bubbles rise to the surface and are skimmed off. The skimmed bubble concentrate is then dried into huge heavy blocks of grey-black powder which is almost pure molybdenum. A further step where the molybdenum is heated to 650°C results in it becoming as close to 100% pure as possible.

Molybdenum is used in aircraft engines.

Around 86% of the mined molybdenum is used to produce **alloys**. Alloys are a combination of two or more different elements with a metal being the main component. By combining different elements (especially two different metals) you get a product with better properties than the pure element alone. For example, while iron is strong, it does bend under pressure. With added carbon, it makes a much harder material (steel). Steel made with small amounts of molybdenum is super strong and can withstand extreme temperatures. This makes it useful for armour, engine parts, weapons and aircraft parts. Molybdenum is cheaper than some other metals such as tungsten (W) so it is sometimes used as a substitute. This happens in low energy X-ray machines used to produce **mammograms** and in some light bulbs.

Molybdenum is a little known element, that rarely makes it into daily conversation but just remember, without it, life wouldn't be the same. So next time you sit down with a bowl of rice to watch TV pay a little tribute to mighty molybdenum.

[1] Igneous rocks are formed from the cooling and solidification of molten rock magma.

Silkworm Food and Fabric

Silkworm cocoons on a branch.

Silkworm moth and cocoon.

Silk fibres are triangular in shape which reflects light and makes the material shimmer and shine. The protein fibres that make up silk are called fibroin which is one of the strongest natural fibres on Earth. Many insects produce silk for webs, catching prey and to encase themselves when they go through metamorphosis, like when a caterpillar becomes a butterfly. Other insects include spiders, raspy crickets (who make shelters from rolled leaves tied with silk), bees, ants, silverfish and mayflies. Caddisfly larvae, a common sight in New Zealand Rivers, make a protective and camouflaging case from silk imbedded with sticks, gravel and sand.

Silk is smooth and soft but not slippery like the man-made fibres nylon and rayon (known as artificial silk). Because of this, cloth made from silk tends to hug to the human body. The science behind its clinginess is that it is a poor electrical conductor so the static electricity produced in the body makes it stick and cling. Because silk is a natural fibre, it breaks down when exposed to sunlight for long periods of time and insects will attack and damage it. Not only this but it is weaker when wet and loses its shape if stretched, with some shrinkage over time.

Silk is mainly used for clothing and furnishings. It can also be blended with other fibres to give it a more rigid structure in curtains, rugs and bedding. Some lesser known uses of silk include parachutes (due to its lightness and strength) and some bicycle tyres (a silk woven strip coated in latex). Because silk is breathable, light and natural it has been used as garments for eczema sufferers to prevent irritation to their skin. Even some surgical stitches are made from silk. Scientists in Singapore have found a way to make silk so strong it can withstand bullets which means it could be used for body armour that is lighter and more flexible than traditional materials like metal and ceramic plates.

The production of silk is a long, costly process which is why the material that is made costs a greater amount of money than other fibres. It can average around $50 (NZD) per metre of fabric. In order to get 1 kg of silk thread, it takes 3000 Silkworm cocoons. China is the largest producer of silk in the world, making 54% of the world's silk, India is the second largest producer with 14%. Other countries that also produce silk include: Uzbekistan, Brazil, Iran, Thailand, Vietnam and Korea.

Silkworms feeding on mulberry leaves.

Bombyx mori or the Silkworm of the mulberry tree is the main domesticated silk producer. It is farmed following a very specific method and there is evidence that this insect has been farmed for over 5000 years. The moth of the Silkworm is a large white or silver grey hairy insect with a 5 cm wingspan. Despite these large wings, they can no longer fly. Females are slightly larger than males as they have to carry the eggs.

To make silk, male and female Silkworm moths are selectively bred together and the eggs collected. The eggs are kept in special incubator units until they hatch, which generally takes around 14 days. The larvae produced eat white mulberry tree leaves in large amounts and continue to eat continuously until they are ready to moult. Moulting is when animals remove their feathers, hair, horns, shells or outer layer. Silkworm larvae moult their entire outer layer much like a cicada, in order to allow them to grow bigger. Once they have moulted, they are called an 'Instar' which looks slightly different to the original larvae – they are white with little horned spikes down their backs. They continue to eat and moult a further three times. The Instar larvae then spin a thick, white cocoon of silk around themselves. Once inside the cocoon they are referred to as a pupa or pupae. The silk is made in their salivary glands and is extruded as two separate fibres that are then glued together with a protein called sericin. The cocoon that the silkworm makes is called a 'bave'. The job of the cocoon is to protect the silkworm while it is becoming a moth. When it has changed into a moth it releases a special enzyme (small proteins that break down or make chemical substances) that dissolves a small hole in the cocoon for the moth to escape and continue the life cycle.

Silkworm farmers don't want the moths to secrete the enzymes because they destroy the silk and cut it into small pieces. This silk can still be used for stuffing pillows and duvets but it is not worth as much money as it can't be spun into a thread for weaving. To stop this from happening, the farmers either put a pin into the pupae's head through the cocoon to kill it or they boil the pupae and cocoon in water, which also kills them. The boiling water also makes the silk easier to unravel. Each cocoon can contain silk in a single strand of up to 900 m. The silk is then spun into threads and woven into fabric. The pupae from inside the cocoons are

often eaten. In several Asian countries, the boiled pupa are roasted or fried with chillies or sweet and sour sauce.

The production of silk has come under some controversy in recent years. Animal rights groups like PETA are against the production, use and wearing of silk because the silkworm pupa are killed in the silk-making process and it has been compared to fur products. They recommend the use of alternative fabrics that don't require the death of the animal, such as wool or plant based fabric like cotton and linen.

Silkworm pupae cooked as food.

Wood and Natural Rubber

Wood being processed at a sawmill.

Wood is a structural component of stems and roots of woody plants such as trees. It is **porous** and full of strong, flexible **interlacing** fibres when green and strong rigid fibres when dried. Humans have used wood for thousands of years as fuel and a building material. Wood timber for construction is obtained from trees by a mechanical process, where the tree is cut down and the limbs are removed. This leaves a relatively straight trunk. The trunk is then cut lengthwise into long strips and the bark is removed. Any off-cuts from this process are often put into a large chipper and made into chips for gardening or **fuel pellets**. The long flat strips are then cut into planks of varying sizes; some are then treated with chemicals to ensure that they last when exposed to the weather outdoors. An untreated piece of wood will only take around 5 years to decompose whereas a treated piece of wood can last for 40 years. For other purposes such as paper, furniture and fuel in firewood is all cut from trees but the method after the initial felling may differ slightly.

Wood is a naturally occurring material that is composed of **cellulose** fibres which are very strong and found within a set of **polymers** called **lignin**. The structure of wood prevents it from being compressed and gives it great strength. Wood varies in its hardness, strength, colour and flexibility depending on the type of tree that it comes from. For example, mahogany is a hardwood that's strength makes it ideal for furniture. Balsa on the other hand is very light and flexible which is why it is so good for building models such as airplanes.

When using wood as a fuel, a hardwood is preferred because it burns for longer and produces less smoke. In construction, all ships and boats were made from wood up until the late 19th century as it is light and strong and can be shaped into a waterproof **hull**. As well as for transport, buildings are also made from wood as it is easily obtained and can be made into many shapes whilst still maintaining its strength. Buildings today, especially in New Zealand, are still often made of wood or have major components made from wood.

The top five timber producing countries in the world are the USA, India, China, Brazil and Canada. Just a quick look around most buildings and you will see many pieces of furniture and utensils made of wood, such as tables, shelves, chopsticks, toothpicks and chairs. At one time, wood was the main material used by humans but with the **advent** of plastics its uses have **diminished** but are not completely gone. Wood will always have a place in human society.

Tapped rubber tree.

Trees from the family Euphorbiaceae are a group that produce a sticky milky sap that is described as a **colloid solution**. This means a solution with **insoluble** particles **suspended** in it, much like milk. We have been using rubber for a long time and it is thought that rubber from trees was first used in 1600 BC to make a ball for a traditional Mayan game. Natural rubber in the right conditions will never decompose but humans haven't been using it long enough to test this fact. 81% of the world's natural rubber comes from the following countries: Thailand, Indonesia, Malaysia, India, China and Vietnam.

The trees have cuts made in their bark by hand and the fluid that seeps out is collected in containers for further processing. Trees that have been **tapped** (as it's called) don't die or become sick because the cuts are only into the bark not through to the wood inside. Each tree can be cut and have the sap removed many, many times throughout its lifetime and still continue to grow and be healthy. The rubber formed is called **latex**. Once collected from the tree it is **coagulated** (changed from a liquid to a gel) and dried to form bales which are then processed further and many rubber products are made. Rubber is useful because of its ability to be stretched, absorb energy and it is waterproof.

The latex from the tree sap has many uses. In fact, 42% of all rubber made each year is natural rubber and 70% of this is used to make tyres. The top quality latex is used to make medical gloves, condoms and balloons. There are numerous other uses for rubber but some of the main ones are hoses, machinery belts, flooring and glues in the paper and carpet industries. Also, rather obviously, rubber bands and erasers are made from latex rubber.

Natural rubber can weaken over time and is prone to **perishing**. In order to improve its durability, it can be **vulcanised**. Vulcanisation is where the latex is heated with sulfur and peroxide, and this also gives the advantage of improving the rubber's strength and elasticity.

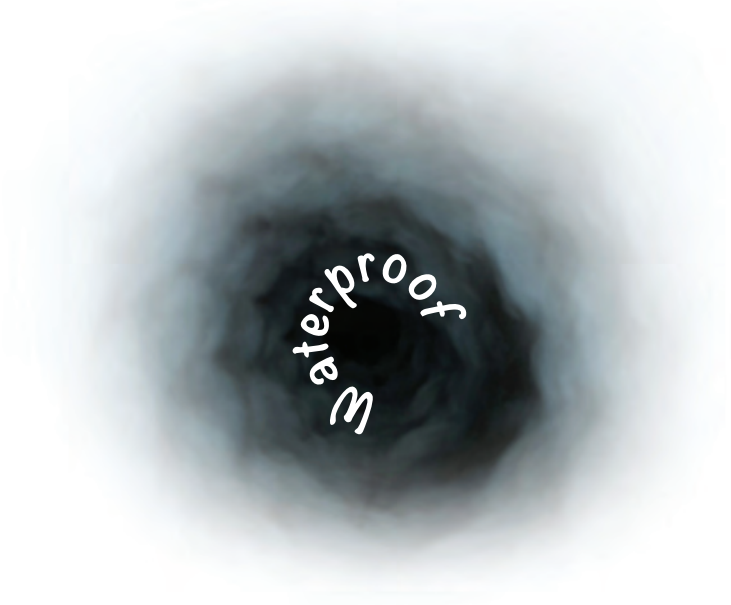
Other non-natural rubber is made from **petrochemical** sources which has its origins in oil. Due to the amount of oil on Earth **diminishing** rapidly, other sources are being sought that could keep some of the pressure for rubber off the rubber trees. Dandelions contain some latex in the milky white sap of their roots but it is in tiny amounts. German scientists have recently produced tyres from dandelion rubber using a newly developed technique.

Natural rubber sheets drying on a bamboo hanger.

Word Games

1. Terminology Tornado

Using the following science term, see how many words of 3 or more letters you can make in 10 minutes.



Points
3-4 letters = 1 point
5+ letters = 2 points

Scores
0-5 points = awful
6-10 = average
10+ = amazing

2. Six Word Scramble

Use the clues to work out what the 6 key science words are and then spell the word in the grid by colouring in the squares that make up the word. Use different colours for each answer.

NCY	DI	IC	MAL
AST	OYA	OPA	BU
QUE	LEA	UM	SA
LT	SO	PL	BLE

Clues

a. A reactive metal from group 1 of the Periodic Table. (6) _____
b. Property of metals that means they can be shaped. (9) _____
c. Non-metal mineral obtained from the sea. (4) _____
d. Another word for the ability to float. (8) _____
e. The opposite of transparent. (6) _____
f. A material that has replaced many traditional materials such as metal and glass... (7) _____

3. Block Buster

Cross out each of the words that fit with one of the clues. You will be left with one word that doesn't fit; this is your answer.

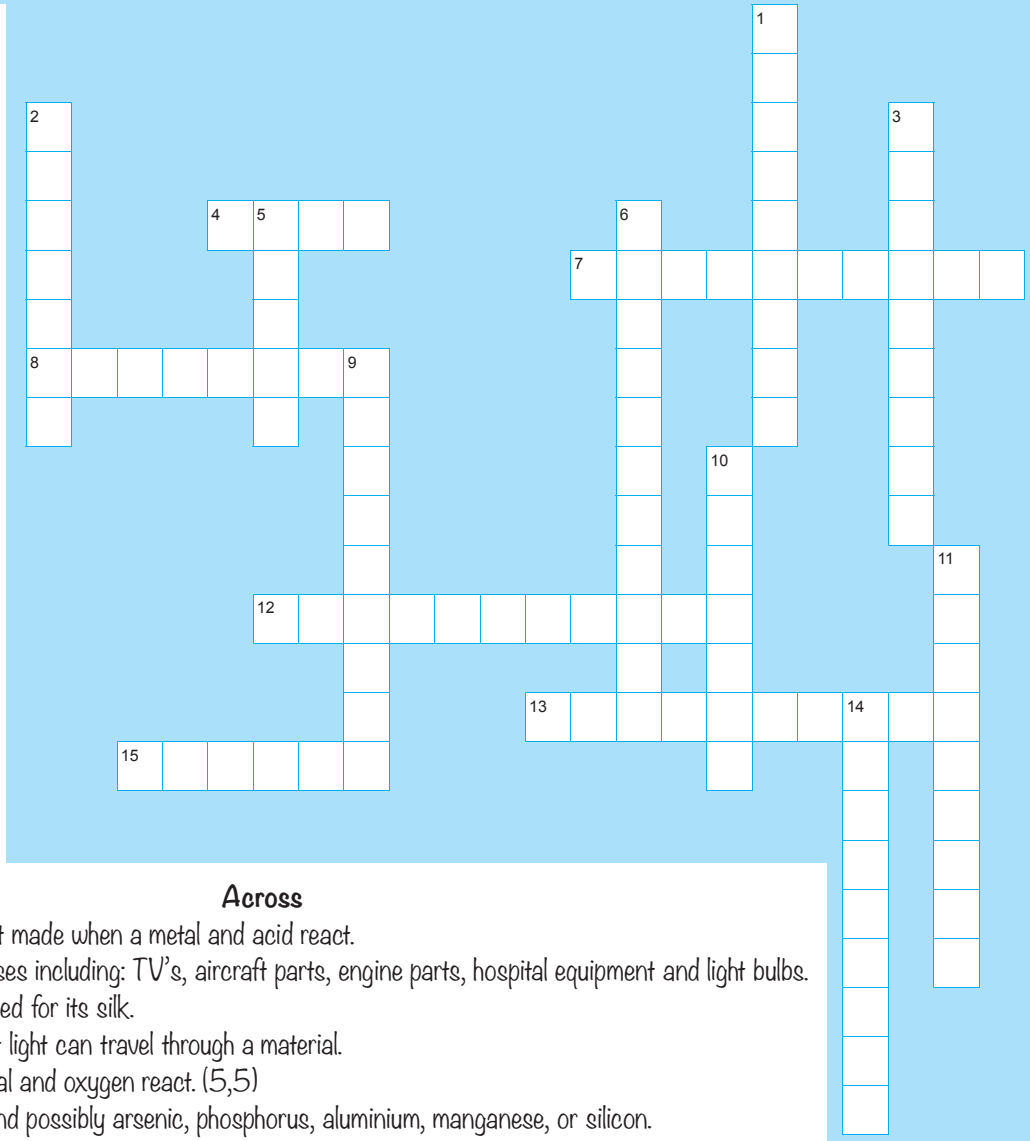
ductile	hydrogen gas	magnesium	conducts heat	potassium	durable
calcium	easily coloured	metal hydroxide	salt	beryllium	malleable
radium	lustrous	strong	long lasting	barium	metal oxide	strontium
dense	light	conducts electricity	high melting point	easily shaped	

Clues

a. Group 2 metals.
b. Properties of metals.
c. Properties of plastics.
d. Products of metal reactions.

Answer

4. Crossword



Down

1. A material that can take up a lot of liquid is said to be...
2. The test for hydrogen gas is called the... (3,4)
3. The twelfth element on the Periodic Table.
5. A material made from two or more different elements with a metal as the main part.
6. All metals do this as they allow heat energy to pass through them easily. (7,4)
9. Able to be bent and shaped without breaking.
10. Able to be stretched into a wire without breaking.
11. This turns cloudy in the presence of CO_2 gas.
14. The scientific name for rust.

Across

4. The non-gaseous product made when a metal and acid react.
7. A metal that has many uses including: TV's, aircraft parts, engine parts, hospital equipment and light bulbs.
8. An organism that is farmed for its silk.
12. This property means that light can travel through a material.
13. This is made when a metal and oxygen react. (5,5)
15. An alloy of copper, tin and possibly arsenic, phosphorus, aluminium, manganese, or silicon.

5. What's my Opposite?

Match each of the following properties with the picture that best shows the **opposite** of that property by drawing a line between them. Each word and picture is only used once.

opaque | hard | waterproof | conducts heat | flexible

6. Topic Word Find

R	E	M	U	L	O	V	E	C	V	T	T
O	O	U	T	M	G	C	D	O	C	N	P
T	N	I	O	P	G	N	I	L	I	O	B
A	S	C	L	A	A	E	S	O	T	L	N
L	U	L	E	G	L	A	P	U	E	I	T
U	B	A	E	T	R	G	L	R	N	O	N
S	M	C	T	S	N	L	A	L	G	S	G
N	E	I	N	I	N	D	C	E	A	S	S
I	R	O	T	N	U	E	E	S	M	C	I
B	G	L	A	T	E	X	D	S	G	N	O
C	E	B	U	O	Y	A	N	T	N	N	A
M	D	T	O	O	N	E	Y	T	T	E	U

Colour Key	Clue or Question	Answer
	The most reactive metal out of lead, calcium and zinc.	
	In density measurements, V is the symbol for?	
	An object is _____ if it has lots of particles close together.	
	When an object neither floats nor sinks completely.	
	When an object floats or sinks, the water that is shifted is said to have been...	
	Another name for natural rubber.	
	When a material breaks easily under pressure it is said to be...	
	If a material stops heat or electricity it is said to be an...	
	The temperature at which a liquid turns into a gas.	
	Having no colour.	
	This is high in metals which makes them excellent for cooking utensils.	
	Iron or cobalt are attracted to a magnet.	
	The ability to float is called being...	