Name:

Junior Science
Planet Earth

Downloadable Resource

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Mohs Scale

This is a **gauge** that uses the observable properties of different minerals and relates them to a number. It is similar in style to the surveys you sometimes fill out where you give your happiness with a product a rank from 1-5. They aren't actual measurements but rather **relative values**. Relative means that they are compared to each other to give an order, rather than being **classified** because of actual scientific values. Mohs scale takes common minerals or everyday objects and uses them to determine the hardness or scratch **resistance** of different minerals. While it isn't a precise measure, it is very useful because it can be done quickly, doesn't require expensive equipment, can easily be used in the field and gives an idea of the minerals present. Just remember, the numbers allocated to the hardness's are really just relative to each other, they give a rough order of hardness not an actual hardness measurement.

Mohs Scale	Mineral	Actual Hardness*
1	talc	1
2	gypsum	3
3	calcite	9
4	fluorite	21
5	apatite	48
6	feldspar	72
7	quartz	100
8	topaz	200
9	corundum	400
10	diamond	1600

As this table shows, the number given on Mohs scale doesn't correspond to the actual hardness of the mineral nor does it fit with the differences between the minerals. The difference between calcite and fluorite on Mohs scale is 1 but in reality the difference is 12. These numbers really do just give us an idea of what is harder than what. Minerals can fall in between the whole numbers shown here in the table. For example, emerald has a hardness of 7.5 and lignite of 2.5.

Common Object	Mohs Scale
metal file	6.5
copper coin	3.5
nail	6.5
glass	5.5
knife blade	5.0
fingernail	2.5

The best way to use the scale is by using samples of these minerals to scratch other unknown minerals. For example, if an unknown mineral can be scratched by topaz but not quartz, then it is likely to be 7.5 on the scale. If a second unknown mineral is tested with fluorite and no scratch is made, then apatite and still no mark is made but is scratched with feldspar, this unknown mineral is likely to be around 5.5. If minerals are the same hardness then a slight mark will be made. As samples of each mineral aren't always available, items such as copper coins, nails, glass or even a person's fingernail can be used. Special hardness picks can also be used, each one has a different tip with a range of hardness's, including plastic and copper.

This classification system was developed by the German **geologist** and **mineralogist** Friedrich Mohs in 1812. He was born in Germany and studied at the University of Halle and a mining academy. He had interests in Mathematics, Chemistry and Physics. Initially, Mohs worked in a mine but later used his mining skills and education to identify and classify minerals in an Austrian museum. Up until this point, minerals had been grouped according to their chemical makeup. Mohs began looking at the similarities in their **physical properties**. He took his idea for the Mohs scale from the ancient Greeks Pliny the Elder and Theophrastus. These two men had both made written reference to the physical properties of different stones and in particular their hardness's in 70AD and 200BC respectively. Mohs took the idea that diamond could scratch quartz (so therefore diamond must be harder than quartz) and created his scale. He ranked commonly found minerals in comparison to talc (very soft) and diamond (very hard) creating a range based on what scratched what.

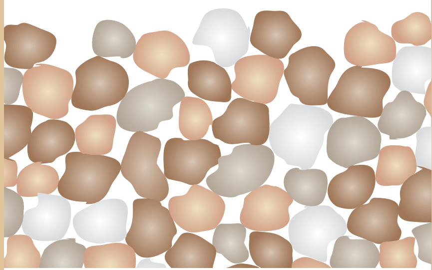
In today's world, geologists tend to use the chemical **composition** of minerals (in a more advanced manner than what Mohs would have seen in his day) to group and classify them as it is much more accurate. However, Mohs scale is still very useful when scientists are working out in the field for a quick relative classification.

**Actual hardness is found using a sclerometer which measures the width of a scratch made with a diamond.*

Quicksand

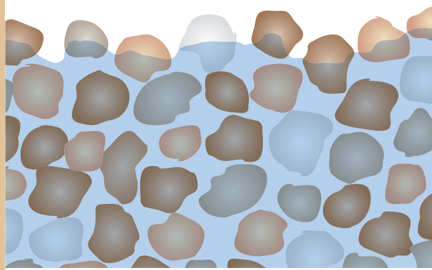
When you walk across the beach, you will notice that the dry sand (farthest from the water) holds your weight but it is quite hard to walk on because you do sink into it. However, as you get nearer the water, the wet sand holds you firmly and it is much easier to walk on. This phenomenon relates to how quicksand works.

Dry Sand



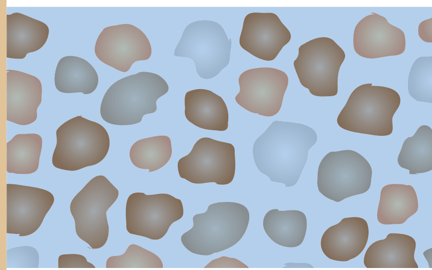
- The particles of dry sand are touching one-another as friction holds them together as a solid.
- Dry sand is able to withstand downward pressure, holding objects on top.

Wet Sand



- There are gaps between the particles of wet sand and water fills them in, holding it together very tightly.
- Wet sand is able to withstand downward pressure, holding objects on top.

Quicksand



- The particles of quicksand are separated and water surrounds each particle, resulting in very little friction.
- Quicksand is unable to withstand downward pressure so objects sink.

Newtonian fluids are those that behave as expected when under stress such as water. Non-Newtonian fluids, on the other hand, behave in odd ways. Take a mixture of cornflour and water for example. When you hit or squeeze the mixture (apply force to it), it feels solid. Yet if you slowly stir or pour it, it runs like a liquid. Both the cornflour mixture and quicksand are non-Newtonian. Quicksand behaves in an opposite manner to the cornflour mixture. Quicksand is made up of very fine particles (sand or silt), clay and water. It is a **shear-thinning non-Newtonian** fluid. Sheer-thinning refers to the fact that it gets thinner and more liquid when under stress or with movement/vibration. It is more solid with little force and more liquid with lots of force.

The make-up of quicksand is described using another set of scientific terms; **colloidal hydrogel**. An example of another colloidal substance is milk. The fat particles in milk are **dispersed** through a watery solution; they are essentially **microscopic** particles floating in a solution. Quicksand is made up of very fine silt or sand **suspended** throughout water. These types of suspension solutions don't tend to separate out if you leave them to sit. A hydrogel is a **matrix** of long compound chains that hold water in between them. Because of their structure, they are able to hold large volumes of water but not feel wet. An example of an artificial hydrogel is the material inside disposable nappies which is able to suck in and contain large amounts of urine. Quicksand is a naturally occurring hydrogel as it is composed of **miniscule** particles surrounded by water molecules.

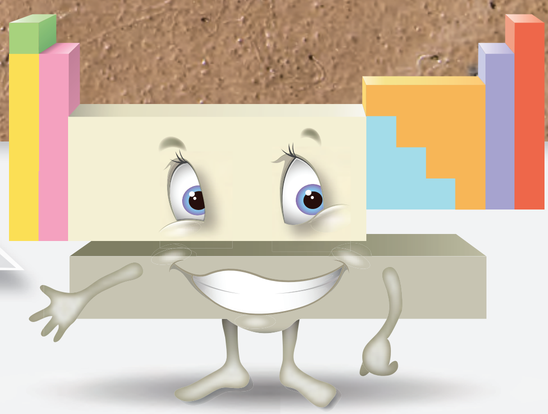
If you look at quicksand, it looks solid. Even if you walked slowly onto it, it would likely hold your weight for a short time. Quicksand acts like a solid when unstressed but as soon as it becomes stressed through rapid movement or vibration, it quickly changes to behaving like a liquid and like any liquid, it won't hold any weight.

Quicksand that is unstressed has equal dispersion of water and particles. → appears solid → Pressure of steps or addition of body weight. → liquid → Object sinks into liquefied quicksand. → solid → Object is trapped in the solidified quicksand. → solid → Struggle to get free from the quicksand. → liquid → Object sinks deeper into quicksand. → solid → Object becomes more trapped.

People who enter quicksand and sink due to their weight, need to keep calm, move slowly and make their body as flat as possible in order to increase their **surface area** and decrease the pressure their body is applying to the quicksand. If a person panics and thrashes around to try to escape, they will sink quite rapidly as the stress of their movement's causes the quicksand to undergo a sudden and rapid decrease in **viscosity**. Once the person has sunk into the quicksand, the water and sand separate which forms hard areas of sand that hold the limbs of the person tight. In order to pull themselves out, they need to apply a large amounts of force to the quicksand to turn it back into a liquid and get themselves free. Even if the person does panic, it is unlikely that they will sink below their waist as the quicksand isn't normally that deep. By moving slowly, the viscosity is increased and allows the limbs to be pulled out.

Despite what is shown on movies and TV shows, it really is unlikely that a person would be swallowed whole by quicksand because the human body actually floats better on quicksand than water. Quicksand has a density of 2g/mL and the human body has a density of 1g/mL (similar to water, the human body is around 75% water after all). Because the density of quicksand is greater than the density of the human body, the human body should float on it. The only reason it sucks people in is because their movements stress the substance and cause it to change from a solid to liquid and back again. While quicksand is unlikely to suck someone in and cover them completely, it can be dangerous. For example, if the person is on their own and has become tired from struggling in the quicksand, it could result in the person dying from **dehydration**, **hypothermia** or even drowning if tides come back in. The key thing to remember if you become stuck in quicksand, is to stay calm and move slowly.

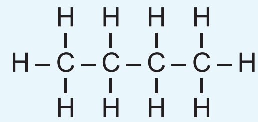
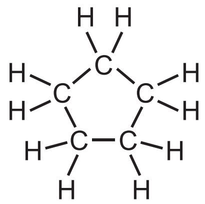
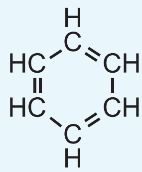
Check out this clip of Bear Grylls in quicksand...
youtube.com/watch?v=MJTGwZM05lQ



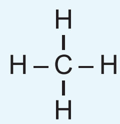
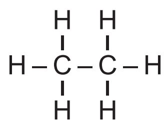
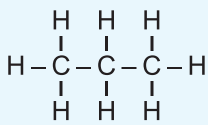
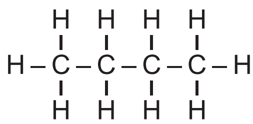
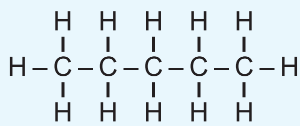
Oil

Crude oil is a thick black (sometimes brown, red or even yellow) liquid found deep within sedimentary rock beds. It was formed millions of years ago from the **decomposition** of dead organisms. The organisms that typically turn into oil are **algae** and **zooplankton** (small water-living organisms that feed off other plankton and **decaying** material). These organisms died and became covered by sediments which were compressed into sedimentary rocks. The decaying organisms were also compressed and heated, transforming them into oil.

Crude oil is primarily made up of **hydrocarbons** – long chains of carbon and hydrogen atoms. There is a large range of different hydrocarbons that make up oil but the most common groups are shown in the table below.

Group Name	Percentage in Crude Oil (%)	Description	Example Diagram
alkanes	30	Chains of carbon and hydrogen atoms.	
cycloalkanes	49	Rings of carbon atoms.	
aromatics	15	Hexagonal rings of carbon atoms.	
asphaltics	6	Carbon compounds that include H, N, O, S, V and Ni.	not applicable

In the ground, crude oil is often found beneath a layer of natural gas which consists of mainly methane. It is called 'natural gas' because it occurs naturally and is in gaseous form at normal **atmospheric** temperature. Crude oil is a high energy **yielding** fuel that can be separated into various products including petrol, diesel, LPG, jet fuel, **paraffin** and bitumen (asphalt/road tar). The key component in crude oil for these fuels are the alkanes. Alkanes are chains of carbon atoms **saturated** by hydrogen atoms. They can vary in length from one to around forty carbon atoms (though

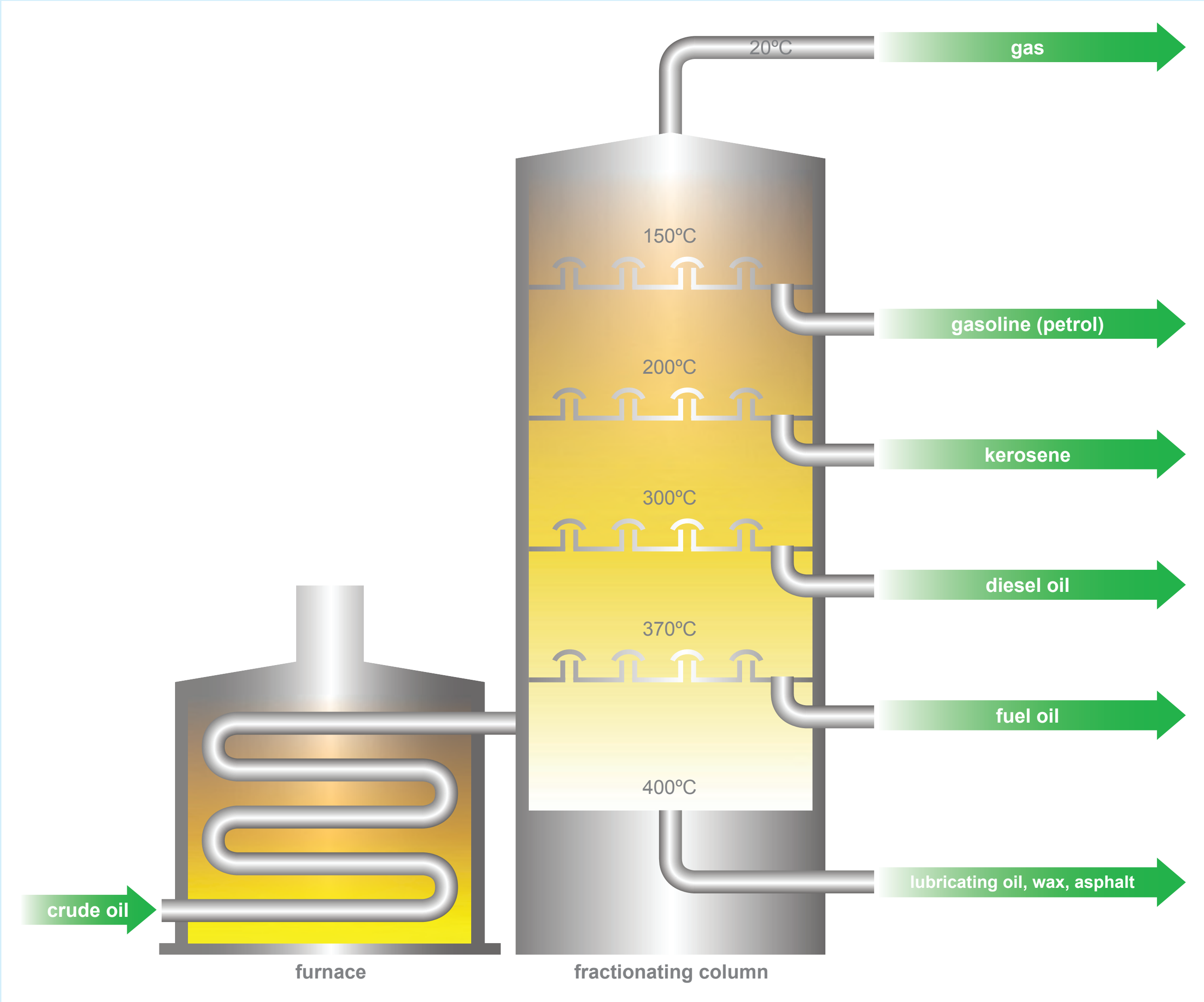
Number of Carbon Atoms	Number of Hydrogen Atoms	Formula	Example Diagram	Name
1	4	CH_4		methane
2	6	C_2H_6		ethane
3	8	C_3H_8		propane
4	10	C_4H_{10}		butane
5	12	C_5H_{12}		pentane

longer ones do exist). The first five are outlined in the table at the bottom of the previous page. They show a common trend in their ratio of carbon to hydrogen atoms which can be expressed as the equation: C_nH_{2n+2}

For example, methane with one carbon would be: $C_1H_{(2 \times 1)+2}$ which equals CH_4

If we looked at propane with three carbons then it would be: $C_3H_{(2 \times 3)+2}$ which equals C_3H_8

These different length chains are used for different products and need to be separated from the crude oil in order to be useful. Luckily, each one has a different **boiling point** (temperature that they turn from a liquid to a gas) which is determined by their chain length. The crude oil is put into a special apparatus called a **fractionating column** which carries out the process of **fractional distillation**. It is called 'fractional' because it splits the crude oil into fractions or parts.



The crude oil enters the column at its base where it has been heated to around 400°C. The longer chains of 25 carbons or more remain in liquid form and are removed to be used as paraffin or asphalt. The remaining alkanes (which are in gas form) rise up the tower to the higher levels. The next section is cooled to around 370°C and alkanes with 16 to 25 carbons **condense** (become liquid again) and are removed for fuel oil (oil that is used in heating and running furnaces). This process continues, removing different fractions along the way. The shortest chains (5 to 8) don't condense until they reach the very top where they are cooled to around 150°C. These chains are used for petrol production. Any remaining smaller chains (those under 5) exit out the top remaining in gas form. From here they can either be used to power the **refinery's** furnace, compressed to form LPG or burnt so as not to pollute the atmosphere. Some of these smaller gases have more specific uses; butane is used in cigarette lighters and propane for cooking, BBQ's and gas heaters.

It is fascinating to think that something made from dead and decaying **aquatic** life has been transformed into something humans have relied on for heating, cooking and transport for many, many years. Crude oil is an amazing material with a diverse range of uses but using it releases CO_2 gas. Is there another way to get the energy we need without relying on fossil fuels?

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.

VA	CR	RUS	ON
BDU	CTI	CA	WEA
THE	VES	EXT	LA
IVE	RING	UST	SU

Clues

a. Process where rock is broken down. (10) ____________
b. Igneous rock formed outside the Earth's surface. (9) ____________
c. Magma outside the Earth's surface. (4) ____________
d. The top layer of the Earth. (5) ____________
e. Formed by acidic water dissolving limestone . (5) ____________
f. When one tectonic plate goes under another. (10) ____________

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.

rain | nail | erosion | granite | basalt | knife

rhyolite | compaction | scoria | uplift | hail | melting

sleet | gabbro | high pressure | copper coin | schist | snow | glass

obsidian | pumice | deposition | fingernail | crystallisation

Clues

a. Processes in the rock cycle.
b. Types of igneous rocks.
c. Forms of precipitation.
d. Tools used in Mohs scale testing.

Answer

4. Topic Word Find

The following word find contains…

- 9 types of sedimentary rock.
- 8 layers of the Earth.
- 6 processes in the water cycle.

Find each of these in the word find below then write their names in the correct column in the table that follows.

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

Sedimentary Rocks	Earth's Layers	Water Cycle Processes