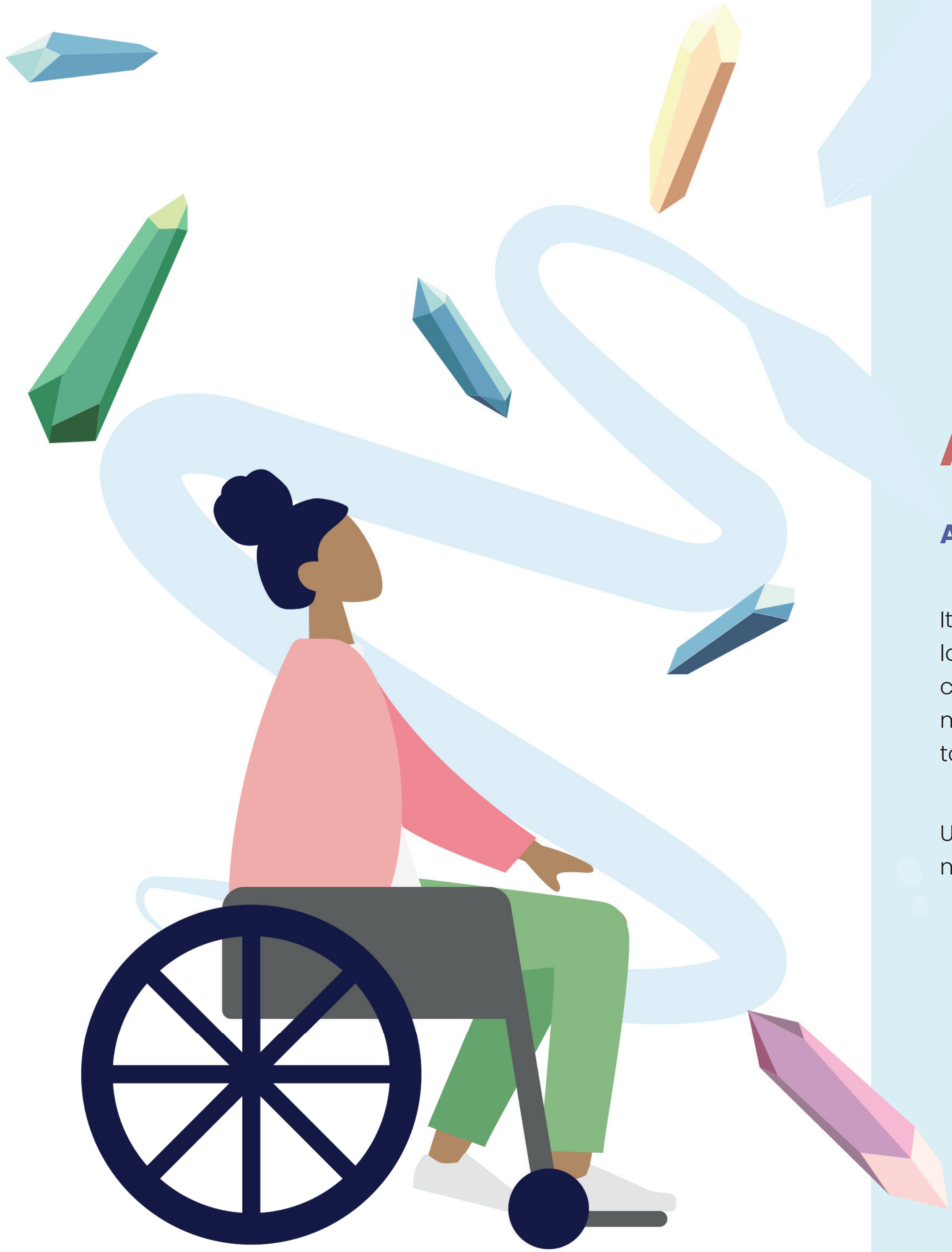

PRIMARY + STEM

Teaching Resource

ACTIVITY: Crystals

ACTIVITY OVERVIEW

It's hard to resist the beauty of crystals, produced naturally in such a large variety of colours and shapes. Whether it's adding to your own collection, fossicking on a walk, admiring beautiful specimens at the museum, or playing Minecraft, there is much that can be learnt on this topic.

Use crystals to teach about the chemistry of solids, liquids, dissolving, mixtures, properties, and reversible changes.

SYNOPSIS

It's hard to resist the beauty of crystals, produced naturally in such a large variety of colours and shapes. Whether it's adding to your own collection, fossicking on a walk, admiring beautiful specimens at the museum, or playing Minecraft, there is much that can be learnt on this topic. Use crystals to teach about the chemistry of solids, liquids, dissolving, mixtures, properties, and reversible changes.

Foundation – Year 2

- Everyday materials can be physically changed or combined with other materials in a variety of ways for particular purposes (VCSSU045)

Year 3 – 4

- A change of state between solid and liquid can be caused by adding or removing heat (VCSSU059)
- Natural and processed materials have a range of physical properties; these properties can influence their use (VCSSU060)

Year 5 - 6

- Changes to materials can be reversible, including melting, freezing, evaporating, or irreversible, including burning and rusting (VCSSU077)
- Solids, liquids and gases behave in different ways and have observable properties that help to classify them (VCSSU076)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity - Crytal painting

Mix a colourful, saturated solution of common salt and use this to create your own crystal painting. This is a fast way for students to see crystal growth and learn more about mixing materials and reversible changes.

Materials for 30 students

Teacher to prepare earlier:

1. 1 litre coloured saturated table salt solution
    - 750mL water
    - 1 cup table salt (sodium chloride)
    - Food dye
2. 1 litre coloured saturated Epsom salt solution
    - 750ml warm water
    - 2 cups Epsom salts (magnesium chloride)
    - food dye

Notes on solution preparation – Epsom salts can be found in the bathroom section of the supermarket.

The concentrated food dyes (in small bottles) work better than the dropper ones that come in a 4-pack.

If you have extra time and materials, it's fun to make two colours of table salt (e.g. red, and yellow), plus two colours of Epsom salt (e.g. green, and blue), so that the students can have more options for the painting part of the activity.

- Art paper (one piece per student) – this does not work using regular printer paper; it needs to be thicker
- Paintbrushes (one per student, but works better if you keep the brushes in the same colour and students don't move them around)
- Small cups/bowls for coloured solutions (one of each colour for each group of students). For example, if I have four coloured solutions and five tables of students, I will need 20 small cups/bowls
- Pens/pencils to write names on paper

Instructions

1. Show students the prepared saturated solutions, as well as the solid that was dissolved into water (salt and Epsom salt). Explain that these have been mixed. See further information about dissolving in the key themes section below.

2. Students to write their names on the paper (pen/pencil) and then paint a picture, using any combination of the coloured, saturated solutions. Make sure that you dip your brushes into the colour regularly. The painted sections should be shiny and wet, and not so spread out that they are already dry.

3. But try to avoid big puddly sections, as this may tear the paper. The teacher can direct painting by suggesting a theme appropriate to the class, such as plants, numbers, family, animals, and food.

4. Put the painting somewhere safe to dry (this can be sped up by putting it in a sunny or warm spot but should be dry in a few hours).

When dry, the table salt solution will look sparkly, with small cubic salt crystals formed throughout the painted section. The Epsom salt solution forms larger needle-like crystals.

How have these crystals formed?

The solid salts have been dissolved in the water. We can't see them in the coloured painting solutions when we paint them onto our page. But then the painting starts to dry, and the water is evaporating (changing from liquid water into water as a gas, in the air around us).

The salts can't stay dissolved in the water any more and they come out of the solution, where we can see them again. The thicker paper that we are using helps give the crystals a point to start forming on. Then lots of tiny salt molecules start hanging on to each other, like a class of children holding hands.

Usually, we get bigger crystals when they take longer to form, and when we have slower evaporation of water. But these crystals are pretty good for something that we can make in our classroom in less than a day!

If you leave some of the saturated salt solution in an open container (cup/bowl), eventually - when all the water present has evaporated - it will form crystals too. These slower-forming crystals will be larger than the ones formed in the crystal painting, although still the same shapes (cubes for table salt and needles for Epsom salt).

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation – Year 2

Sometimes when we mix things together, we can make something beautiful, like crystals! We can make our own crystals by combining salt, water, and food dye.

The crystals form when the water and salt unmix from each other and the salt is left behind. Usually, crystals take longer to form in nature, but this is a nice speedy way of doing this in our classroom.

We use a mixture of water, salt, and food dye as our paint. We can't see the salt when it is dissolved in the water, it's hiding in between all the bits of water.

Then we paint the crystal paint onto our paper. We know that paint is wet when we paint it onto paper, and then it dries. When water dries up, we say that it has evaporated. Evaporation is when liquid drops of water change into water as a gas, in the air around us. This is also what happens when our washing dries or puddles disappear.

Then, we have just the salt left on our paper. The bits of salt that are left all grab onto each other and form the crystal shape. Different materials have different crystal shapes. This is a fun mix and un-mix activity.

Students have seen that beautiful crystals can form when we unmix water and salts. Extend this knowledge by giving them a more complicated mixture to unmix. Mix together sand, salt, and corn kernels (unpopped popcorn) and challenge students to separate the materials.

Students needing more guidance can be given a choice of the following steps, while other students can be left with the materials and the problem to solve.

- Step 1 – Pick out corn with fingers or pick out sand with fingers? Corn.
- Step 2 – Pick out sand with fingers or add water and stir? Add water and stir.
- Step 3 – Pour salty water into a cup or pick out sand with fingers? Pour salty water. We can leave this and the water will evaporate, like our crystal paintings, leaving us with just the salt.

Years 3/4

Use this crystal painting activity to investigate natural materials that interest children (particularly those interested in the computer game Minecraft).

Crystals are an example of a natural material with particular properties (repeating pattern of atoms/molecules, formed under specific conditions). Crystals form predictable shapes and are found in many different colours and locations. There are many different coloured and shaped crystals found in nature.

Extend students' understanding of materials and properties, as well as the interest in computer games found in many children of this age by asking students to research crystals and minerals found in the game Minecraft, e.g. amethyst, calcite, ice, snow, diamond, emerald, gold, iron, quartz.

Years 5/6

When studying chemistry, students are often most interested in irreversible chemical changes (or reactions), making bangs, pops, and fizzes, rather than reversible physical changes. Use this crystal painting activity as an example of a reversible (physical) change, where materials are combined and then separated, without any chemical change, to form beautiful crystals.

This activity also increases students' understanding of solids and liquids through the chemistry of dissolving.

If time permits, conduct an irreversible chemical change to use as a comparison to the physical change crystals. Use cream containers (with coloured pop-off lids) to make mini volcanoes. Pour half a cup of vinegar into the container.

Place a teaspoon of bicarb in one layer of tissue. Quickly, drop the tissue into the container and place the lid on.

Step back! Watch as bicarb soda reacts with vinegar in a chemical change, forming carbon dioxide gas that pushes the lid off the container with a bang. Note – never trap vinegar and bicarb inside a container with a screw top lid.

Reversible (physical) change

In our crystal painting, we see the salt mixed with the water, then separated, as the water leaves and salt crystals are left behind. This is a reversible change. We have not made any new products. It is just salt, and water being mixed and unmixed.

Irreversible (chemical) change

What is happening with the vinegar/bicarb explosions here? This is an irreversible change, a chemical reaction, where new products are being made. We start with bicarb and vinegar but end with carbon dioxide gas being formed. When we look at solids, liquids, and gases, we know that gases have the most energy. The carbon dioxide gas formed tries to spread out to fill as much space as possible, pushing the lid out of the way with this energy.

DISCUSSION SECTION AND KEY THEMES

What is a crystal?

Crystals are solids – they have fixed shapes and volumes. Examples of crystals include snowflakes, diamonds, and table salt.

But what makes crystals different from other types of solids?

Crystals are the result of:

- repeating patterns of identical atoms or molecules
- the right conditions (i.e., high temperature and pressure, formed over long periods of time)

The scientific study of crystals is called crystallography.

Diamond is a well-known crystal. It is made of carbon, as are coal and graphite (found in our lead pencils). How do we end up with three very different materials made from the same thing?

Natural diamonds can only form under particular temperature (over 105°C) and pressure (more than 150km below the Earth's surface) conditions and are made of carbon atoms, arranged into tetrahedral shapes. Diamond is the hardest known material on Earth (no other material can scratch it), is transparent, we use it to break other materials and as an abrasive (yes, a member of your family may have use diamonds to remove rough dead skin from the heels of their feet, but diamond may also be found in drilling or grinding tools).

Coal is formed from plants that have been under pressure and heat for millions of years, and contains other minerals (hydrogen, sulphur, oxygen, nitrogen).

Graphite is also made solely from carbon atoms. But due to formation under different temperatures and pressures, these atoms are arranged in a honeycomb-shaped lattice. Layers are easily removed from this shape, which is how we use it to write on paper.

Crystal formation

Scientists describe crystals as growing, even though they are not alive. Many crystals are formed underground, from water containing dissolved minerals.

As water leaves the mixture, slowly the minerals come back out of the solution, as they can no longer remain dissolved in the reduced amount of water. These minerals join onto each other, arranging in a repeated pattern, to form crystals. Crystals start off small and then increase in size as more and more atoms join in a repeated pattern.

Scientists think the Earth's core may be an enormous crystal of iron, over 2000km in diameter, which would make it the largest crystal on Earth. The Cave of Crystals in Mexico contains huge crystals of gypsum, about 11m long.

Crystal shapes

There are seven main identified crystal shapes, based on their edges, size and shape of faces, and the angles between these.

These are the natural shapes that all crystals form. Because colour alone can't be used as a reliable identifier, shape is one of the ways that crystals can be identified by. Here are a few examples of the different crystal shapes:

- **Cubic** - halite, table salt, diamond
- **Orthorhombic** – sulphur
- **Monoclinic** – mica, gypsum
- **Triclinic** – feldspar
- **Trigonal** – ruby, quartz, calcite
- **Hexagonal** – ice, quartz, calcite, emerald, graphite
- **Tetragonal** – zircon, rutile

The shape of a crystal depends on the conditions of its formation, including the temperature and pressure. Because of this, some minerals can form more than one crystal shape.

What are crystals used for?

For many years, people have used crystals for jewellery, ornamentation, and abrasives to assist in sawing into rock and stone.

Now, we can manufacture crystals, growing them in laboratories and factories. Synthetic (man-made) crystals are stronger, cheaper, and easier to obtain. Natural crystals are still valued highly for their beauty and are found in jewellery and ornamentation.

Synthetic diamonds are used in saws, drills, and polishing other gems. Tiny diamonds are also used in beauty products, such as nail files and dry skin exfoliators.

Synthetic quartz, ruby, and sapphire are used in watchmaking.

Synthetic ruby is used in ruby lasers, and used in cosmetic surgery to remove tattoos, birthmarks, and freckles.

Synthetic quartz (very small thin pieces) can be used in electronics.

Dissolving

When a solid is mixed with a liquid, sometimes it dissolves. If the solid (e.g. salt, sugar) spreads throughout water and/or disappears it has dissolved. Not all things dissolve in water. Sand does not dissolve in water; it does not spread out or disappear.

Dissolving occurs because water can 'rip apart' and surround chemicals like baking soda, salt, and sugar. While atoms and molecules of can be 'ripped apart', nothing new is made. This is why dissolving is a physical change.

We can compare solids dissolving in water to a hotel. We can imagine that a cup of water is a like a hotel, with lots of empty rooms inside (the spaces between the water molecules).

When a material like salt is mixed with water, its molecules are ripped apart and sent into different hotel rooms. We can dissolve more and more salt until all of the 'hotel rooms' are full. When there is no space left for salt to dissolve, we say that it is a saturated solution. This is a fully occupied hotel! Crystals form from saturated solutions.

Evaporation

Evaporation is when liquid water changes to water as a gas. Energy (heat) must be added to liquid water for this to happen. We describe this process as a change of state. Children experience evaporation in their everyday lives when they observe puddles drying up or wet washing drying.

Solids

In primary school, students learn about three states of matter – solid, liquid, and gas, with the main example of change of state given as water.

Solids have a fixed volume and shape. Some examples of solids are a chair, book, person, and glasses. These materials will remain the same shape and take up the same amount of space, no matter where they are placed.

Matter can exist in different forms, also known as states of matter. Depending on how much energy they possess, the same atoms and molecules may exist in different states, with each state showing very different properties. Because the atoms and molecules themselves do not change while they change states, this process is considered a physical change.

Minerals, crystals, rocks, stones – what's the difference?

A mineral is a natural inorganic substance with a regular crystal structure, and a distinctive chemical composition.

- **natural** – not made by people
- **inorganic** – not made from anything that was once living
- **distinctive chemical compositions** – minerals are always made from the same chemical elements, e.g. quartz is always made from silicon and oxygen

From this definition, we can see that all naturally formed **crystals are minerals**. Sometimes, a mineral can form different shaped or coloured crystals, depending on the temperature, pressure, or trace elements present. For example, quartz can form differently coloured crystals.

Rock is a solid material that is part of the Earth's surface. In writing, the words rock and stone are often used to mean the same thing. However, stone is generally used to describe a smaller piece of rock, related to building.

QUESTIONS AND ANSWERS

What's the difference between crystals and gems?

A gem, gemstone, or precious stone is a mineral valued for its beauty, that has usually been cut and polished. This is not a scientific classification. Some gems are not crystals.

What other crystals can I paint with?

You can try crystal painting with other dissolvable solids found in your home, including sugar, bicarb, or borax (be careful if using with children).

Remember that you need to mix up a saturated solution (one where all the hotel rooms are full!) if you want crystals to form when the water evaporates. The easiest way to do this is to use warm water and keep adding a spoonful of your solid at a time until you can't get any more to dissolve.

You might like to experiment with the needle-like Epsom salt crystals and see what happens when you dry them at different speeds. Which crystals look the best – dried in the sun or the shade? Under the heater or in a cold place? With a hair dryer or with no extra help?

Are all the minerals in Minecraft real? (Is redstone a crystal?)

There are a lot of materials in Minecraft that exist in the real world. However, redstone and glowstone do not actually exist (sorry!). You can read more about the rocks and minerals of Minecraft on this website – https://www.mindat.org/a/minecraft

True minerals found in Minecraft include amethyst, calcite, diamond, emerald, gold, iron and quartz.

How are there so many different coloured crystals?

Different crystals are formed from different minerals, which can be many different colours. However, what is more interesting are minerals like quartz that can form in a variety of colours.

This is due to tiny amounts of other minerals being present. Quartz is made from silicon and oxygen atoms ($SiO2$), which on their own form transparent crystals. But if you have a tiny amount of iron dissolved in the water with silicon and oxygen, when crystals form, they will have a purple colour – we call this amethyst. Other minerals that can influence colour include titanium (blue), nickel or chromium (green), manganese (pink).

Note - sometimes people selling gems will colour them to make them look more attractive.

Where are the best places to find crystals in Australia?

If you want to look at great crystal and mineral collections, head to your local museum or university.

In Melbourne you might visit Melbourne Museum and the Dynamic Earth gallery, or contact your local university, where they may have displays of their mineral collections accessible to members of the public (e.g. Rock Garden at Monash University, F.A. Singleton Earth Sciences Collection at The University of Melbourne).

You can find out more about the places crystals are mined in Australia at this website - https://www.ga.gov.au/education/classroom-resources/minerals-energy/australian-mineral-facts/australian-gems including a map and further information about the minerals found the most in Australia. These include diamonds, opals, sapphire, ruby, emerald, garnet, topaz, and jade.

Note – opal is not a crystal, as it does not have the repeated pattern of molecules needed to be classified as a crystal. However, opals are beautiful gemstones.

People who search for minerals are known as prospectors or fossickers. In Victoria, you must have a license if you are over 18 years and want to search for minerals with hand tools. https://earthresources.vic.gov.au/licensing-approvals/fossicking This website includes information about licenses and locations that are good for fossicking in Victoria.

Does the temperature make a difference to crystals?

Temperature is crucial to the development of crystals, both in nature and in the ones we grow in our classrooms.

In nature, we see a wide range of temperatures that are needed for specific crystals to form. Tiny ice crystals, forming high up in the sky, become the snowflakes that fall to the ground. These snowflakes can be made from just one, or as many as 200 ice crystals that have joined together.

You are probably familiar with the symmetrical snowflake patterns formed, although sometimes snowflakes can be flat, a column, or a prism shape too. The temperature must be below 0°C for ice crystals to form, gathering around tiny specks of dust up in the clouds.

An example that requires much warmer temperatures is the formation of emeralds. Emeralds form underground, from materials left dissolved in water after magma has cooled. Temperatures here are around 400 – 500°C and emeralds may take many years to form.

When we grow our own crystals, generally, we see larger crystals form when the drying time is slower. If our crystal paintings dry quickly, we are likely to see many small sparkly crystals throughout the painted area.

Is glass a crystal?

Glass is not a crystal. Some scientists classify glass as its own state of matter. Glass does not have a repeated organised pattern in the arrangement of its molecules, so it can't be classed as a crystal. Opal and obsidian are the same, with both materials described as having an amorphous (shapeless) structure. They can be beautiful and coloured but are not crystals. The main ingredient of glass is silica (sand).

Sometimes people think that their good collection of drinking glasses is made from crystal. But, when drinking glasses are described as being crystal, they are still not actually crystals. Crystal glasses have lead added, giving them slightly different properties to regular glass.

What crystals have the most amazing shapes?

Different chemicals make different crystal shapes. This is because atoms and molecules arrange themselves in a shape that makes them most stable.

Naturally formed crystals will always form in the shapes of the seven groups listed above. However, if you go to a shop selling crystals, you will see that they can be shaped by people. Minerals can be tumbled (turned in a machine with water and grit), to give them smooth surfaces. Here, we are copying the weathering processes found in nature.

Think about the smooth rocks that you find in rivers or on beaches, where water has rounded them over time. These smooth tumbled minerals are popular for jewellery making.

You may also see spheres, or even small animals, shaped from some minerals.

Browsing a book about crystals and minerals is a great way to see different shapes. Be careful when searching for information about crystals online, as there is a lot of non-scientific information about the use of crystals in healing.

How do I make bigger crystals?

If we keep supplying saturated solution to our crystal (e.g. top up the liquid) move to a new container containing the saturated solution, we can keep it growing.

The crystals that we form on our crystal paintings are tiny. But, if we leave a container of saturated solution to dry out, we will get bigger crystals. Remember, we know that crystals need to dry slowly to grow bigger. People growing sugar crystals at home have had good success with large crystals.

Can I grow crystals that I can eat?

Yes, it is easy to grow your own sugar crystals at home. As long as you use clean equipment, you can safely eat sugar crystals. There are many instructions for doing this available online. Here's one with easy-to-follow steps: https://littlebinsforlittlehands.com/grow-sugar-crystals-rock-candy/

OUTSIDE OR SUPPLEMENTARY READING

The rocks and minerals of Minecraft

https://www.mindat.org/a/minecraft

For kids (or adults) who are interested in the science of Minecraft, this website provides great information comparing naturally occurring minerals in real life to those found in Minecraft.

Crystal shapes (Australian Museum)

https://australian.museum/learn/minerals/what-are-minerals/crystal-shapes

Australian gem information (Australian Government)

https://www.ga.gov.au/education/classroom-resources/minerals-energy/australian-mineral-facts/australian-gems

Australian mineral information (Australian Government)

https://www.ga.gov.au/education/classroom-resources/minerals-energy/australian-mineral-facts

Recreational fossicking and prospecting (Victorian Government)

https://earthresources.vic.gov.au/licensing-approvals/fossicking

A crystal experiment to try at home (Scientific American)

https://www.scientificamerican.com/article/bring-science-home-crystals/

Lack of scientific evidence for crystal healing

https://www.livescience.com/40347-crystal-healing.html

TOPIC WORDS

- crystal
- solid
- liquid
- dissolve
- saturated
- solution
- mixing
- mineral
- chemistry
- reversible
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