1. Rocks and Minerals

To earn this badge, you should demonstrate how to identify many of the most common minerals and learn the basic rock types. Other activities you might choose involve learning about crystals and growing crystals and your State Rock, State Mineral, or State Gemstone. This unit also helps you start building, curating, and maintaining your own rock and mineral collection.

Activity 1.1: Learning the characteristics of minerals.
Buy a book or pick one up at the library or turn to websites to learn all about minerals. Make a chart of common minerals and their characteristics in terms of things such as color, streak, cleavage, fracture, luster, hardness, crystal shape, and weight (or specific gravity). In your chart, list various common minerals down the first column, then have separate columns to note characteristics of each mineral.

Activity 1.2: Making and using a mineral ID kit.
Make a mineral ID kit that will allow you to demonstrate familiarity with characteristics of minerals such as color, streak, hardness, relative weight, reaction to a weak acid solution such as vinegar, etc. Using your mineral ID kit, along with a chart of mineral characteristics, successfully identify at least a half dozen minerals presented by your youth leader.

Activity 1.3: Building a mineral collection.
Build a collection of 10 to 20 minerals. Some collectors focus on a single mineral with specimens from around the world to show different forms. A quartz collection might include amethyst from Brazil, clear crystals from Arkansas, smoky quartz from Pikes Peak, cairngorm from Scotland, and rose quartz from South Dakota, California, or Switzerland. Other collectors concentrate on a local area and collect all the minerals that might be found in one quarry, city, county, or state. Still others focus only on self-collected minerals. Most of us opt for variety and collect a little bit of everything. Whichever form you choose for your collection, be sure to follow the basics of good curation: label each specimen and keep a catalog with key information about what it is and where it came from. (See Badge 5: Collecting.)

Activity 1.4: The three rock types.
Learn about and describe the three basic rock types (igneous, sedimentary, and metamorphic) and build a collection with samples of each type. (See Badge 10: Earth Processes.)

Activity 1.5: Crystal shapes.
Draw crystal shapes and/or make crystal models with blocks of styrofoam or with styrofoam balls and dowels, with construction paper or cardboard or other materials, or with a 3D printer, which you can sometimes find in a library. Some common crystal shapes are cubic, hexagonal, orthorhombic, monoclinic, triclinic, tetragonal, and trigonal. Construct as many different varieties as you can.

Activity 1.6: Growing crystals and making geodes.
Using a material that dissolves in water like sugar, table salt, borax, or Epsom salts, grow different forms of crystals, create an "eggshell geode," or craft a stalagmite.

Activity 1.7: State rocks, minerals, and gemstones.
Just as each state has its own flag, many have a State Mineral, a State Gemstone, and/or a State Rock. Find out what your state rock, mineral, or gemstone is and write a report about it for your club newsletter or talk about it at one of your club meeting. If your state doesn't have an official mineral or rock, write to your governor and state legislature to nominate one!

Activity 1.8: The elements.
Learn what an element is and about the periodic table of chemical elements and how each element is classified into different groups (transition metals, halogens, etc.). Then pick one of the following activities to complete: 1) pick an element and write about its traits and properties; 2) write about what makes each group of elements different than the others and the properties of the elements in that group; or 3) make a collection of "native element minerals." If you choose to make a collection, be sure to follow the basics of good curation. Label each specimen and keep a catalog with information about what it is and where it came from. Identify on your label what the atomic number and chemical symbol are for each native element mineral in your collection. (See Badge 5: Collecting)

Activity 1.9: Name that mineral!
With your youth leader serving as the moderator, participate with fellow club members in a panel like a TV game show. The moderator will describe characteristics of rocks and minerals and their uses. The participant who can name the most correctly wins! To prepare, review Activity 1.1 on the characteristic of minerals and Activity 2.1 on everyday uses of minerals.

1. Rocks & Minerals

□ 1.1 Learning the characteristics of minerals

□ 1.2 Making and using a mineral ID kit

□ 1.3 Building a mineral collection

□ 1.4 The three rock types

□ 1.5 Crystal shapes

□ 1.6 Growing crystals and making geodes

□ 1.7 State rocks, minerals, and gemstones

□ 1.8 The elements

□ 1.9 Name that mineral!

To earn your Rocks & Minerals badge, you need to complete at least 3 of the 9 activities. Check off all the activities you've completed. When you have earned your badge, sign below and have your FRA leader sign and forward this sheet to the AFMS Juniors Program chair.

_____
Date completed

_____ _____
My signature Youth leader's signature

_____
Name of my club

Leader's preferred mailing address for receiving badge:

_____

_____

_____

Back-up page 1.1: Learning the characteristics of minerals.

Definition: A **mineral** is a solid chemical element or compound which:

1) occurs naturally;
2) is inorganic (not a product of biological or life forces);
3) has a definite chemical composition; and
4) has an orderly atomic structure often expressed in a crystal form.

For instance, graphite and diamonds (made of carbon) are considered minerals but coal (also made of carbon) is not because coal is an organic product that formed from fossil remains of plants, or once-living organisms.

Kids should learn to identify several common minerals using simple tests of physical properties such as color, streak, luster, crystal shape, cleavage, fracture, hardness, chemical reactivity, and weight, or specific gravity. To help them, you should direct them to a rock and mineral guidebook and encourage them to buy at least one for their own reference. Many good ones are available to purchase at all levels of pricing or to borrow from a library. Here's just a sampling from the seemingly endless supply:

- Bonewitz, *Smithsonian Rock & Gem* (2005)
- Chesterman, *National Audubon Society Field Guide to North American Rocks & Minerals* (1978)
- Cook, *Minerals & Gemstones: 300 of the Earth's Natural Treasures* (2007)
- Eid & Viard, *Minerals of the World* (1995)
- Farndon, *The Complete Guide to Rocks & Minerals* (2006)
- Farndon & Parker, *The Complete Illustrated Guide to Minerals, Rocks & Fossils of the World* (2012)
- Fuller, *Pockets Rocks & Minerals* (2003)
- Hurlbut, *Dana's Manual of Mineralogy* (1971—or any recent edition or reprint)
- Jackson, *What's that Rock or Mineral? A Beginner's Guide* (2014)
- Korbel & Novák, *The Complete Encyclopedia of Minerals* (1999)
- Lagomarsino, *A Pocket Guide to Rocks & Minerals* (2008)
- Peck, *Mineral Identification: A Practical Guide for the Amateur Mineralogist* (2007)
- Pellant, *The Complete Book of Rocks & Minerals* (1995)
- Pough, *Rocks & Minerals: Peterson Field Guide* (1996)
- Roots, et al., *The Nature Companion's Rocks, Fossil & Dinosaurs* (2002)
- Schuman, *Handbook of Rocks, Minerals, & Gemstones* (1993)
- Simon & Schuster's *Guide to Rocks & Minerals* (1978)
- Zim & Shaffer, *Rocks, Gems, & Minerals: A Golden Guide, Revised* (2001)

The "official" book for use in naming and labeling minerals entered into Federation-sponsored competitions is *Fleischer's Glossary of Mineral Species* (from The Mineralogical Record, www.mineralogicalrecord.com). For one-stop shopping, distributor Gem Guides Book Company (www.gemguidesbooks.com) offers a whole

range of books on all topics rock-related, as does the annual Lapidary Catalog of Kingsley North, Inc. (www.kingsleynorth.com).

Farndon's *e.guides Rock and Mineral* (2005) combines the traditional print content of a book with links to websites offering interactive multimedia, games and quizzes, and downloadable images. And since I've now transitioned to websites, any number of them have sprung up to assist with mineral ID. One fun one is "Yup…Rocks," www.yuprocks.com. Another one geared specifically to kids is "Mineralogy4Kids" at www.mineralogy4kids.org/mineral-identification. In addition to providing an interactive way for kids to identify a mineral by going step-by-step through a series of questions, this website also has sections on crystals, the rock cycle, uses of minerals, etc. Another site geared to kids and to interactive learning is "The Learning Zone" from the Oxford University Museum of Natural History: www.oum.ox.ac.uk/thezone/minerals/. Finally, the mineral identification website that has become a standby for rockhounds young and old is the Mineral Database, www.mindat.org. (Guide your kids to these and other websites when working on Badge 15: Rocking on the Computer.)

Here are some basics of mineral identification:

- ***Color*** can be the most striking aspect of a mineral, and some can be identified by color. For instance, malachite is always green, azurite is blue, realgar is red. But color alone is usually not enough. For example, quartz occurs in many colors caused by minute impurities and may be clear, cloudy (milky quartz), yellow-orange (citrine), purple (amethyst), pink (rose quartz), a sparkly green (aventurine), etc.
- ***Streak*** is the color left when a mineral is scratched on an unglazed porcelain tile plate. This can surprise you in that it is sometimes very different from the mineral's outward color. For instance, silvery gray hematite leaves a red streak and golden pyrite a green-black streak.
- ***Luster*** is a reflective property of mineral surfaces. The way a mineral reflects light may make it look hard and shiny or dull or waxy. A mineral may be metallic (pyrite), adamantine (sparkling like a diamond), vitreous or glassy (quartz), silky (gypsum), waxy (jade), resinous, pearly, earthy, greasy, etc.
- ***Crystal shape*** is the characteristic appearance of a crystal, usually determined by the underlying atomic structure. Crystal shape may be cubic (pyrite or galena), octahedral (fluorite), rhombohedral (calcite), hexagonal (quartz), etc. For more on crystal shapes, see Back-up page 1.5: Crystal Shapes.
- ***Cleavage*** is the tendency of some minerals to split or break along characteristic planes corresponding to directions of minimum cohesion. For instance, mica cleaves in thin sheets, a form known as basal cleavage. Other common forms of cleavage include rhombohedral (calcite), cubic (galena), and octahedral (fluorite).
- ***Fracture*** is the manner in which a rock or mineral breaks if it doesn't exhibit cleavage. For instance, a break may be conchoidal (curved like a clam shell, as in breaks on obsidian), uneven (with a rough surface, e.g., lepidolite), or fibrous (splintery, e.g., ulexite).

- ***Hardness*** is the resistance of a mineral to scratching. The Mohs' scale is a relative measure of this property, comparing the hardness of ten different minerals from softest to hardest: 1 – talc, 2 – gypsum, 3 – calcite, 4 – fluorite, 5 – apatite, 6 – feldspar, 7 – quartz, 8 – topaz, 9 – corundum, 10 – diamond. To arrive at approximate hardness, you can use some common tools: a fingernail is hardness 2.5, a penny is 3, a pocketknife blade or steel nail is 5, glass is 5.5, a steel file is 6.5.
- ***Chemical reactivity*.** Some minerals will chemically react. For instance, a good test for carbonates (calcite, limestone, dolomite, etc.) is a drop of acetic acid, or vinegar. If it fizzes, it contains calcium.
- ***Weight, or Specific Gravity*.** To determine the weight, or specific gravity, of a mineral requires special equipment. Specific gravity (SG) is technically defined as the density of a mineral compared to the density of water. The light mineral borax has SG 1.7, whereas the heavy mineral gold has SG 19.3. For most purposes, kids can just judge the relative weight, or heft, of a mineral, whether heavy, light, or in-between.

Darryl Powell (aka "Diamond Dan") has prepared a wonderful variety of mineral identification resources you may wish to purchase to use with your club's kids in learning about minerals. These include *The World of Minerals & Crystals* (a coloring book introducing minerals from A to Z, with commentary on physical properties, forms, and uses in everyday life) and *Earth Digger Clubs* (a series of mineral-identification exercises in kits of one-hour activities, complete with patches as rewards for kids who complete an activity; kids learn about individual minerals such as calcite, pyrite, quartz, gypsum, or fluorite, as well as about properties of minerals such as hardness, color, crystal formation, etc.). These resources may be purchased from Diamond Dan Publications, c/o Darryl Powell, phone 585-278-3047, email diamonddan@rochester.rr.com, web address www.diamonddanpublications.net.

Another helpful partner in educating kids about the earth sciences is Myrna Martin, who began a home-based business called Ring of Fire Science Company LLC in Oregon (www.RingofFireScience.com). Inspired by the eruption of Mount Saint Helens 90 miles from her home, she crafted a set of lesson plans on volcanoes that grew into a whole "Hands-on Science" series. These include *Minerals: Hands-on Science*, which is beautifully designed and illustrated with easy-to-follow instructions for each activity along with "Teacher's Notes" that fill you in on lesson objectives, how the activity fulfills National Science Education Standards, and vocabulary with definitions.

For those who like to play games that also educate, check around for the Smithsonian Institution's *What Do You Know About Rocks, Minerals, and Gems? Quiz Deck.* It's a deck of cards, each with a colorful photograph and question on one side and answers on the back. It's published by Pomegranate Communications, Inc., www.pomegranate.com.

The following table provides you with a "cheat-sheet" of a wide variety of minerals and their various characteristics. In addition, we've provided a blank table you can copy and give to kids to fill in with different minerals they wish to test.

Back-up page 1.1: Table for Mineral Identification								
MINERAL	**COLOR**	**STREAK**	**CLEAVAGE**	**FRACTURE**	**LUSTER**	**HARDNESS**	**SHAPE**	**WEIGHT**
Apatite	Brown, yellow, green	White	Basal, imperfect	Conchoidal	Vitreous, greasy	5	Hexagonal	3.1-3.3
Azurite	Blue	Light blue	Perfect	Conchoidal	Earthy/dull	3.5-4	Monoclinic	3.8
Barite	Light blue, brown, yellow	White	Basal, perfect	Uneven	Glassy/pearly	3-3.5	Orthorhombic	4.4
Beryl	Clear, green, blue, golden	White or colorless	Basal, poor	Conchoidal	Glassy	7-8	Trigonal / hexagonal	2.6-2.9
Borax	Clear, white	White	Perfect	Conchoidal	Vitreous, dull, resinous	2-2.5	Monoclinic	1.7
Bornite	Bronze	Gray-black	None	Uneven	Metallic	3	Isometric (rare)	5
Calcite	Clear, white, yellow, blue	White	Rhombohedral perfect	Conchoidal	Glassy	3	Trigonal / hexagonal	2.7
Chrysocolla	Sky blue, green	White	None	Conchoidal	Glassy or waxy	2-4	Monoclinic	2-2.3
Cinnabar	Red, red-brown	Red-brown	Perfect in 3 directions	Uneven	Earthy	2-2.5	Hexagonal	8-8.2
Copper	Copper	Shiny brown	None	Hackly	Metallic	2.5-3	Isometric / Cubic	8.9
Corundum	Red (ruby), Blue , etc.	White	None; basal parting	Conchoidal	Glassy	9	Trigonal / hexagonal	4
Diamond	Clear & many colors	White	Perfect, 4 directions	Conchoidal	Adamantine to greasy	10	Isometric / cubic	3.5
Dolomite	White, gray, pink	White	Rhombohedral	Conchoidal & uneven	Vitreous	3.5-4	Hexagonal	2.8-2.9
Feldspar	White, yellow, pink, gray	White	2 perfect cleavages	Uneven	Glassy or pearly	6-6.5	Mono- or triclinic	2.5-2.7

Back-up page 1.1: Table for Mineral Identification (cont.)								
MINERAL	**COLOR**	**STREAK**	**CLEAVAGE**	**FRACTURE**	**LUSTER**	**HARDNESS**	**SHAPE**	**WEIGHT**
Fluorite	Clear, yellow, green, blue	White	Octahedral, perfect	Uneven, subconchoidal	Glassy	4	Cubic or isometric	3.1
Galena	Silver-gray	Gray	Cubic, perfect	Conchoidal	Metallic	2.5	Cubic	7.4-7.6
Garnet	Red, green, black, brown	White	None	Conchoidal	Glassy	6.5-7.5	Isometric	3.5-4.3
Gold	Golden	Yellow-golden	None	Hackly	Metallic	2.5-3	Isometric / cubic	15.6-19.3
Graphite	Black, dark gray	Gray-black	Basal, perfect	Fibrous	Shiny, metallic	1-2	Trigonal / hexagonal	1.9-2.3
Gypsum	White, yellow, brown, clear	White	Perfect	Conchoidal or splintery	Pearly, glassy	2	Monoclinic	2.3
Halite	White, pink, blue, clear	White	Cubic, perfect	Conchoidal	Glassy	2-2.5	Isometric / cubic	2.1-2.2
Hematite	Black, steel-gray	Red-brown	None	Uneven	Metallic	5.5-6.5	Trigonal / hexagonal	4.9-5.3
Jade	Green, white, black, purple	White	None	Uneven, difficult	Waxy or pearly	6.5-7	Monoclinic	3.2-3.5
Kyanite	Blue to white	White	Good, two directions	Splintery	Vitreous	5.5-7	Triclinic	3.5-3.7
Magnetite	Black	Black	None	Semi-conchoidal	Metallic	5.5-6.5	Isometric / cubic	4.9-5.2
Malachite	Green	Light green	Perfect, one direction	Conchoidal or splintery	Silky, dull	3-4	Monoclinic (rare)	3.9-4
Mica	Black-brown, clear	Gray-brown or white	Basal, perfect	Uneven	Pearly	2.2-3	Monoclinic	2.8
Olivine	Green-yellow, brown	White	Indistinct	Conchoidal	Glassy, vitreous	6.5-7	Orthorhombic	3.3-4.3

Back-up page 1.1: Table for Mineral Identification (cont.)								
MINERAL	**COLOR**	**STREAK**	**CLEAVAGE**	**FRACTURE**	**LUSTER**	**HARDNESS**	**SHAPE**	**WEIGHT**
Opal	White, varicolored	White	None	Conchoidal	Glassy, pearly	5.5-6.5	None	2
Pyrite	Brassy yellow	Greenish-black	Cubic & octahedral	Uneven	Metallic	6-6.5	Cubic / isometric	4.9-5.2
Quartz	Clear, pink, black, purple	White	None	Conchoidal	Glassy, vitreous	7	Trigonal / hexagonal	2.65
Serpentine	Green, black	White	Basal, perfect, or fibrous	Uneven or splintery	Waxy, silky	3-5	None	2.3-2.6
Silver	Silver, black	White, silvery	None	Hackly	Metallic	2.5-3	Isometric (rare)	10.1-11.1
Smithsonite	Green, brown, yellow	White	Perfect, rhombohedral	Uneven	Vitreous	4-4.5	Trigonal (rare)	4.3-4.5
Sodalite	Azure-blue	White	6 directions, poor	Uneven to conchoidal	Vitreous	5.5-6	Cubic (rare)	2.3
Sphalerite	Yellow, red, brown, black	White/yellow or pale brown	Dodecahedral	Conchoidal	Submetallic, greasy	3.5-4	Cubic / isometric	3.9-4.1
Sulfur	Yellow	Yellow	None	Conchoidal	Waxy, resinous	1-2.5	Orthorhombic	2-2.1
Talc	White, green, yellow, pink	White	Perfect, one direction	Uneven	Earthy, dull or greasy	1	Monoclinic (rare)	2.7-2.8
Topaz	Yellow, brown, pink, green	White	Basal	Uneven, subconchoidal	Vitreous	8	Orhorhombic	3.4-3.6
Tourmaline	Black, red, green, golden	White	None	Conchoidal	Glassy, vitreous	7-7.5	Hexagonal	3-3.3
Turquoise	Light blue, blue-green	Pale blue-green or white	None	Uneven or conchoidal	Waxy, earthy, or dull	5-6	Triclinic	2.6-2.8
Wulfenite	Orange-yellow, brown	White	Pyramidal	Subconchoidal	Resinous, adamantine	3	Tetragonal	6.5-7

Back-up page 1.1: Sample Table to Use for Mineral Identification (**Note:** not important that every box be filled for every mineral.)

MINERAL	COLOR	STREAK	CLEAVAGE	FRACTURE	LUSTER	HARDNESS	SHAPE	WEIGHT

Back-up page 1.2: Making and using a mineral ID kit

Following is the Moh's Scale and examples of some common tools kids can use to help judge the relative hardness of different minerals by creating their own mineral ID kit:

Moh's Hardness	Mineral	Common Tools
1	Talc	easily scratched by a fingernail
2	Gypsum	fingernail (hardness 2.5)
3	Calcite	copper penny (3 to 3.5)
4	Fluorite	easily scratched by a knife
5	Apatite	knife blade/steel nail/steel washer (5)
6	Feldspar	glass/a glass marble (5.5); steel file (6.5)
7	Quartz	easily scratches glass
8	Topaz	easily scratches glass
9	Corundum	easily scratches glass
10	Diamond	scratches all other materials

In addition to the tools noted in the above table, a mineral ID kit might include an unglazed porcelain tile for checking the streak of a mineral and a small bottle of acetic acid (vinegar) to test whether a mineral contains calcium carbonate.

See the table accompanying Back-up page 1.1 for info about various characteristics for a number of common minerals. A similar blank table is provided for you to copy and give to kids to use to complete a mineral identification exercise, or you can encourage them to create their own table listing just the characteristics they wish to test.

A good selection of minerals to present to juniors to demonstrate ability to identify minerals might include sulfur, pyrite, fluorite, quartz, hematite, galena, mica, and calcite. There are a number of ways of testing a kid's ability to identify minerals. The most basic is to provide kids individually with an assortment of minerals and to ask them to apply various tests. You might also create a bag of sand and gravel. "Salt" it with some of the minerals noted above and ask kids to screen out various minerals to identify. To make it challenging, include two specimens that look similar (for instance, a clear piece of quartz and a clear piece of topaz).

An even more fun activity is the "Mineral Identification Game." At a club meeting, have an assortment of a dozen to two dozen minerals spread out on a table, each with a number. Give kids sheets of papers with numbers down the side and ask them to go around the table identifying and writing down the names of each mineral matched to the appropriate number. Give them perhaps 15 minutes to do this before discussing the answers. This could be done individually, or kids could be divided into teams and this could be made into a contest to see which team gets the most correct answers.

In another version of the Mineral Identification Game, different mineral specimens might be put on a table along with mineral identification books. The first kid to identify a particular "mystery mineral" correctly gets to keep it. This is a definite motivator! Anyone winning a mineral steps out of the contest so that one child doesn't end up walking away with all the specimens.

Back-up page 1.3: Building a mineral collection.

Back-up pages for Badge 5 on Collecting provide information on building a collection. You should refer to those back-up pages for reference in assisting kids in satisfying Activity 1.3. For instance, there you'll find information about how to organize a catalog or logbook for an entire collection, how to create labels for individual specimens within a collection, and how to store a collection.

Note: *Kids can use this activity to satisfy requirements toward earning the Collecting badge simultaneously (Activity 5.1).*

Back-up page 1.4: The three rock types.

In this activity, kids would be expected to

a) explain the differences among the three basic rock types of igneous, sedimentary, and metamorphic and how these different rock types typically form;

b) identify specific examples of each rock type; and

c) build a small collection of representative samples.

The three basic rock types are:

- ***Igneous.*** Igneous rocks are formed by crystallization of magmas, either deep within the earth (intrusive igneous rocks: granite, gabbro, diorite, granodiorite) or extruded onto the surface (basalt, andesite, dacite, rhyolite, obsidian, pumice, scoria, ash).

- ***Sedimentary.*** Sedimentary rocks are formed by clastic sediments such as gravel, sand, or mud created by the eroding actions of wind, water or ice breaking down older rocks (examples: conglomerate, breccia, sandstone, siltstone, mudstone, shale) or chemically by minerals precipitating out of water (limestone, dolomite, evaporates such as gypsum, anhydrite, or halite). They might also be biologic in origins (coal, diatomaceous earth, chert).

- ***Metamorphic.*** Metamorphic rocks have been changed by heat and/or pressure and other earth forces and are classified as foliated (slate—formed from shale; schist—formed from shale that's been more intensely altered; gneiss—formed from granite) or non-foliated (quartzite—formed from sandstone; marble—formed from limestone).

Abdo Publishing provides three little books from their Core Library Rocks and Minerals series geared to kids in grades 3-5: Lisa Owings' *Igneous Rocks* (2015), Rebecca E. Hirsch's *Sedimentary Rocks* (2015), and Jennifer Swanson's *Metamorphic Rocks* (2015). The series includes still more books on crystals, fossils, gems, and the rock cycle. Each book includes glossaries, "Learn More" references to other books and websites, and links to more info on the publisher's website. It's a great basic series for both kids and adults!

For this activity, you might provide kids with the following fill-in-the-blank page to use.

Note: *Kids can use this activity toward satisfying requirements for the Earth Processes badge simultaneously (Activities 10.1, 10.3, 10.4, and 10.5)*

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The Three Rock Types & My Collection

Igneous rocks are defined as_____

My collection includes the following igneous rocks:_____

Sedimentary rocks are defined as_____

My collection includes the following sedimentary rocks:_____

Metamorphic rocks are defined as_____

My collection includes the following metamorphic rocks:_____

Back-up page 1.5: Crystal shapes.

Crystals come in wonderful and amazing shapes that are based upon their underlying chemical structure. Some common forms are cubic, tretragonal, monoclinic, triclinic, hexagonal, trigonal, and orthorhombic. The shape of a crystal is an important trait that can help you identify a mineral, so you should familiarize kids with these basic crystal forms. Here are brief descriptions of each:

- Cubic: very symmetric and orderly, shaped like a square cube, with 6 faces, or sides (note, however, that some are shaped like octahedrons—or diamond-shaped—with 8 faces, and still others are shaped like dodecahedrons, with 10 faces)

- Tetragonal: shaped like cubic crystals that have been stretched out along one axis.

- Monoclinic: these are shaped like tetragonal crystals that have been skewed or tilted in one angle.

- Triclinic: triclinic crystals are similar to monoclinic ones but aren't usually symmetrical from one side to the other; they can look like monoclinic crystals that someone stepped on and squished!

- Hexagonal: these crystals look like six-sided prisms; viewed from the top, they look like hexagons.

- Trigonal: similar to hexagonal, but possessing a 3-fold axis of rotation instead of the 6-fold axis of hexagonal crystals.

- Orthorhombic: these crystals look like two elongated pyramids stuck together, but they're skewed at a bit of an angle.

Because it can be difficult to visualize these systems using words alone, you should get a book illustrating different crystal forms and bring in pictures and samples of minerals that illustrate each (for instance, a cubic pyrite or fluorite crystal; a hexagonal quartz crystal).

A couple of activities provide kids with hands-on fun in learning about these shapes. In one, build crystal shapes using tinker toys or dowels and Styrofoam balls or gum drops and toothpicks. (Kids especially like the last option because they get to eat the results!)

Another way to illustrate crystal shapes in hands-on fashion is through making models by folding colorful construction paper, cardstock, or thin cardboard and pasting or taping them together. Darryl Powell (aka "Diamond Dan") has prepared a couple of great resources you may wish to purchase to use with your club's kids. These include *Corundum Carl's Great Crystal Adventure* (introduces crystallography and includes 13 crystal models that can be cut out and folded into 3-dimensional crystal shapes, along

with a recipe for growing crystals) and *Crystal Clips V* (a CD-ROM holding over 900 mineral and crystal drawings in both color and black-and-white in TIFF and JPEG formats). These resources may be purchased from Diamond Dan Publications, c/o Darryl Powell, phone 585-278-3047, email diamonddan@rochester.rr.com, web address www.diamonddanpublications.net.

The following website from the California Department of Conservation has links to a number of really neat masters you can download and print for free to then copy on paper or cardstock for kids to craft cut-and-fold 3D models of different crystal shapes: http://www.conservation.ca.gov/cgs/information/Pages/3d_papermodels.aspx.

Finally, another nice resource is Rebecca Hirsch's book *Crystals* (2015), a part of a whole series from Abdo Publishing called the Core Library Rocks and Minerals series geared to kids in grades 3-5.

Back-up page 1.6: Growing crystals and making geodes.

Growing Crystals.

Some minerals grow into crystals in water solutions. This process can be observed using readily available materials, such as sugar, salt, alum, and Epsom salts dissolved into a **saturated solution** in boiling hot water. A saturated solution contains the maximum amount of salt that will dissolve in a given amount of hot water.

Materials.

- Crystal-building material: sugar, table salt, Epsom salts (from a pharmacy), or powder alum (from the grocery store spice section). Other materials you might use include borax, photographic fixer, or saltpeter. Copper sulfate (from pool supply or hardware stores) is used to create blue chalcanthite crystals. With young kids, though, it's probably best to stick with basics, such as table salt or sugar.
- Water
- Measuring cups
- Spoon
- Cooking pan
- Glass jars
- Pebbles
- Stick or pencil
- String (cotton twine), cut into small lengths, with a paperclip tied to one end
- (optional) food coloring

Procedure.

1. Heat water to a boil, then turn off the heat.
2. If using table salt, mix one-half cup of salt into three-quarters cup of hot water. If using Epsom salts, mix one-half cup Epsom salts into one cup of water. If using alum, mix one-quarter cup alum into one cup of water.
3. Stir your solution. If all of your mineral dissolves, the solution is not yet saturated, and you should add a bit more mineral until no more will dissolve. (Note: you can make colorful crystals by adding a couple drops of food coloring.)
4. Place a few pebbles in the bottom of a glass jar and pour your solution over the pebbles. Or, tie string to a stick or pencil, pour your solution into a glass jar, and dip the string into the solution with a paperclip to weigh the string down, and leave it hanging there from the pencil.
5. Set your jar aside in a spot where it won't be disturbed and don't bump or bounce it. Check every so often the next few days. As water evaporates, you'll see crystals forming on your pebbles or string.

Assign different salts to different kids, and at your next monthly meeting, have everyone bring their jars to compare the different forms of crystals each produced.

In addition to home-made crystals, you can grow crystals using commercial crystal-growing kits. Check places like Ward's Natural Science (order their Earth Science and Geology catalogs; phone 1-800-962-2660 or check their web site at www.wardsci.com). Another source is Edmund's Scientific (1-800-728-6999; www.scientificsonline.com). Or check in toy stores, nature stores, or stores specializing in teacher supplies.

Making Geodes.

Geodes are round or elliptical rocks with an outer shell and a hollow interior lined with crystals, often quartz or calcite. With this fun crystal-growing activity, kids can make their own geodes using eggshells or walnut shells.

If using eggshells, carefully crack eggs and pick out the best halves, choosing ones that don't have any long cracks in them. Carefully peel away the "skin" on the insides of the shells with tweezers or by rubbing with your fingers. If using walnut shells, crack a number of walnuts in half, clean out the meat, and choose shells lacking any long cracks.

Next, set your eggshell or walnut shell halves in egg cartons, where they'll be stable and secure. Using the same recipes described earlier for growing crystals, prepare a crystal-growing solution and pour or spoon a little into each egg- or walnut shell. Set the egg carton aside in a warm, dry spot where it won't be disturbed for the next week or more as the water evaporates, leaving you with sparkling geode halves.

The Women in Mining (WIM) Educational Foundation also provides a neat geode activity wherein you split a coconut, clean out the meat, drill a hole in one half, and lacquer the outside of both halves. Once all has dried, glue the two halves back together with silicone and pour a crystal-growing solution into the hole. A week or two later, pour out any remaining solution and cut open the coconut along the seam to reveal a sparkling interior.

Growing Stalactites, Stalagmites, and Towers.

Stalactites, stalagmites, and towers grow in caves by the steady drip-drip of mineral-laden groundwater oozing from a cave ceiling. Usually that water is laden with calcium carbonate (calcite and limestone). With this activity, kids can grow their own stalactites, stalagmites, and towers with a powder you can find with the detergents and washing supplies at your local grocery store.

Materials.

- 10 tablespoons of borax (washing soda)
- 24 ounces of hot water
- Measuring spoon and cup
- Stirring spoon or stick
- Cookie sheet

- 2 pint-size glass jars + 1 jar lid
- Strip of old towel (1X18 inches)

Procedure.

1. Place a cookie sheet in an area where it will be undisturbed for several days or even a couple weeks.
2. Place 2 jars on the cookie sheet next to each other and separated by the jar lid.
3. Measure out and fill each jar with 12 ounces of hot water and 5 tablespoons of borax then stir until the borax is fully dissolved in each jar.
4. Place one end of the towel in each jar with a dip in the center between the jars.
5. Exercise patience! Now it's time to let nature take its course, so sit back and observe.

The borax/water solution will travel along the towel. At the dip you created in the center, the solution will build up then drip down into the jar lid and the water will evaporate, leaving behind the borax that was held in solution. Drop-by-drop, it should create a stalactite hanging from the towel and a stalagmite growing up from the jar lid. If let go long enough, the stalactite and stalagmite eventually will meet and grow together to create a tower. All three features are common in limestone caves.

By the way, for those like me who always get confused as to which is which, here's an easy mnemonic for remembering the distinction between a stalactite and a stalagmite. The word "stalactite" has a "c" in the middle. Let that stand for "ceiling." A stalactite grows down from the ceiling of a cave. The word "stalagmite" has a "g" in the middle. Let that stand for "ground." A stalagmite grows up from the ground of the cave. (Now if someone would only come up with a mnemonic for helping me remember how to spell "mnemonic"!)

Popcorn or Bubble Rock.

For about five bucks, you can purchase what's packaged and sold as "Popcorn Rock" or "Bubble Rock." Both are billed as "the rock that grows." Basically, these are small chunks of gray limestone from Utah. As you soak them for 1 to 3 weeks in a bowl of distilled white vinegar, you'll see white popcorn-like "rock bubbles" grow as the vinegar evaporates and aragonite crystals form atop the rocks.

Note: *Kids can use this activity toward satisfying requirement for the Earth Processes badge simultaneously (Activity 10.4.a. – A).*

Back-up page 1.7: State rocks, minerals, and gemstones.

The following table lists the officially designated rock, mineral, and/or gemstone for each state in the U.S. Have your kids to learn why their particular rock, mineral, or gemstone was selected. Some were selected because the rock or mineral was especially important to the economy of the state. For instance, limestone is the state rock of Indiana because of the contribution of limestone quarries to the state's economy. Indiana limestone helped to rebuild Chicago after its big fire in the nineteenth century and has been used in such historic buildings as the Washington Monument and the Empire State Building. Other state emblems were selected because they are unique to that particular state. For instance, benitoite was chosen as the state gemstone of California because it's only found in California. Kids can check with the state geological survey to learn the details behind their state rock, mineral, and/or gemstone, or they might try to unearth the original legislation that designated the official rock.

If you don't see a rock, mineral, or gemstone for your state, encourage your pebble pups and junior members to organize a letter-writing campaign to your state governor and legislature to nominate one! In organizing such a campaign, they should tell why the rock, mineral, or gemstone has special significance for the state. They might also write to rock clubs across the state to encourage others to join in their effort.

State	Rock	Mineral	Gemstone
Alabama	Marble	Hematite	Star Blue Quartz
Alaska		Gold	Jade
Arizona	Petrified Wood	Fire Agate	Turquoise
Arkansas	Bauxite	Quartz	Diamond
California	Serpentine	Gold	Benitoite
Colorado	Yule Marble	Rhodochrosite	Aquamarine
Connecticut		Garnet	
Delaware		Sillimanite	
Florida	Agatized Coral		Moonstone
Georgia	Quartz	Staurolite	Amethyst
Hawaii			Black Coral
Idaho			Star Garnet
Illinois		Fluorite	
Indiana	Limestone		
Iowa	Geode		
Kansas			
Kentucky	Kentucky Agate	Coal	Freshwater Pearl
Louisiana	Petrified Palmwood	Agate	
Maine		Tourmaline	
Maryland			Patuxent River Stone
Massachusetts	Roxbury Pudding Stone (Jasper)	Babingtonite	Rhodonite

State	Rock	Mineral	Gemstone
Michigan	Petoskey Stone		Chlorastrolite
Minnesota		Iron	Lake Superior Agate
Mississippi	Petrified Wood		
Missouri	Mozarkite (Chert)	Galena	
Montana		Agate	Sapphire
Nebraska	Prairie Agate		Blue Chalcedony
Nevada	Sandstone	Silver	Black Fire Opal & Turquoise
New Hampshire	Conway Granite	Beryl	Smoky Quartz
New Jersey	Unofficially, brownstone, known as Stockton Sandstone.	As of 2016, Franklinite & Prehnite are being debated.	
New Mexico			Turquoise
New York		Hematite	Garnet
North Carolina	Granite		Emerald
North Dakota			
Ohio			Flint
Oklahoma	Barite Rose		
Oregon	Thunder Egg	Oregonite & Josephinite	Sunstone
Pennsylvania			
Rhode Island	Cumberlandite	Bowenite	
South Carolina	Blue Granite		Amethyst
South Dakota		Rose Quartz	Fairburn Agate
Tennessee	Limestone	Agate	River Pearl
Texas	Petrified Palmwood		Blue Topaz
Utah	Coal	Copper	Topaz
Vermont	Marble, Slate, Granite	Talc	Grossular Garnet
Virginia			
Washington			Petrified Wood
West Virginia			Chalcedony Coral
Wisconsin	Wausau Red Granite	Galena	Ruby
Wyoming			Nephrite Jade

Note: *Kids who write a paper or give an oral report for this activity can also use it to satisfy requirements toward earning the Communication badge simultaneously (Activities 7.1 and 7.2).*

Back-up page 1.8: The elements.

Chemists have identified 118 elements. They have been called "the universe's building blocks" in that, individually or combined, they form all matter (except for so-called "dark matter"). Use this activity to help kids learn about the periodic table and how each element is classified into different groups (transition metals, halogens, noble gases, etc.). Then encourage them to write about what makes each group different than the others and the properties of the elements in that group. Or, after studying the elements, have kids pick one of their favorites and write about its unique traits and properties.

Two great reference books in large, colorful formats are:

- Theodore Gray, *The Elements: A Visual Exploration of Every Known Atom in the Universe*, 2009.
- Image Publishing, *How It Works Book of the Elements*, 2015.

It's fairly unusual to find a mineral consisting purely of a single element. More often, an element is combined with others into a compound. For instance, iron (Fe) can be found on its own but is more often found in iron oxide minerals like hematite (Fe_2O_3) or magnetite (Fe_3O_4). Lead (Pb) also can be found on its own but is more often found as galena (lead sulfide, PbS). However, some elements do occur in relative abundance in nature in uncombined forms with distinct mineral structures. They are called "native element minerals." Encourage your kids to build a collection of some of the more common and readily available ones, such as copper, sulfur, and carbon (as graphite). You also see iridescent hopper crystals of bismuth sold at gem and mineral shows, but these are lab-grown. We don't encourage kids to try collecting all 30 native element minerals given that some are toxic (for instance, arsenic, lead, mercury). Following are some common native element minerals that would make for an interesting collection:

Element	Symbol	Atomic Number	Atomic Weight
Bismuth (usually as lab-grown crystals)	Bi	83	208.98038
Carbon (as Graphite or Diamond)	C	6	12.0107
Copper	Cu	29	63.546
Gold	Au	79	196.96655
Silver	Ag	47	107.8682
Sulfur	S	16	32.065

Another fun activity might be to work with kids to draw up a list of 10-20 elements and everyday objects that contain them; for instance, an incandescent tungsten lightbulb, neon signs, nickel-cadmium rechargeable batteries, car bumpers decked out with chrome, copper pipes or electrical wire. The two books noted above are filled with examples.

Note: *Kids who build a collection of native element minerals can use this activity to satisfy requirements toward earning the Collecting badge (Activity 5.1). Those who write a paper for this activity can also use it to satisfy requirements toward earning the Communication badge simultaneously (Activities 7.1 and 7.2).*

Back-up page 1.9: Name that mineral!

Here's your chance to be a TV game show host! Review back-up pages for Activities 1.1 and 2.1 and prepare questions to test your kids' knowledge of mineral characteristics and uses. Then, as in a game show, stand behind a podium with your questions (and their answers) on large cards. Have participating kids lined up and seated behind a table with name cards in front of each or with name tags on their shirts. Then let the contest begin!

Award five points for each correct answer. You might award partial points if kids come up with an answer than is justifiably close but not exactly what you were looking for. (For instance, if the hints are that the mineral is blue with a light blue streak and soft hardness of 3.5-4.0 Mohs and the answer is "azurite," but someone answers "aquamarine", you might award partial points. Aquamarine is a blue form of beryl, but it leaves a colorless or white streak and is much harder at 7-8 Mohs. Still, it is blue!)

Have a really nice mineral specimen as a prize for the winner with the most points. You might also have second and third place prizes, ribbons, a little trophy, cash, or whatever prizes your society decides is best. The main thing is to have fun! You might do this as a program at one of your monthly meetings. (Adults are not allowed to shout out hints!)

Here are some examples of questions you might ask:

- **Question:** This mineral has a distinctive blue color. In fact, its name even means "blue." It leaves a light blue streak and is fairly soft on the Mohs scale at 3.5-4. *Name that mineral!* **Answer:** azurite.

- **Question:** This is the hardest of all minerals. In fact, it's 10 on the Mohs scale. Many married women wear it on a finger. *Name that mineral!* **Answer:** diamond.

- **Question:** This mineral has one name if it's red but a different name if it's blue or other colors. It's very hard; in fact, it's the mineral for 9 on the Mohs scale. It's a precious gemstone and is faceted for jewelry. Cabbed forms can exhibit asterism, or a star effect. *Name that mineral!* **Answer:** corundum (ruby and sapphire).

- **Question:** This mineral has a shiny pinkish-red or orange-brown color with metallic luster. It is soft and malleable. You might find it in your home's plumbing or in your electrical wiring. *Name that mineral!* **Answer:** copper.

- **Question:** This mineral forms very soft crystals that are clear or white and that leave a white streak. You may find it in your laundry detergent. Large quantities of it are mined in Boron, California. *Name that mineral!* **Answer:** borax.

- **Question:** You might find yourself sprinkling this salty soft and cubic mineral on your dinner or on an icy sidewalk. *Name that mineral!* **Answer:** halite.