ROCKS

MINERALS

WEATHER

STARS

ANNA COMSTOCK'S

HANDBOOK OF NATURE-STUDY

Handbook of Nature-Study:

Earth and Sky

ANNA BOTSFORD COMSTOCK, B.S., L.H.D

LATE PROFESSOR OF NATURE-STUDY IN CORNELL UNIVERSITY

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How To Study Minerals

Lesson

MANY children are naturally interested in stones. I once knew two children, aged seven and five, who could invariably select the boulders and pebbles of metamorphic rock in the region about Ithaca. They also could tell, when the pebbles were broken, which parts were quartz and which mica. They had incidentally asked about one of these stones, and I had told them the story of the glacial period and how these stones were torn away from the mountains in Canada and brought down by ice and dropped in Ithaca. It was a story they liked, and their interest in these granite voyagers was always a delightful element of our walks in the field.

For the pupils in the elementary grades it seems best to limit the study of minerals to those which make up our granite and common rocks. In order to teach about these minerals well, the teacher should have at least one set of labelled specimens. Such a collection may be obtained from Edward E. Howell, 612 17th St., N. W., Washington, D. C., and also from Ward's Natural Science Establishment, College

Avenue, Rochester, N. Y. These collections vary in number of specimens and price from one to two dollars and are excellent. The teacher should have one or two perfect crystals of quartz, feldspar and calcite. An excellent practice for a boy is to copy these crystals in wood for the use of the teacher.

The physical characteristics used in identifying minerals are briefly as follows:

1. *Form.* This may be crystalline, which shows the shape of the crystals definitely; granular, like marble, the grains having the internal structure, but not the external form, of crystals; compact, which is without crystalline form, as limestone or flint.

2. *Color.*

3. *Luster or shine,* which may be glassy like quartz; pearly like the inside of a shell; silky like asbestos; dull; or metallic like gold.

4. *Hardness* or resistance to scratching, thus: Easily scratched with the finger nail; cannot be scratched by the finger nail; easily scratched with steel; with difficulty scratched with steel; not to be scratched by steel. A pocket knife is usually the implement used for scratching.

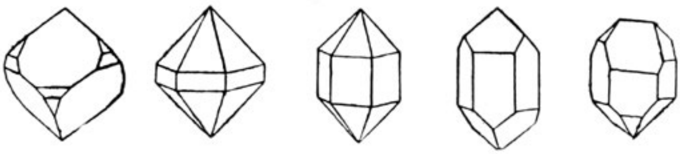
A rock collection

Quartz

Teacher's Story

THERE is in the Cornell University Museum a great quartz crystal, a six-sided prism several inches in thickness. One-half of it is muddy and the other half clear, transparent and beautiful. The professor in charge, who has the imagination necessary to the expert crystallographer, said to his class: "This crystal was begun under conditions which made it cloudy; then something happened, perhaps some cataclysm that changed all the conditions around the half-grown crystal, and it may have lain a hundred or a thousand years unfinished, when, some other change occurring, there came about conditions which permitted it to resume growth, and the work began again exactly where it was left off, the shaft being perfected even to its six-sided pyramidal tip." And ever afterwards that crystal, half clouded and half clear, remained in the minds of his pupils as a witness of the eternal endurance of the laws which govern the growth of crystals.

Quartz is the least destructible and is one of the most abundant materials in the crust of the earth as we know it. It is made up of two



Forms of quartz crystals

elements chemically united—the solid silicon and the gas oxygen. It is the chief material of sand and sandstones, and it occurs, mixed with grains of other minerals, in granite, gneiss, and many lavas; it also occurs in thick masses or sheets, and sometimes in crystals ornamenting the walls of cavities in the rocks. Subterranean waters often contain a small amount of silica, the substance of quartz, in solution; from such solutions it may be deposited in fissures or cracks in the rock, thus forming bodies called "veins." Other materials are often deposited at the same time, and in this way the ores of the precious metals came to be associated with quartz. Sometimes quartz is deposited from hot springs or geysers, forming a spongy substance called sinter. In this case, some of the water is combined with the quartz, making what is called opal. Quartz crystal will cut glass.

Quartz occurs in many varieties: (a) In crystals like glass. If colorless and transparent it is called rock crystal; if smoky brown, it is called smoky quartz; if purple, amethyst. (b) In crystals, glassy but not transparent. If white, it is milky quartz; if pink, rose quartz. (c) As a compact crystalline structure without luster, waxy or dull, opaque or translucent, when polished. If bright red, it is carnelian; if brownish red, sard; if in various colors in bands, agate; if in horizontal layers, onyx; if dull red or brown, jasper; if green with red spots, bloodstone; if smoky or gray, breaking with small, shell-like or conchoidal fractures, flint.

Rock crystals are used in jewelry and especially are made to imitate diamonds. The amethyst is much prized as a semi-precious stone. Carnelian, bloodstone and agate are also used in jewelry; agate is used also in making many ornamental objects, and to make little mortars and pestles for grinding hard substances.

One of the marvels of the world is the petrified forest of Arizona, now set aside by the government as a national reserve. Great trees have been changed to agate and flint, the silica being substituted for


Purple quartz is called amethyst

the tissues of the wood so that the texture is preserved though the material is changed.

When our country was first settled, flint was used to start fires by striking it with steel and letting the sparks fly into dry, fine material, called tinder. It was also used in guns before the invention of cartridges, and the guns were called flintlocks. The Indians used flint to make hatchets and for tips to their arrows. The making of flint implements dates far back into prehistoric times; it was probably one of the first steps upward which man achieved in his long, hard climb from a level with the brute creation to the heights attained by our present civilization.

Quartz sand is used in making glass. It is melted with soda or potash or lead, and the glass varies in hardness according to the minerals added. Quartz is also used for sandpaper and glass paper; and ground to a fine powder, it is combined with Japans and oils and used as a finish for wood surfaces. Mineral wool is made from the slag refuse of furnaces where glass is made, and is used for rat-proof and fireproof padding for the walls of houses. Quartz combined with sodium or potassium and water, forms a liquid called water-glass, which is used for waterproof surfaces; it is also fireproof to a certain degree.

Smoky quartz

Water-glass is the best substance in which to preserve eggs; one part of commercial water-glass to ten parts of water makes a proper solution for this purpose.

Lesson

Leading thought— Quartz is one of the most common of minerals. It occurs in many forms. As a crystal it is six-sided, and the ends terminate in a six-sided pyramid. It is very hard and will scratch and cut glass. When broken, it has a glassy luster and it does not break smoothly but shows an uneven surface.

Method— The pupils should have before them as many varieties of quartz as possible; at least they should have rock crystal, amethyst, rose and smoky quartz and flint.

Observations—

1. What is the shape of quartz crystals? Are the sides all of the same size? Has the pyramid-shaped end the same number of plane surfaces as the sides?

2. What is the luster of quartz? Is this luster the same in all the different colored kinds of quartz?

3. Can you scratch quartz with the point of a knife? Can you scratch glass with a corner or piece of the quartz? Can you cut glass with quartz?

4. Describe the following kinds of quartz and their uses: amethyst, agate, flint.

5. How many varieties of quartz do you know? What has quartz to do with the petrified forests of Arizona?

The Story of the Stars

Teacher's Story

"Why did not somebody teach me the constellations and make me at home in the starry heavens, which are always overhead, and which I don't half know to this day."

—Thomas Carlyle

FOR many reasons aside from the mere knowledge acquired, children should be taught to know something of the stars. It is an investment for future years; the stars are a constant reminder to us of the thousands of worlds outside our own, and looking at them intelligently, lifts us out of ourselves in wonder and admiration for the infinity of the universe, and serves to make our own cares and trials seem trivial. The author has not a wide knowledge of the stars; a dozen constellations were taught to her as a little child by her mother, who loved the sky as well as the earth; but perhaps nothing she has ever learned has been to her such a constant source of satisfaction and pleasure as this ability to call a few stars by the names they have borne since the men of ancient times first mapped the heavens. It has given her a sense of friendliness with the night sky, that can only be understood by those who have had a similar experience.

There are three ways in which the mysteries of the skies are made plain to us: First, by the telescope; second, by geometry, trigonometry and calculations—a proof that mathematics is even more of a heavenly than an earthly science; and third, by the use of the spectroscope, which can only be understood after we study physics. It is an instrument which tells us, by analyzing the light of the stars, what chemical elements compose them; and also, by the means of the light, it estimates the rate at which the stars are moving and the direction of their motion.

Thus, we have learned many things about the stars; we know that every shining star is a great blazing sun, and there is no reason to doubt that many of these suns have worlds, like the earth, spinning around them although, of course, so far away as to be invisible to us; for our world could not be seen at all from even the nearest star. We also know that many of the stars which seem single to us are really double—made up of two vast suns swinging around a common center; and although they may be millions of miles apart, they are so far away that they seem to us as one star. The telescope reveals many of these double stars and shows that they circle around their orbits in various periods of time, the most rapid making the circle in five years, another in sixteen years, another in forty-six years; while there is at least one lazy pair which seems to require fully sixteen hundred years to complete their circle. And the spectroscope has revealed to us that many of the stars which seem single through the largest telescope are really double, and some of these great suns race around each other in the period of a few hours, which is a rate of speed we could hardly imagine.

Astronomers have been able to measure the distance from us to many of the stars, but when this distance is expressed in miles it is too much for us to grasp. Thus, they have come to measure heavenly distance in terms of the rate at which light travels, which is 186,400 miles per second or about six trillions of miles per year; this distance is called a light-year. Light reaches us from the sun in about eight minutes, but it takes more than four years for a ray to reach us from the nearest star. It adds new interest to the Pole-star to know that the light which reaches our eyes left that star almost half a century ago, and that the

light we get from the Pleiades may have started on its journey before America was discovered. Most of the stars are so far away that we cannot measure the distance.

Although the stars seem always to be in the same places, they are all moving through space just as our sun and its family are doing; but the stars are so far away that, although one may move a million miles a day, it would require many years of observation for us to detect that it moved at all. We know the rate at which some of the stars are moving but have no idea of their goal; nor do we have any idea where our sun is dragging us at the rate of nearly 800 miles per minute. It is thought that our sun and the other suns are whirling around some greater center or centers; but if so, the orbits are so many trillions of miles across that the suns all seem to be going somewhere in a straight line, each attending strictly to its own business.

Through the spectroscope we know something of the life of stars; we know that when they are young they are composed of thin gases and shine white or blue; and as they grow older, they become more solid and shine yellow, like our sun; and when older still, they grow red and are yet more condensed, like Betelgeuse in Orion, which is an aged sun and which will, in time, grow cold and dark and invisible to us. The spectroscope reveals many dark stars whirling through space—vast, dead suns with their fires extinguished, never to be lighted again unless, in its swift course, one of them should hurl itself against another star with a fearful force which shall shatter it into gaseous atoms, and these be thrown into fierce spiral whirlpools, from which it shall again be fashioned into a white-hot sun and become a star in our sky.

The scientists are coming to understand a little of how the stars are made; for scattered through the skies are masses of misty light, called nebulae, which means clouds; nebulae are vast gaseous bodies composed of the stuff of which stars are made. Each nebula keeps its own special place in the heavens—just like a star, and is moving through space—like a star. The spectroscope shows that many of these shining, misty masses are made up of glowing gases, largely hydrogen; and many are disk-shaped, twisted into a spiral. There are grounds for believing that these spiral nebulae are stars in the process of forming. Nebulae are mostly telescopic, although two or three may be detected by the keen, unaided eye as a little blur of light, like that surrounding the third star of Orion's sword. There are eight thousand or more nebulae which have been discovered and mapped. Some idea of their tremendous size is given by Ball when speaking of the ring nebula of Lyra, which we cannot see with the naked eye, and yet if a railroad train started to cross its diameter at the middle, and went at the rate of a mile a minute, one thousand years would not complete the journey.

The number of stars that may be seen with the unaided eye, if one were to travel from the southern to the northern polar region, would be between six and seven thousand; but it would require very keen eyes to see two thousand at one time. With the help of the telescope, about eight hundred thousand stars have been discovered, classified and catalogued, while photography of the skies reveals millions. It is thought that the new international photographic chart, which shall cover all the space seen from our globe, may show thirty millions of stars. The Milky Way or Galaxy, that great, white band across the heavens, is made up of stars which are so far away that we cannot see them, but see only their diffused light. It is well called a "River of

Stars" flowing in a circle around our whole solar system; and, except during the spring months, one-half of it may be seen directly above us while the other half is hidden below us. The place of the Milky Way in the heavens seems fixed and eternal; any star within its borders is always seen at the same point. When the Northern Cross lifts itself toward the zenith we are able to see that, near that constellation, the star river divides into three streams with long, blue islands between.

Reference books— There are a large number of excellent text-books and popular books on astronomy. The following are a few which I have used most often: *Astronomy for Everybody,* Newcomb; *Todd's New Astronomy*; *The Friendly Stars,* Martin; *Starland,* Ball; *The Stars Through an Opera Glass,* Serviss; *Other Suns than Ours,* Proctor; *Other Worlds than Ours,* Proctor.

For children— Earth and Sky, Holden; *Stories of Starland,* Proctor; *The Children's Book of Stars,* G. E. Mitton; *Storyland of the Stars,* Pratt; *Stars in Song and Legend,* Porter; *The Planisphere,* Thos. Whittaker.

How To Make a Sundial

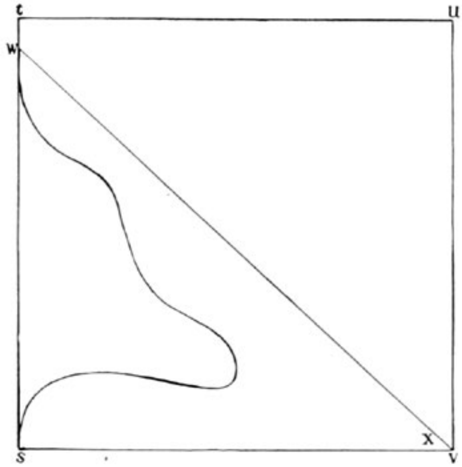
Lesson

Method— The diagram for the dial is a lesson in mechanical drawing. Each pupil should construct a gnomon *(no-mon)* of cardboard, and should make a drawing of the face of the dial upon paper. Then the sundial may be constructed by the help of the more skillful in the class. It should be made and set up by the pupils. A sundial in the school grounds may be made a center of interest and an object of beauty as well.

Materials— For the gnomon a piece of board a half inch thick and six inches square is required. It should be given several coats of white paint so that it will not warp. For the dial, take a board about 14 inches square and an inch or more thick. The lower edge may be bevelled if desired. This should be given three coats of white paint, so that it will not warp and check.

To make the gnomon— The word gnomon is from a Greek word meaning "one who knows." It is the hand of the sundial, which throws its shadow on the face of the dial, indicating the hour. Take a piece of board six inches square, and be very sure its angles are right angles.

Let s, t, u, v represent the four angles; draw on it a quarter of a circle from s to u with a radius equal to the line vs. Then with a cardboard protractor, costing fifteen cents, or by working it out without any help except knowing that a right angle is 90°, draw the line vw making the angle at x the same as the degree of latitude where the sundial is to be placed. At Ithaca the latitude is 42° 27' and the angle at x measures 42° 27'.



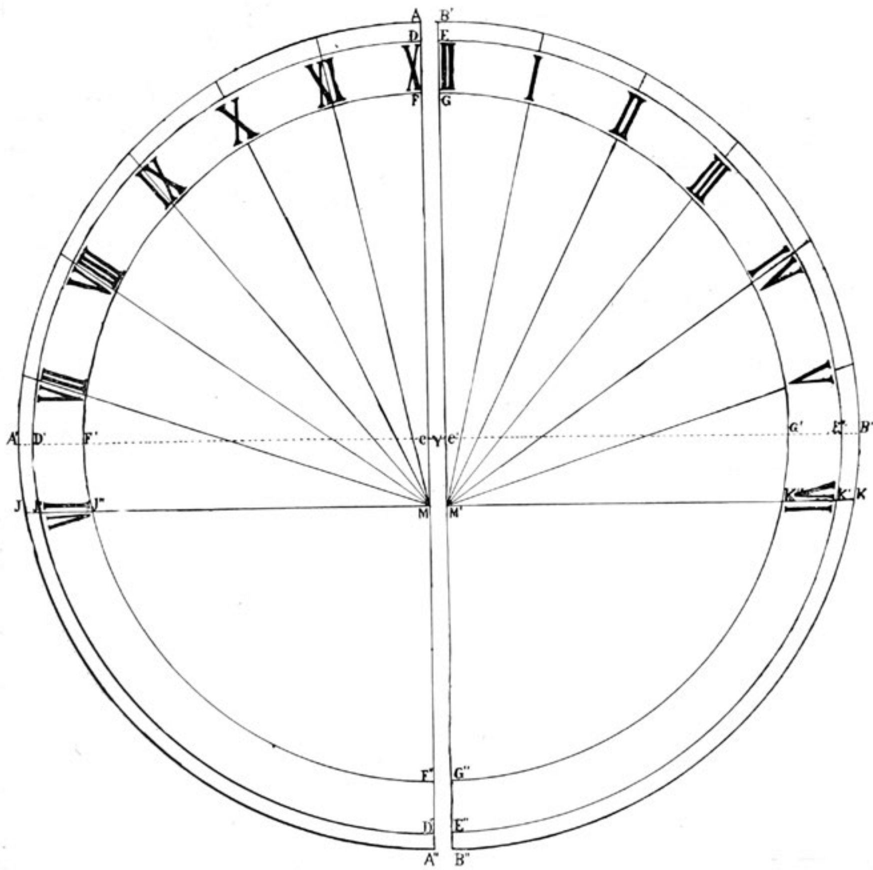
The gnomon.

Then the board should be cut off at the line vw, and later the edge sw may be cut in some ornamental pattern.

To make the dial— Take the painted board 14 inches square and find its exact center, y. Draw on it with a pencil the line A A" a foot long and one-fourth inch at the left of the center. Then draw the line B B" exactly parallel to the line A A" and one-fourth inch to the right of it. These lines should be one-half inch apart—which is just the thickness of the gnomon. If the gnomon were only one-fourth inch thick, then these lines should be one-fourth inch apart, etc.

With a compass, or a pencil fastened to a string, draw the half-circle A A' A" with a radius of six inches with the point C for its center. Draw a similar half-circle B B' B" opposite with C' for its center. Then draw the half-circle from D, D', D", from c with a radius of five and three-quarter inches. Then draw similarly from c' the half-circle E, E', E". Then draw from c the half-circle F, F', F" with a radius of five inches and a similar half-circle G, G', G" from c' as a center.

Find the points M, M' just six inches from the points F, G; draw the line J, K through M, M' exactly at right angles to the line A, A'. This will mark the six o'clock point so the figures VI may be placed on it in the space between the two inner circles. The noon mark XII should be placed as indicated (the "X" at D, F, the "II" at E, G). With black paint outline all the semi-circles and figures.



The face of the sundial.

To set up the sundial— Fasten the base of the gnomon by screws or brads to the dial with the point s of the gnomon at F, G, and the point v of the gnomon at M, M', so that the point W is up in the air. Set the dial on some perfectly level standard with the line A, A" extending exactly north and south. If no compass is available, wait until noon and set the dial so that the shadow from W will fall exactly between the points A, B, and this will mean that the dial is set exactly right. Then with a good watch note the points on the arc E, K', on which the shadow falls at one, two, three, four, and five o'clock: and in the morning the points on the arc J' D on which the shadow falls at seven, eight, nine, ten and eleven o'clock. Draw lines from M to these points, and lines from M' to the points on the arc E K'. Then place the figures on the dial as indicated in the spaces between the two inner circles. The space between the two outer circles may be marked with lines indicating the half and quarter hours. The figures should be outlined in pencil and then painted with black paint, or carved in the wood and then painted.

Twilight, twilight of the west,
Sky-lines fading into rest,
Cloud-bars lying far and slight,
Shadows sinking into night,—
O moon, ye moon, so faint and still,
Hanging, hanging as ye will
Low along the western sky,
Far and far and yet so nigh
A finger's breadth within the sheen
And silent shoreless vasts between—
Thy aching heart is long ages lost,
And clear and calm as film of frost,
Ye know no longer strain or stress,
All passionless and passionless.

—From "The New Moon," L. H. Bailey.