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L A P I D A R Y

Subject Area: HUMANITIES

Core Curriculum Content Standards: 1.1.A & B, 1.2.D, 1.5.B, 3.3.A, 3.4.A, 4.2.A, 5.6.A, 5.8.A, 6.5.A

DESCRIPTION: This session focuses on the demonstration and practice of the various techniques of shaping and polishing semi-precious gemstones. It also includes some very basic mineralogy. The aesthetic properties, historical particulars and folklore aspects of gems, especially of the birthstone gems, are also investigated. Traditional methods of using gems are demonstrated, as are contemporary uses of the non-gem varieties of the gem minerals. As culmination, each student can assemble a jewel to take home.

OBJECTIVES:

Students will differentiate a gem from a mineral.

Students will assemble an item of jewelry for themselves.

Students will describe the environmental impacts of extracting some, particularly the organic, gems.

Students will identify their own birthstones by physical appearance, and explain one aspect of the gem's folklore or historical importance.

Students will articulate their perceptions of aesthetics in relation to gems.

BACKGROUND INFORMATION: While they are not essential to life as are the biotic components of the natural environment, such as oxygen, food, water, shelter and sunlight, gems nonetheless furnish the important dimension of aesthetic appreciation. It could be said that the capacity for aesthetic appreciation separates human beings from the other animals. In this class, students have the opportunity to determine and articulate their own perceptions of the aesthetic qualities of gems — perhaps something they have not yet had the opportunity to do. In the words of John Keats, "Beauty is its own excuse for being." and in the words of David Hume, "Beauty is in the eye of the beholder." However, humankind has long attributed properties and potencies to gems, in addition to using them for sheer adornment. Students will consider the medical and talismanic uses of gems in antiquity as well as modern technological applications, of which they are undoubtedly unaware. Methods of obtaining and extracting some gems have severe impacts on the local and global environment. This aspect of the lapidary arts will be discussed with the students.

MATERIALS NEEDED: This session is always conducted in Cayuga Blue classroom, located on the Sequoya Campus. All of the visual aids and other materials needed for this class are located there. Before class, locate: 1) ashtray, necklace, figurines; 2) tray of stones; 3) glue, toothpicks, pliers, jump rings, bell caps and pin backs; 4) Gem Cards; 5) quartz, beryl, calcite, and fluorite crystals, and the 300 carat boule. At the same time, review the information written on the Gem Cards.

PROCEDURES:

1. Show ashtray, necklace, and figurines. Ask: What do all these items have in common? (*A human fashioned them from minerals. Also, they are shiny; polishing is the last step of the lapidary process).*
What do you think lapidary is? Hint: a lapidary is also called a 'rock hound' (*a person who likes to collect and polish rocks).* Lapidary is the art of fashioning decorative objects from gem materials.

2. Most gems are minerals, not rocks. What is the difference? (*Use an analogy of a chocolate chip cookie: a rock is the whole cookie while the chocolate chips, butter, flour, sugar, etc. are minerals).* Define rock: (*a naturally occurring aggregate of minerals).* Define mineral: (*a naturally occurring inorganic solid with definite crystalline structure).* Break definition into two parts: 1) Define inorganic: *(without carbon, a gem that comes from a non-living source; minerals are/were never alive.)* Is the door organic? (*Yes, because it comes from a tree, which was once alive).* 2) Define crystal: *(patterns of orderly, internal atomic arrangement.)* Pass around the two similar crystals of quartz and beryl. Ask students to

distinguish between them. *(Quartz has 3 long side & 3 short sides; and beryl has 6 equal sides*). Also, pass around calcite crystal, which is also six sided but shows a different morphology.

3. But what makes a gem? There are 4,000 mineral species but only 80-100 are considered gems. Bring out the box of gems and have each student choose the gem s/he considers the most beautiful and place it on the white cloth on the table. Ask each student to describe why s/he chose that gem. This will lead into a discussion of why we only consider a small proportion of minerals to be gems.

4. Discuss the characteristics of gems shown on the green chart: beautiful, durable, rare, and fashionable. What makes a gem beautiful?
Color - Ask: How many shades do you think the human eye can perceive? *(up to 1 million shades of color).* There are differences in male and female perceptions of color: it is thought that females perceive colors better, perhaps because their eyes have more cones, or because they are trained to match colors more so than males). But color is one of the least reliable means of identifying a gem. Show photograph of the British crown jewels. For many years, the red stone in the center of the crown (known as the Black Prince's Ruby, and carried by Henry IV in the Battle of Agincourt in the 14th century) was thought to be a ruby, but when it was able to be chemically analyzed, it was discovered to be a spinel.

Define durability - ***hardness*** (resistance to scratching) and ***toughness*** (tendency to split or crack on a cleavage plane). Refer to the *MOH's Scale of Hardness* and highlight examples from the chart. Pass around the calcite (3), fluorite (4), and quartz (7). Diamond (10) is the hardest mineral on the scale. Minerals usually have to be harder than 7 to be scratch-resistant enough to be considered gems. The major exceptions are the organic gems (2-4) and a few mineral or rock gems which are softer than 7: turquoise (4-5) and opal (6), but the beauty of these gems overrides their softness.

5. Show students the finished products of the lapidary arts. Separate faceted stones into a grouping. Ask how these are similar. Define facets — little flat edges, mathematically calculated, that refract light. Therefore, which gems should be faceted? (*Only those that light will pass through*; *the material dictates how the gem should be cut).* Discuss optical property terms: transparency, translucency, opacity.

transparency (transparent)– light that is able to pass through, with little or no interruption or distortion.
translucency (translucent)- scattered light passing through with difficulty.
opacity (opaque)- imperviousness to light.
luster - the reflection of light from the surface, which is best seen on a smooth surface, which explains polishing.
refraction - a bending of the ray of light.
dispersion - the mineral's ability to separate light into the component colors of the spectrum.

Separate cabochon gems, those which are cut with a flat bottom and a domed top *(You can note that both transparent and translucent gems can be cut using the cabochon pattern).* Again, the material dictates the use. Show template and discuss how it is used to choose the cut pattern. Show the red tiger eye slab and ask if they would like to use this as a gem. Then show the cabochon red tiger eye gem, compare it with the rough stone (an unpolished stone is also called a rough stone), and explain that the role of the lapidary is to finish the product in a way that will make it appealing. Discuss the importance of shininess in making a gem appealing. What other type of animal also has very good eyesight? (*Birds of prey—a raptor has such acute vision that if it were a human it would be able to read a newspaper 1/2 mile away).* Ask: Do shiny objects appeal to other birds and other animals, too?
(An alternate procedure would be to pick an assortment of faceted, cabochon, and tumbled cut stones, place these randomly on the cloth and ask a student to separate them into three groups, according to how they are cut. Then ask the other students to critique and use the discussion to bring out the characteristics discussed above.)

6. Discuss the organic gems (amber, coral ivory and pearl). If they are organic, where do they come from? (*A living source*). Show the Gem Cards for the organic gems. Everything comes from nature. Discuss the importance of knowing exactly where something we use comes from. *(In order to be aware of how our actions affect the environment).* Where do we get ivory? When they kill the elephant and take its tusks, what do they do with the rest of the elephant? (*Usually, it just rots*). What has happened to the elephant population because so many people wanted bracelets and carvings made out of ivory? Would we want to buy a bracelet made out of ivory if it results in the killing of elephants? What about coral? Where does it come from? Has anyone ever seen a coral reef? What does it look like? (Show laminated picture). Is it alive? What else lives there? What are some important functions that coral reefs perform? (*They provide a habitat for many fish species, and they form a barrier that protects the shores from rough waves).* What would happen if people destroyed a coral reef to make necklaces? [*Stress again the importance of understanding that our actions have an effect on many other parts of the Earth, and introduce the concept of*

relative value (e.g. is it more important to have an elephant or an ivory bracelet? A coral necklace or a coral reef?)]. Pearls, one of the June birthstones, have increased tremendously in cost due to water pollution, especially that caused by oil spills. Read on the Pearl Gem Card the section "Mineralogical Notes." Why are all of these tankers carrying huge amounts of crude oil? (*If you wish, this topic may lead into a discussion of "rights" of entities of Nature versus "rights" of human beings).*

7. Discuss the historical background of gems. Did ancient peoples use gems? (*Yes, for medicinal and talismanic as well as aesthetic purposes).* People have long revered precious stone. Archaeologists have found them in even the oldest graves and settlements. Also, the oldest operating mines for turquoise, are still in operation and have produced steadily for the past 7,000 years. The oldest known gems are organic. Why? (*Probably because those were the most easily available gems and they were also the most easily worked because they are soft).*

Why have humans valued gems? Refer again to the characteristics listed on the green chart. The colors are among the richest and purest in nature, and in ancient times they didn't have the synthetic manufacturing processes we have today. Also, they are hard and durable, and people, with a relatively short life span in geologic terms, have been awed by their beauty, longevity and permanence. Gemstones have always been easily transportable currency since they are high in value/cost and small in size. Ask students: suppose that you had $1,000,000 in $100 bills. How many $100 bills are in $1,000,000? (*Cancel zeroes = 10,000).* How much space would this amount of paper money occupy? How heavy would it be, considering that money is paper? How much space would $1,000,000 in gemstones occupy? (*One stone could be worth that much. Several, totaling that cost, could fit in the palm of your hand.)*

8. The origin of rocks only became known about 200 years ago, but long before that people had evolved fantastic theories about gems. Where do you think ancient people thought gems came from? *Some examples: they thought diamonds were nourished in the brains of dragons, and less valuable jewels might be found in toad's heads. Also, some were thought to have fallen from heaven. The Navajo believed that the god of thunder was jealous of the beauty of the rainbow and, in a fit of temper, threw thunderbolts at the rainbow, thus shattering it into billions of pieces of colored light. These fell to the earth and became the gemstones.*

9. What are our reasons for wearing jewelry today? *[To show belonging (wedding ring) or religious affiliation (cross or Star of David), or to enhance appearance or bring good luck].* In early times, people wore gems because they believed that the gems had magical properties. Stones were thought to: protect owners from misfortune; be an antidote to poison; prevent fires; enhance a person's desirability; make the wearer invisible; bring fortune. If you thought a gem could make you invisible, would you think it was valuable? They were also used frequently in medications, and as late as the 1600's, doctors prescribed medicines that were based on gems, either whole or powdered. Distribute the "R_x" cards. Ask students to match the illness/condition with the cure. Ask if they think those "medicines" really worked. But if they didn't work, why did people use them? (*Because people didn't understand what caused diseases, and they didn't know how to cure them).* Also, certain gems had specific properties associated with them. Red stones were thought to stop bleeding or cause an enemy to bleed to death, and were frequently worn in battle. Aquamarines were thought to protect sailors, and blue stones (sapphire and lapis lazuli) were thought to give the eyes the ability to gaze into the sky and see the future.

10. Certain gems were also thought to be associated with people born in a particular month. These are called birthstones, and we still have them today. Do you know what your birthstones are? Discuss the individual birthstones: starting with January, ask which students were born in each month as you show them the photo on the Gem Card of the gem associated with that month. Ask a student born in a particular month to read aloud the folklore section, on the other side of the Gem Card which describes the qualities associated with a person born in that month.

11. Discuss the difference between a jewel and a gem. (*A gem is a cut and polished stone. A jewel is a gem that has been placed in a metal setting to protect and enhance the gem).*
Have students make jewels from gems. The stones you'll be working with are tumble cut and polished. What does that mean? Show the tumbler and describe how it works: *(You start with uncut material. Show them the "rough" stones in the tumbler. Add abrasive and water. Cover and tumble for 25 - 40 days. The last step of the lapidary process is the polishing, which takes 7 - 10 days).* What in nature functions as tumbling machines? (*Oceans, streams and rivers).* Show the findings *(pin backs and bell caps),* then allow students to choose their gem. Explain the process for fitting the stones. (*Press the metal bell cap so that it touches the stone all around; be certain that the stone has a surface flat enough to contact the flat metal surface of the pin back.)* Mix the glue when most of the students have selected and fitted their jewels. Only a small amount of glue is needed. The amount contained within one fluted bottle cap should be sufficient to glue 15 stones.

12. Discuss the difference between a carat and a karat. carat = a unit of weight for gemstones. karat = a measure of the purity of gold. Pure gold is 24 karats, but it is too soft to be used and so it is alloyed with other metals. Pass around the 300 carat boule. [300 carats = 2 ounces]. Have a student determine his/her weight in carats: [150 carats/oz. x 16 oz/lb. x #lbs. = student's weight in carats]

13. Discuss the environmental impacts of gems. How do we obtain most gems? (*Either by mining or from placer deposits).* Thus, many gems can be regarded as mineral resources. What are some other mineral resources? (*Try to get them to think of coal and oil).* Discuss the effect mining has on the environment. For example, much of the coal mining that is done today is surface mining or mountain top removal because most of the large coal seams have been mined already. We have begun to mine seams that are approximately a foot thick. Ask them to think about what the land looks like when miners dig a pit 100 feet deep or take off the top off of a mountain. What happens to the animals and plants that live there? Do you think they can reclaim the land to be as healthy as it was before it was mined? How can each of us help to reduce the demand for coal so that we don't need to do as much mining? How is coal used? *(Factories and power plants).* What do power plants provide for us? (*Electricity).* So what can we do to help the power plants use less coal? (*Conserve electricity).* How? (*Ask students individually to describe a method of conserving electricity).*

WRAP-UP INTERPRETATION:
Let's review some things we learned about gems. How did we say they are obtained? (*Mining and placer deposits).* Do you think mining for gems has an effect on the environment, too? Read the description from The Color Treasury of Gemstones (pp. 27-28, 30-31) of what happens when people mine for diamonds. What effect would that have on the environment? What would happen if diamonds were discovered in a wilderness area like Stokes Forest? What would happen to the forest if we mined for the diamonds? Why is it important to have wilderness/forest areas like Stokes? *(To provide oxygen, a home for animals, a place for people to get away from the city, to store water, to stabilize the soil and prevent erosion).* And what do we use diamonds for? So, which is more important for us to have? This is a question for all of us to think about. If somebody is going to hurt the environment to give us something we don't really need, should we let him or her do it? Why is it important for us to know where the things we use come from? (Review the discussion about organic gems. See #6.)

VARIATIONS:
A. Bring out the green tray of specimens. Distribute the written descriptions. Have students match their description to the proper specimen. (Answer Key available.)
B. Have students play the "Gem Rummy" card game located in the top middle drawer of the lapidary cabinet. Directions are enclosed with the cards. This will familiarize them with not only cut and polished gems, but also with decorative carvings and other ornamental uses of gem materials.

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VOCABULARY

AGATE - a variety of translucent to opaque cryptocrystalline quartz (chalcedony) with a banded structure in differently colored layers.
ALLOCHROMATIC - refers to minerals whose coloring is caused by extraneous elements which are not constituent parts of the chemical composition. (SEE: Idiochromatic)

ASTERISM - the optical phenomenon of star-like lines of light on cabochon cut gemstones, caused by reflection of light on suitably oriented inclusions.

BAROQUE - irregularly shaped; for example, the tumbled and polished gems the students will use.

BOULE - a pear shaped fabricated crystal formed by the Verneuil or hydrothermal process. The Verneuil process, commonly used to mass produce synthetic corundum, entails feeding pulverized material through a blowpipe via a stream of an explosive mixture of hydrogen and oxygen. The powder is melted down by the torch flame and falls on a platform where the boule forms. See diagram of the Verneuil furnace.

BRILLIANCE - comprises all optical properties [luster, refraction, diffraction, dispersion] affecting light falling on a cut gemstone.

CABOCHON - [Fr. 'domed'] an opaque or translucent gem cut with a convex, highly polished surface and a flat bottom. Not faceted.

CARAT - a unit of weight for gemstones. One carat = one-fifth of a gram (0.20 gm). A carat is further divided into 100 points. Approximately 142 carats equal one ounce. One ounce equals 28.35 grams. (SEE: karat)

CHATOYANCY - [Fr. 'cat'] describes the occurrence of a wavering shimmer of light, which moves over the domed surface of a gemstone as a narrow line of light, reminiscent of the slit pupil of a cat's eye. The phenomenon arises from reflection of incident light by fine parallel fibers in the interior of the gemstone.

CLEAVAGE - the tendency of a gem to split in a preferred direction, i.e. along planes parallel to possible crystallographic faces, and along planes of weakness in the atomic structure.

CRYPTOCRYSTALLINE - describes mineral aggregates, which consist of such submicroscopically fine crystals that the individual components cannot be seen with a magnifying lens.

CRYSTAL - a homogeneous three dimensional body in the form of a geometric solid bounded by polyhedral faces, the nature of which is an expression of the orderly and periodic arrangement of its constituent atoms.

CRYSTALLINE - describes minerals or aggregates whose components are macroscopic, i.e. can be seen with the unaided eye. (SEE: Cryptocrystalline)

CUTTING - the process by which a lapidary transforms a rough gemstone into an ornamental one, while attempting to enhance its optical properties and eliminate any flaws.

DISPERSION - the separation of white light, which is the mixture of all colors, into its constituent colors, producing flashes of color. Also called 'fire,' this property is seen prominently in diamond and its man-made counterparts—cubic zirconia and titania. This separation occurs because the various colors, or wavelengths composing white light, are each bent (refracted) a different amount. Red is bent least, followed in order by orange, yellow, green, blue, indigo, and violet, which is bent most.

DOPSTICK - a tool to which a gemstone is firmly attached during the cutting process.

GEM - a general name for any mineral or aggregate which possesses the characteristics of beauty, durability, rarity and which is, to some extent, fashionable. Gems are used primarily for ornamental purposes—jewelry, carvings, intaglios, etc.

HARDNESS - resistance of the surface of a gemstone to scratching or abrasion. Measured by the Moh Scale of ten indicator minerals, from 1 [talc] as the softest, to 10 [diamond] as the hardest.

IDIOCHROMATIC - self-colored; a gemstone in which the coloring agent is a constituent part of its chemical composition. (SEE: Allochromatic)

IGNEOUS - rocks formed from the crystallization of a silicate melt.

INCLUSION - a flaw; a gaseous, liquid or solid foreign material incorporated in a crystal during its formation or resulting from mechanical pressure or structural alteration. Inclusions affect the clarity and therefore the transparency of gems BUT also serve as important evidence of genuineness and of source. Many gemstones have characteristic inclusions.

INORGANIC - composed of other than plant or animal matter. Synonymous with mineral.

JEWEL - the cut and polished gem mounted in a setting appropriate to protect it, as well as enhance its beauty.

KARAT - a measure of the purity of gold, equaling 1/24 part of pure gold in an alloy. Pure gold measures 24 kt. and is far too soft/malleable to be serviceable.

MATRIX - the natural rock in which minerals occur interbedded (the 'mother rock').

METAMORPHISM - the alteration of minerals and aggregates in situ (after deposition) by external actions such as contact with temperatures and pressures different from those of the environment in which they were formed. This can change the form and/or chemical composition of the mineral(s) as well as of the rock.

MOLECULE - the smallest particle of a substance that retains the properties of the substance and is composed of one or more atoms.

OPAQUE - impervious to light; not permitting light to pass through.

PLACER - an alluvial deposit containing particles of gems and, especially, gold.

REFLECTION - luster, i.e. light reflected from the surface of the gemstone.

REFRACTION - bending of the ray of white light, internally. The degree of refraction is due to the species of the gemstone, since light travels through different substances at different velocities. A *refractometer* measures the degree to which cut stones bend light and aids in identifying the gemstone, since few gems bend light to exactly the same degree. The measurement obtained is the *refractive index* of the gemstone.

ROUGH - uncut and unpolished gem minerals.

SEDIMENTARY - resulting from deposition from water. The sedimentary processes include all means whereby rocks and minerals are broken down and re-deposited through reworking or new formations on the earth's surface, in waters, and in the uppermost crust of the earth.

SLURRY - a watery mixture of abrasive grit and small pieces of minerals/rocks, necessary for the tumbling process.

SPECIFIC GRAVITY - an expression of the relationship between the weight of a gemstone and the weight of an equal volume of water.

STREAK - the color of a fine powder of a mineral obtained by rubbing it across a white porcelain surface; an identification characteristic.

SYNTHETIC – human-made stones, manufactured by chemical-technological processes, but having the same chemical, structural, and physical properties as the natural counterpart. (SEE: Boule) They may be distinguished from the genuine gemstones by their inclusions.

TRANSLUCENT - light passes through a gemstone but with difficulty.

TRANSPARENT - light passes through a gem with little or no interruption.

TUMBLED - a method of cutting and polishing a quantity of semi-precious gemstones concurrently, using a water and silicon carbide grit and placing all in a small covered tumbling barrel. The resulting shapes are random or baroque. The process is similar to the forces at work in the ocean or a river.