Mining Meteors

Examples of Possible Academic Science Standards to Incorporate:

2nd Grade:

- 7.7.2 Observe rocks of different sizes with a hand lens and describe these materials according to their basic features.
- 7.7.4 Identify simple methods for reusing the earth's resources.
- 7.7.2 Describe rocks according to their origin, size, shape, texture, and color.

3rd Grade:

- 7.6.1 Identify and compare the major components of the solar system.
- 7.7.2 Analyze the physical characteristics of different kinds of rocks.
- 7.6.1 Identify the major components of the solar system, i.e., sun, planets, asteroids, and moons.
- 7.6.2 Compare and contrast major solar system components.
- 7.7.2Describe how rocks can be classified according to their physical characteristics.
- SPI 7.7.4 Determine methods for conserving natural resources.

4th Grade:

- 7.11.1 Describe the position of an object relative to fixed reference points.
- 7.11.2 Identify factors that influence the motion of an object.
- 7.11.3 Determine the relationship between speed and distance traveled over time.

5th Grade:

- 7.6.1 Compare planets (and bodies in the solar system) based on their known characteristics.
- 7.11.1 Design an investigation, collect data and draw conclusions about the relationship among mass, force, and distance traveled.
- 7.12.1 Recognize that the earth attracts objects without directly touching them.
- 7.12.3 Design and explain an investigation exploring the earth's pull on objects.
- 7.12.1 Explain and give examples of how forces act at a distance.

6th Grade:

- 7.6.2 Describe the relative distance of objects in the solar system from earth.
- 7.6.2 Explain how the relative distance of objects from the earth affects how they appear.

7th Grade:

- T/E.1 Explore how technology responds to social, political, and economic needs.
- Inq.5 Design a method to explain the results of an investigation using descriptions, explanations, or models.
- Inq.3 Synthesize information to determine cause and effect relationships between evidence and explanations.
- Inq.3 Interpret and translate data in a table, graph, or diagram.
- Inq.4 Draw a conclusion that establishes a cause and effect relationship supported by evidence.
- Inq.1 Design a simple experimental procedure with an identified control and appropriate variables.
- 7.11.4 Identify and explain how Newton's laws of motion relate to the movement of objects.
- 7.11.4 Recognize how a net force impacts an object's motion.

8th Grade:

- CU 7.12.5 Explain the difference between mass and weight.
- SPI 5.3.3 Recognize that rocks are composed of various combinations of minerals.
- CU 7.12.6 Identify factors that influence the amount of gravitational force between objects.
- CU 7.12.7 Explain how the motion of objects in the solar system is affected by gravity.
- SPI 7.12.4 Distinguish between mass and weight using appropriate measuring instruments and units.
- SPI 7.12.5 Determine the relationship among the mass of objects, the distance between these objects, and the amount of gravitational attraction.
- SPI 7.12.6 Illustrate how gravity controls the motion of objects in the solar system.

Examples of Possible Academic Vocabulary to Incorporate:

For the Academic Vocabulary we encourage you to use as many of these words as possible, not simply pick one or two. The more words we can introduce in a setting that makes sense to our students, the better.

Kindergarten:

- air
- change
- color
- day/night
- food
- natural
- observe
- parts
- senses
- shape
- size
- star
- sun
- temperature
- thermometer
- tools
- weather

1st Grade:

- adult
- balance
- classify
- environment
- freezing
- heat
- invent
- investigate
- light
- location
- matter
- mixed
- planet
- prediction
- property
- push/pull
- texture

2nd Grade:

- Celsius/Fahrenheit
- compare/contrast
- depend
- dissolve
- distance
- energy
- habitat
- infer
- investigate
- observation
- reasoning
- renewable/non-renewable
- scientific inquiry
- scientist
- similarities/differences
- sound
- universe

3rd Grade:

- atmosphere
- cross section
- force
- orbit
- revolution
- rotation
- solar system

4th Grade:

- electricity
- friction
- mass
- reflection
- refraction

5th Grade:

- conduction
- core
- crust

- dissipate
- gravity

6th Grade:

- asteroid
- bias
- cause and effect
- control
- criteria
- protocol
- prototype
- variable

7th Grade:

- acceleration
- momentum
- phenomenon
- speed
- velocity

8th Grade:

- density
- gravitation (universal law)
- magnetic field
- variation
- gravitational effects

Mining Meteors

Metal: Yours? Mine! It's Ours!

http://www.scienceclarified.com/scitech/Comets-and-Asteroids/How-Humans-Will-Mine-Asteroids-and-Comets.html#b

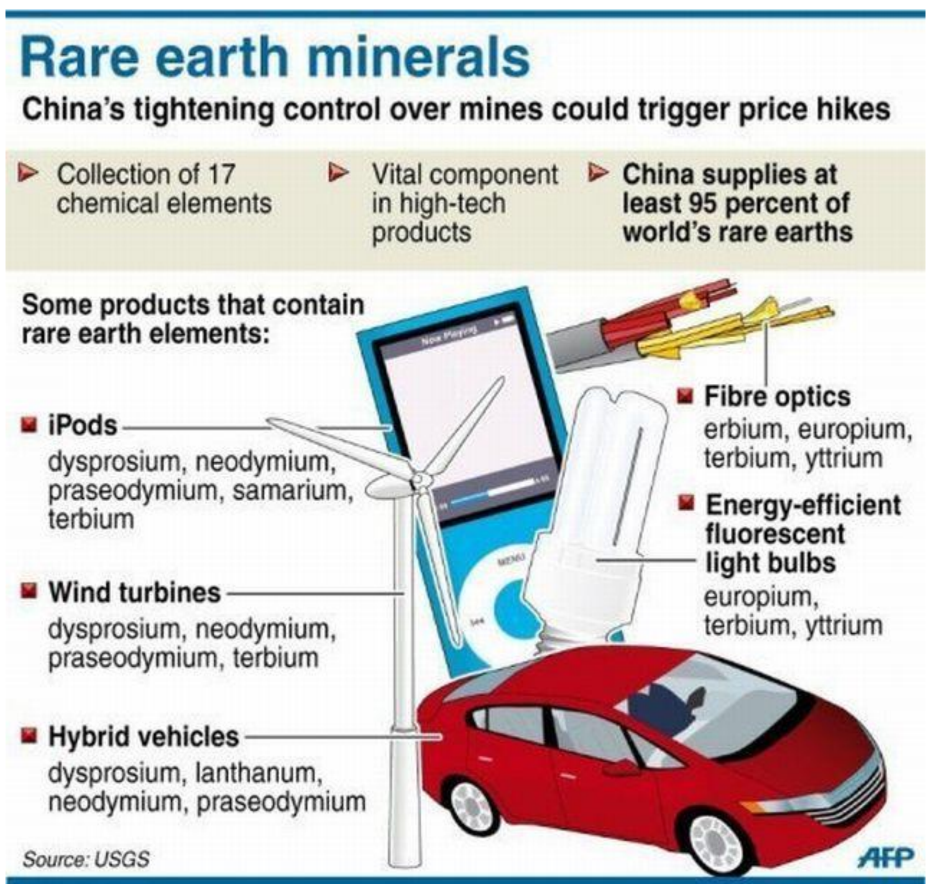
Terms:

- Mineral: A mineral is an inorganic, solid, homogeneous, crystalline chemical element or compound with a set chemical formula; broadly, a mineral or earth material is: any of various naturally occurring homogeneous substances (such as stone, coal, salt, sulfur, sand, petroleum, water, or natural gas) obtained usually from the ground.
- Alloy: An alloy is a substance containing two or more metals, usually created because it has certain more desirable properties than the original metal (ex. stronger).
- Rare Earth Minerals: Rare-earth minerals aren't really rare; they get their name because they are spread widely throughout the earth's crust in small concentrations that in most cases can't be mined economically.

The progress of cave-dwelling humans to today's modern society owes much to Mother Natures' treasury of metal and its alloys [An alloy is a substance containing two or more metals, usually created because it has certain more desirable properties than the original metal (ex. stronger).] No progress in agriculture, transport, technology, advancement in arts and crafts would have been possible if humans had not found metal in familiar materials such as soil and stone. Metals are precious, and called precious metals, because while you can find and extract or mine metals, you can't create them out of thin air you have to work for them, find them, dig them up and there is a finite (limited) supply. Long before government-issued currency (money) existed, people relied on bartering to obtain the things they needed. Merchants and consumers traded goods and services, but trade could get complicated and frustrating. For example, what if the food merchant didn't need your 15 pounds of potatoes, but you really wanted their 10lbs of apples for apple pie, your favorite! If all you had were potatoes, you wouldn't get the apples, sorry. If you were a shoemaker and you broke your arm and couldn't make shoes, what could you in exchange for a head of lettuce? Nothing. You would go hungry.

To make commerce a little easier, buyers and sellers slowly decided that something had to be used as a currency, and that currency had to be portable (easily movable) and widely accepted as a unit of transaction, a store of value, and a medium of exchange. Whatever they chose as currency needed to be something that performed the role of . . . money! For thousands of years, precious metals — primarily gold and silver — filled (and paid) the bill nicely.

Metals were also used to make tools and implements that made agriculture possible. Of course, over 1.8 million years, man has made equal progress in building weapons. Simple tools to keep predators away and defend your family have turned into everything from weapons of mass destruction to cell phones. As our forefathers discovered new metals and new ways to shape them, their lives changed forever. Gold and silver came to be recognized as precious across the globe, along with many other metals.



Who has control over metal has control of the world. It is hard to imagine a history, or a future without metals and minerals! Today everything from smart phones to flat-screen tvs and electric cars relies on minerals to function.

What's My Car Made Of?

Discuss with students: What is a car made of? What does it take to make a car? Where do the materials come from? The average car is made with over 30 materials extracted from the Earth! Each element, mineral and resource has special properties that make them important in the production and performance of the car.

Materials Needed:

- Copy of mineral sheet
- Poster or copies of a picture of car (the bigger the better)
- Pictures of minerals and earth materials listed from a book or poster, cut apart
- Double-sided tape
- Optional: Sticky back Velcro hook and loop fasteners; foam board; Super 77 spray adhesive

There are several ways to do this activity. For younger groups, perhaps the poster activity listed below may be more appropriate. With older students, do the individual activity.

Poster Activity: Hang a large poster of a car in the front of the room. Distribute the cut-up pictures of the elements and minerals. Have some double-sided tape ready. Have students as a group discuss each earth material and what it is used for. As you discuss each material and decide what it is used for in the car, have the student with the material come up and put that picture in the right spot on the car (for example, the quartz picture can be attached to one of the windows.) Continue until all are finished!

Optional: To make this activity reusable, print a picture of the earth materials, spray glue it onto foam board, cut out each piece and attach a Velcro hook on the back of each. Then put the other side of the Velcro piece (the loop) onto an appropriate spot on the car. Then the students can take their small foam board piece, stick it on to the Velcro, and you can take it off and reuse it for another class.

Individual Activity: Give each student or pair of students a copy of a picture of a car. Give each group a sheet with all the earth materials on it. Have them cut out each mineral and figure out where to place it on the car while reading the handout. Tape the picture to the correct spot.

Have students write a concluding statement about the activity. Ask them leading questions that will bring them to the realization that there are many, many minerals used to make items that we use everyday (i.e. were you surprised at how many different earth materials are used to make a car? Where do all of these earth materials come from? How do we get them?). This activity provides an excellent lead in to the following discussion/activities on mining.

Name of material	*Amount in lbs.*	*Use*
Aluminum	240	Light metal used in body of car.
Antimony	Trace	Used to make car upholstery fire resistant.
Asbestos	1.2	Used in brake pads.
Barium	Trace	Used to coat electrical conductors in the ignition system.
Cadmium	Trace	Electrolytically deposited as a coating on metals (steel) to form a chemically resistant coating.
Carbon	46	Used to make iron ore into steel. Steel contains 1% carbon. Also used to add strength to rubber.
Clays	Trace	Used to make ceramics in engine (ex. spark plugs)
Coal	NA	Used to make electricity to produce autos.
Cobalt	Trace	Makes thermally resistant alloys** ('superalloys') in engine.
Copper	42	Used for wiring throughout automobile.
Fluorspar	Trace	Directly or indirectly used to manufacture aluminum, gasoline and steel.
Gallium	Trace	Used in mirrors, transistors and LEDs.
Gold	Trace	Used in the electronics systems.
Iron Ore (see MAGNETITE)	4960	Used to make steel for the frame and engine of the auto.
Lead (see GALENA)	24	From the mineral galena, used in the battery. (960 lbs. of lead ore needed)
Magnesium	4.4	An alloy used to strengthen aluminum and zinc.
Manganese	17.6	Makes an alloy with steel that is tough and resistant to wear for parts such as the axles, pistons, crank shafts and gears. Used in batteries.
Molybdenum	1.0	Used to strengthen steel and lubricants.
Mica	Trace	Fills the shocks.

Nickel	9.0	Used as plating for stainless steel.
Nitrogen	Trace	Used for ceramic materials (spark plugs) and in battery.
Oxygen	Varies	Used for the combustion in engine.
Palladium	Trace	Used as an alloy in electrical contacts.
Petroleum (see gusher, oil rigs, and pipeline pictures)	980	From petroleum we produce plastics (used for the body and interior), rubber tires, paint, synthetic fabrics, gasoline and lubricating oils. Also to make electricity used in the production of the auto.
Quartz sand	170	Used for silica to make glass (85 lbs.)
Silicon	41	Ceramic components.
Strontium	Trace	Used for phosphorescent paint on dials.
Sulfur	2	Used in battery.
Tin	Trace	Alloys with copper, makes solder and lead.
Titanium	Trace	Used to make metallic alloys and as a substitute for aluminum. Also used in paint, lacquers, plastics and rubber.
Tungsten	Trace	Used in filament of light bulbs and for spark plug manufacturing.
Vanadium	1	Used to form alloys that are tough and resist fatigue. Used in axles, crank shafts, gears and other critical components.
Zinc Ore	18 (720 of zinc ore)	Galvanizes screws to be resistant to rust and corrosion. As a filler in rubber tires. Auto industry is the largest consumer.
Zirconium	Trace	Alloy of steel and glass, and used in light bulb filaments.

More and More Metals

These days we there are 86 known metals, but before the 19th century only 24 of these metals had been discovered and, of these 24 metals, 12 were discovered in the 18th century. Therefore, from the discovery of the first metals gold and copper, literally Ages ago, until the end of the 17th century, some 7700 years, only 12 metals were known. Four of these metals were discovered in the thirteenth and fourteenth centuries, while platinum was discovered in the 16th century. The other seven metals, known as the Metals of Antiquity, were the metals upon which human civilization was based, different time periods are even named after the metals that were most popular at the time, like "The Bronze Age" or "The Iron Age." These seven metals were:

- Gold (ca) 6000BC [now worth nearly $1,721.00 per ounce on the market]
- Copper,(ca) 4200BC [now worth about $3.77 a pound]
- Silver,(ca) 4000BC [now worth around $33.77 an ounce]
- Lead, (ca) 3500BC [now about $.97 a pound] Did you know that lead mining in the United States first started with the Native Americans? With just a bit of digging, Native Americans could find chunks of lead ore, also called galena. If these were broken open, the mineral flashed and glittered in the sun. Broken into tiny pieces, the glittering mineral could be used as a body paint.
- Tin, (ca) 1750BC [now worth about $10.89 a pound]
- Iron, smelted, (ca) 1500BC [now worth Per pound: $12.00]
- Mercury, (ca) 750BC the average cost of a flask (as mercury is a liquid at room temperature) of domestic mercury was $550 to $650 in 2008. [Mercury has not been made as a primary mineral commodity in the United States since 1992, though we keep a stockpile and due to recycling of products that contain it, the United States is the leading exporter of mercury (Due to changes in law, all exports of the substance will be banned as of January 1, 2013.). Mercury use has declined in the United States because of mercury poisoning and concerns for human health. Mercury is no longer used in batteries and paints manufactured (made) in the United States. Mercury was imported, refined, and then exported for global use in chlorine-caustic soda production, dental amalgam (mixes used to patch cavities), fluorescent lights, gym floors, and small-scale gold mining. Some button-type batteries, cleansers, fireworks, folk medicines, grandfather clocks, pesticides, and skin-lightening creams and soaps may contain mercury today.]

These metals were known to and used by the Mesopotamians, Egyptians, Greeks and the Romans. Of the seven metals, five can be found in their native states, e.g., gold, silver, copper, iron (from meteors) and mercury. However, the occurrence of these metals was rare and the first two metals to really be used widely were gold and copper. Gold was used for decorations. Gold is easy to work, but it is not strong enough to make tools or weapons out of. For that you need bronze or iron. Copper is mixed with tin to become bronze. You can find gold sometimes just lying in little lumps in streams here and there. But, usually, to get more gold you have to find gold mines underground. Because gold is both rare and pretty, it's valuable, and people have always been willing to work hard to get more gold.

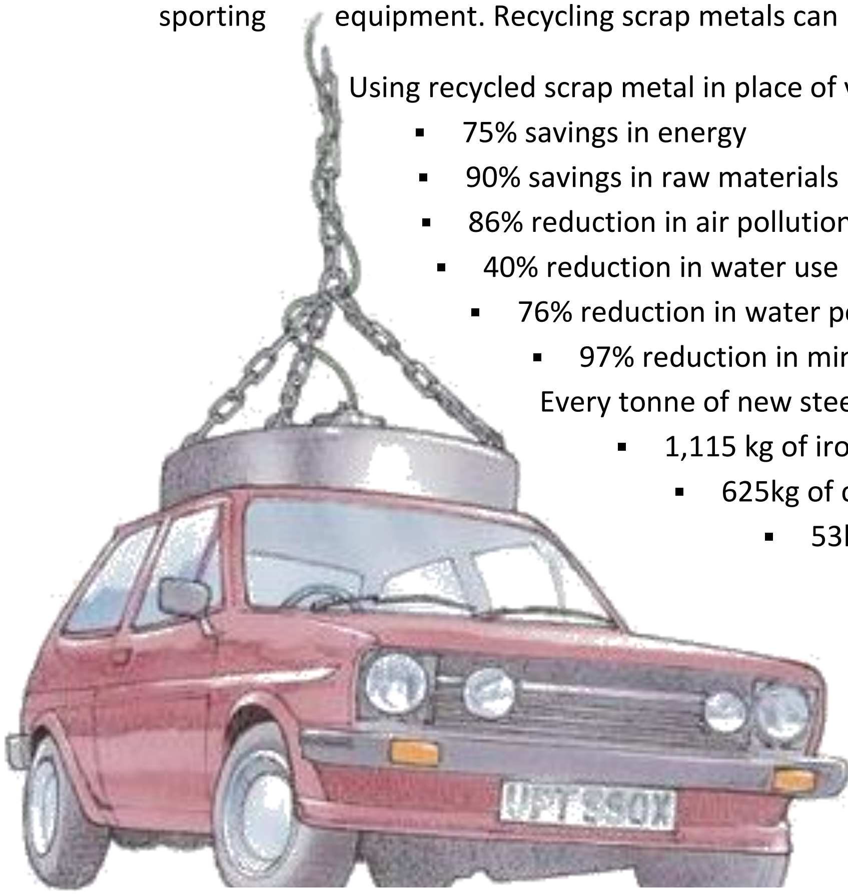
Because the whole center of the Earth is iron, iron is the most common metal on Earth. Other metals are also pretty common, like copper and lead. While aluminum is the most common metal found in the Earth's crust, the most common metal found on and in Earth is iron, mostly because it makes up nearly the whole part of the Earth's core. The heavier the atom, the rarer the metal, so very heavy metals like titanium or uranium are rare - on Earth, and everywhere else in the Universe.

One Man's Junk? Another Man's Treasure

Note: You may want to introduce this idea by reading Carolyn Crimi's Don't Need Friends or the excellent, *Demo: The Story of a Junkyard Dog* by Jon Bozak with students. Everybody loves an underdog, but what happens when the underdog looks scary?

Students have probably seen people along the side of the road pushing carts, picking up cans. It's not just about the littering, though that's a great reason to pick things up, what are those soda cans made from? Metal food and drink cans are usually made of aluminum or steel, kinds of metal, and metal is worth money. In the United States, 60 percent of aluminum drink cans are recycled. Put a magnet on the side of a can. If it falls off, the can is aluminum.

That's why in nearly every area, and a lot of towns, there are scrap metal collection businesses. Some people's "job" or how they get money to pay for things is to go around and pick up scrap metal, bringing it in for different amounts of money based on the kind of metal it is and how much, in weight, they brought. This metal later gets made into other things, or recycled. Old pots and pans, barbecues and lawnmowers are being turned into musical instruments and sporting equipment. Recycling scrap metals can be quite beneficial to the environment.



Using recycled scrap metal in place of virgin iron ore (new ore) can yield:

- 75% savings in energy
- 90% savings in raw materials used
- 86% reduction in air pollution
- 40% reduction in water use
- 76% reduction in water pollution
- 97% reduction in mining wastes

Every tonne of new steel made from scrap steel saves:

- 1,115 kg of iron ore
- 625kg of coal
- 53kg of limestone

Energy savings from other metals include:

- Aluminum savings of 95% energy
- Copper savings of 85% energy
- Lead savings of 65% energy
- Zinc savings of 60% energy

Image Credit: http://www.dkimages.com/discover/Projects/QUEEN/previews/11813583.JPG.

"If it wasn't grown; it was probably mined"

What is mining?

Now, most of the time these metals don’t sit around in lovely chunks on top of the earth, or in the river, ready to be picked up, they have to be mined or panned which means sifting them out. Mining is the extraction (removal) of minerals and metals from earth. Manganese, tantalum, cassiterite, copper, tin, nickel, bauxite (aluminum ore), iron ore, gold, silver, and diamonds are just some examples of what is mined.

Taste of Mine

The purpose of this activity is to give the player an introduction to the economics of mining. Each player buys "property," purchases the "mining equipment," pays for the "mining operation," and finally pays for the "reclamation." In return, the player receives money for the "ore mined." The object of the game is to develop the mine, safeguard the environment, and make as much money as possible.

Materials

- play money ($19 for each student)
- grid paper (1 sheet for each student)
- granola bars with choc chips (**only 1 bar per student**)
- toothpicks (flat and round)
- paper clips
- paper towels (for clean-up)

1. Each player starts with $19 of play money.
2. Each player receives a Granola Mining spread sheet and a sheet of grid paper.
3. Each player must buy his/her own "mining property" which is a single granola bar or oatmeal raisin cookie. Only one "mining property" per player. Two to three types of cookies should be "for sale"; one cheaper one with fewer chocolate chips than the other and another more pricey bar with more chocolate chips or raisins. For example, sell "Store Brand" bars for $5.00 and "Quaker Chewies" for $7.00.

Players choose their "properties" knowing that the more chips they harvest, the more profit they make.

4. After buying the granola bar, the player places it on the grid paper and, using a pencil, traces the outline of the bar. The player must then count each square that falls inside the outline, recording this number on the Granola Mining Spreadsheet along with the properties of the cookie. Note: Count partial squares as a full square.
5. Each player must buy his or her own "mining equipment." More than one piece of equipment may be purchased. Equipment may not be shared between players. Mining equipment for sale is
   Flat toothpick — $2.00 each
   Round toothpick — $4.00 each
   Paper clips — $6.00 each
6. Mining costs are $1.00 per minute.
7. Sale of a chip mined from a bar brings $2.00 (broken chocolate chips can be combined to make one whole chip).
8. After the bar has been "mined," the fragments and crumbs should be placed back into the outlined area on the grid paper. This can only be accomplished using the mining tools — No fingers or hands allowed.
9. Reclamation costs are $1.00 per square over original count. (Any piece of granola bar outside of original rectangle counts as reclamation.)

Granola Mining Rules

1. Players cannot use their fingers to hold the bar. The only things that can touch the bar are the mining tools and the paper on which the bar is sitting.
2. Players should be allowed a maximum of five minutes to mine their granola bar. Players who finish mining before the five minutes are used up should only credit the time spent mining.
3. A player can purchase as many mining tools desired; the tools can be of different types.
4. If the mining tools break, they are no longer usable and a new tool must be purchased.
5. The players that make money by the end of the game win.

All players win at the end of the game because they get to eat the remains of their **one** bar!

Post Activity Class Discussion:

- Was the granola mining activity messy? How was the mine owner responsible for the mess?

- Did this activity help you to understand the way a real mine works? What would happen if one student had only peanut butter chips in his granola bar and another had chocolate chips in hers? How would they work out a way to share their "resources?"
- How does this activity relate to real-life mining?
- Do they think that a real mine would produce a lot of excess material that would need to be cleaned up? [Each player should have learned a simplified flow of an operating mine. Also, each player should have learned something about the difficulty of reclamation, especially in returning the granola bar to the exact size that it was before "mining" started.]
- Can they think of any ways that a mine owner could be made responsible for the impact made on the environment?
- Do they use anything that comes from a mine?
- What is the most valuable thing they know of that can be mined?
- What types of mines are in your state?

Granola Mining Spreadsheet

1. Type of Granola Bar			____________________
2. Price of bar			= $________
3. Size of bar	________ squares covered		
4. Equipment used			
	________ flat toothpicks	x $2.00	= $________
	________ round toothpicks	x $4.00	= $________
5. Cost of removing chips	________ minutes mining	x $1.00	= $________
6. Total cost of mining (add #2-5)			= $________
7. Total value of chips	________ chips	x $2.00	= $________
	________		

8. Reclamations costs	___squares	X$1.00	= $________

How much did I make?			$19.00
		-	
	Total cost of mining		$________
		+	
	Total value chips		$________
		-	
	Reclamation costs		$________
	Profit or loss	**=**	$________


THE UNITED STATES OF AMERICA
ONE DOLLAR

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What is panning?

Wide, shallow pans are filled with sand and gravel that may contain gold. The pan is submerged in water and shaken, sorting the gold from the gravel and other material. As gold is much denser than rock, it quickly settles to the bottom of the pan.

Gold panning is the easiest technique for searching for gold, but is not a cost effective way to get a lot of gold quickly, however before large production methods are used, a new source must be identified and panning is useful to identify gold deposits and get enough gold so it can be evaluated for monetary worth

Panning for BB Bullion

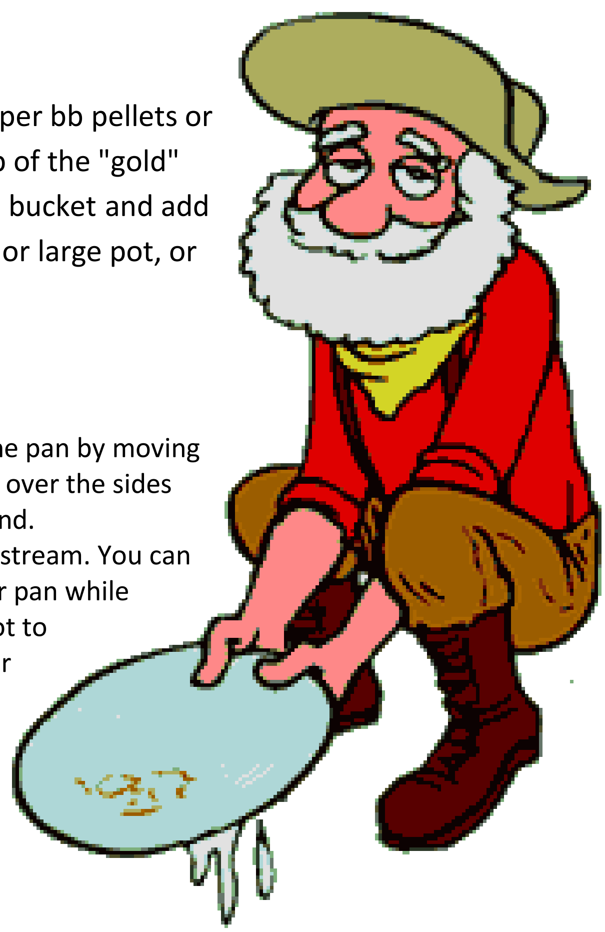
Materials:

- BBs
- Shallows
- Coarse Sand
- Buckets

For a classroom panning exercise, obtain some fine copper bb pellets or iron fillings from a hardware store. Mix one-quarter cup of the "gold" with about 10 liters of coarse sand. Put the mixture in a bucket and add water to make a slurry and swirl it over another bucket or large pot, or outside!

Tell students:

1. Holding your pan on either side, swirl the water in the pan by moving your arms in circular motions. The water should spill over the sides of the pan taking with it fine particles of mud and sand.
2. As you start to lose your water replenish it from the stream. You can pick out the larger particles of rock or simply tip your pan while swirling so they will fall out of the pan. Make sure not to dump your entire pan otherwise you will lose all your potential nuggets!



Tell them not to tip the pan too far and to continue adding plain water while swirling until only the pellets or fillings remain in the bowl.

Why mine?

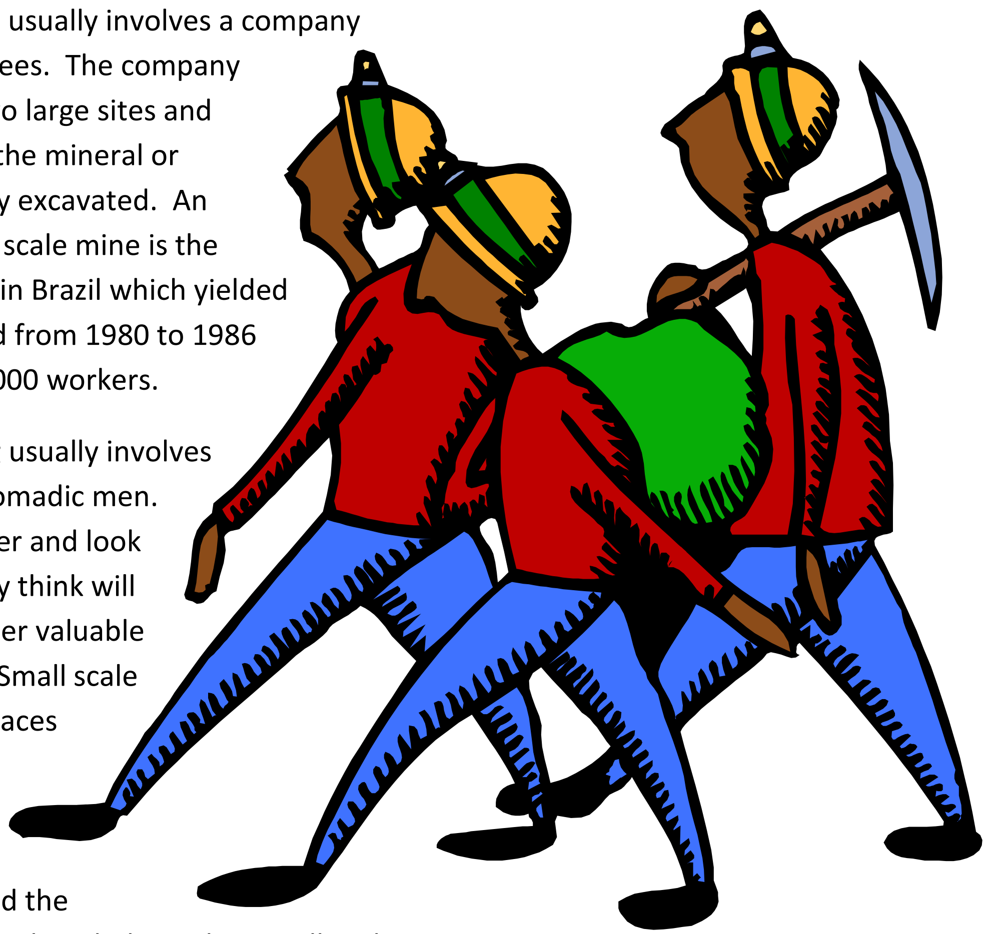
Mining is a money making business. Not only do mining companies prosper, but governments also make money from revenues. Workers also receive income and benefits.

What are the minerals and metals used for?

Minerals and metals are very valuable commodities. For example, manganese is a key component of low-cost stainless steel. It is also used to de-color glass (removing greenish hues), but in higher concentrations, it actually makes lavender-colored glass. Tantalum is used in cell phones, pagers, and lap-tops. Cooper and tin are used to make pipes, cookware, etc. And gold, silver, and diamonds are used to make jewelry.

Large scale mining versus small scale mining:

- **Large scale mining** usually involves a company with many employees. The company mines at one or two large sites and usually stays until the mineral or metal is completely excavated. An example of a large scale mine is the Serra Pelada mine in Brazil which yielded 29,000 tons of gold from 1980 to 1986 and employed 50,000 workers.



- **Small scale mining** usually involves a small group of nomadic men. They travel together and look for sites which they think will yield gold or another valuable metal or mineral. Small scale mining occurs in places such as Suriname, Guyana, Central Africa, and many other places around the world. Some researchers believe that small scale mining is more harmful to the environment and causes more social problems than large scale mining. This will become apparent later in the lesson.

How does mining affect the environment?

Mining is generally very destructive to the environment. It is one of the main causes of deforestation. In order to mine, trees and vegetation are cleared and burned. With the ground completely bare, **large scale mining** operations use huge bulldozers and excavators to extract the metals and minerals from the soil. In order to amalgamate (cluster) the extractions, they use chemicals such as cyanide, mercury, or methylmercury. These chemicals go through tailings (pipes) and are often released into rivers, streams, bays, and oceans. This pollution contaminates all living organisms within the body of water and ultimately the people who depend on the fish for their main source of protein and their economic livelihood.

Small scale mining is equally devastating to the environment, if not more. Groups of 5-6 men migrate from one mining site to another in search of precious metals, usually gold. There are two types of small scale mining: ***land dredging*** and ***river dredging:***

- ***Land dredging*** involves miners using a generator to dig a large hole in the ground and then they use a high pressure hose to uncover the gold-bearing layer of sand and clay. The gold bearing slurry is pumped into a sluice box, which collects gold particles, while rest of the dirt and sludge flows into either an abandoned mining pit or nearby forest. When the mining pits fill with water from the tailings (pipes), they become stagnant water pools, creating a breeding ground for mosquitoes and other insects. Malaria and other water-borne diseases increase greatly whenever open pools of water are nearby.

- ***River dredging*** involves moving along a river on a platform or boat. The miners use a hydraulic suction hose, like a vacuum, and suction the gravel and mud as they move along the river. The gravel, mud, and rocks go through the tailings (pipes) and any gold fragments are collected on felt mats. The remaining gravel, mud, and rocks go back into the river, but in a different location than where it was originally suctioned. This creates problems for the river. The displaced (moved) gravel and mud disrupt the natural flow of the river. Fish and other living organisms often die and fishermen can no longer move through the obstructed rivers.

Reclaiming the land after mining makes it more productive and available once more for grazing, recreation, or wildlife habitat. Reclamation consists of recontouring the land and planting seeds or trees to help prevent erosion and enhance vegetation.

Make it rain

To show students how soil erosion varies according to land surface, have them take turns to pour water on three different mounds-- one made with soil, one with sand, and one with gravel. What happens?

Have students redesign the experiment again using sod or other materials to determine the value of planting vegetation on lands that have been exposed by mining.

How does mining affect the people?

Mining has never been an easy job, at any time throughout history, though it does come with valuable rewards and humans need and use minerals. For example, historically, mining was a cornerstone of the Alaska economy. Many roads, docks, and other infrastructure throughout Alaska, California, and other areas were originally constructed to serve the mining industry. Today, a rejuvenated mining industry is bringing a broad range of economic benefits to different communities. For example, mining offers some of the highest paying occupations in Alaska and provides jobs in many rural areas, where there are few other jobs available. It adds money into the local economy and government through taxes, wages, etc. Coal alone is responsible for more than 40% of the energy produced by humans, more than twice exceeding respective figures for oil and gas.

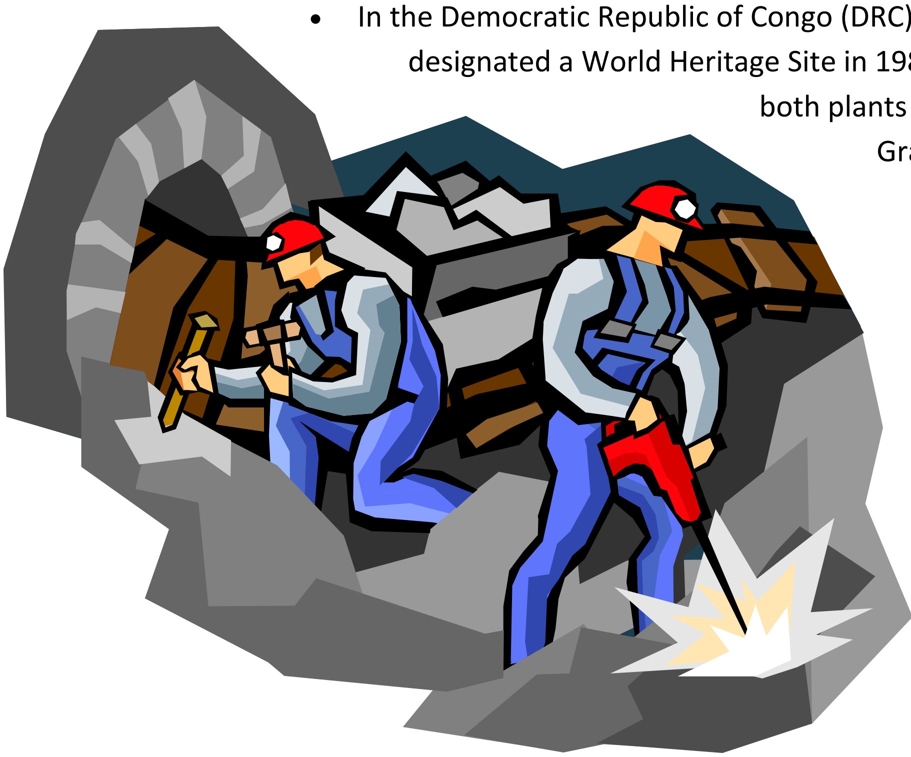
However, there are drawbacks as well. Miners have always faced numerous on-the-job hazards. Regardless of technological advances, this is still a highly dangerous occupation in grueling working conditions. For example, even with technological advances, miners then, as now, face an omni-present fear of death. Falling tools and rocks, cave-ins, rock bursts, and mine fires all take their toll. Every miner knows that some day they may never come back from the mine. Careless blasting of dynamite results in the loss of fingertips, hands, and noses. Fumes from the dynamite caused miners to pass out. Dust thrown out by compressed air drills penetrating certain rocks causes silicosis (a lung disease).

Many times, any people, not just miners, who are exposed to the toxic waste from the waste pipes become sick. They develop skin rashes, headaches, vomiting, diarrhea, etc. In fact, the symptoms of mercury poisoning are very similar to the symptoms of malaria. Many people who cannot afford to go to a doctor, or who live in a village where a doctor is not accessible, are often not treated for their illnesses.

- If the water is contaminated, the people cannot safely use it for bathing, cooking, or washing their clothes.
- If the man of the household is a small scale miner, he often leaves his wife and children in search of work. This means that the wife and children must work and provide for themselves. They must also protect themselves from danger.

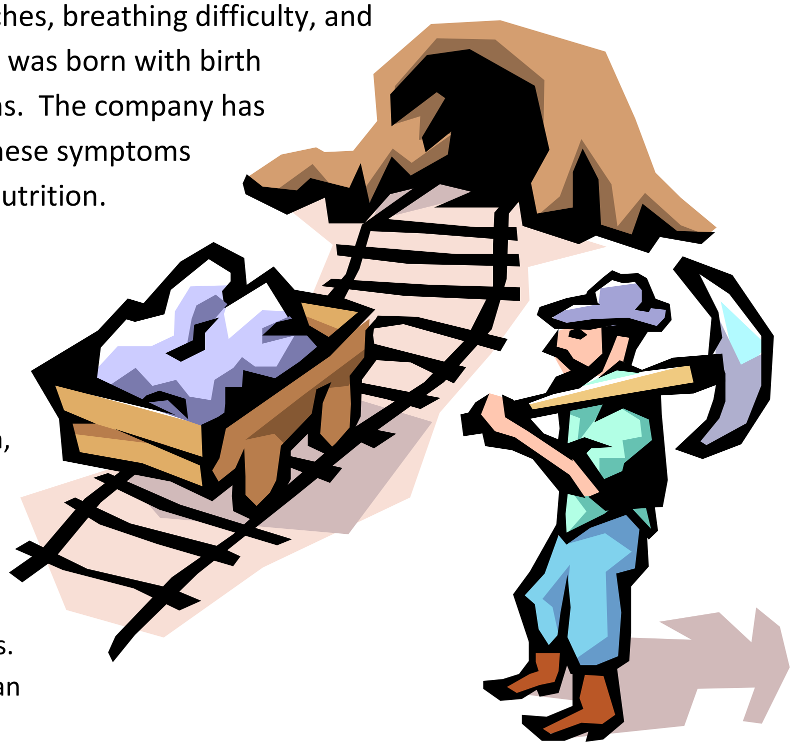
Three case studies:

- In Guyana, both large and small scale mining occur. In the early 1980's, the price of gold spiked from $100-$150 per ounce to $700 per ounce! This created huge incentives for governments to allow mining companies to come into their countries. From 1986 to 2001, one company excavated 3/4 of all the gold in Guyana. Not only was the mining company making huge sums of money, but the Guyana government was also benefiting from the revenues; owning 5% of the companies' shares. However, in 1995 the tailings dam, which was filled with three million cubic meters of waste, collapsed and spilled into the Essequibo River, the biggest river in Guyana. The toxic waste drained north-exposing 10,000 people (both residents and tourists). All of the fish in the river died, and although no humans died from the toxic exposure, many people developed skin rashes and respiratory problems.
- In the Democratic Republic of Congo (DRC) the Kahuzi-Biega National Park was designated a World Heritage Site in 1980 because of its rich bio-diversity in both plants and animals. In fact, 86% of the Grauer's gorilla, a subspecies which is endemic to this region, was found in this park. However, all that has changed. In the late 1990's, armed groups involved in a civil war set up mining operations within the boundaries of the park to extract valuable minerals. Thousands of Congolese whose lives had



been devastated by the war came to the mines in search of money to feed their families. An estimated 15,000 people were thought to be working at about a hundred sites throughout the park. Tragically, not only were minerals removed, but also trees, vegetation, and large mammals. The miners hired hunters to feed the people working at the mining sites. Gorillas, elephants, chimpanzees, buffaloes and antelope at first were easily found within the park. But, as the months passed, it became increasingly more difficult to find large mammals. Hunters searched longer and farther. By March of 2001, most of the large animals had all been killed and eaten. The Grauer's gorilla suffered the most, since this unique gorilla sub-species is only found in this area. Before the mining, the total population was estimated to be 17,000- with 86% living in the Kahuzi-Biega National Park. Now, it is estimated that only 2-3,000 Grauer's gorillas remain. The remaining Grauer's gorilla population is vulnerable to poaching and inbreeding. The fate of this sub-species is unknown at this time.

- In Indonesia, a U.S. mining company based in Denver (Newmont) has been extracting gold since 1996. This company no longer mines in this region for two reasons: (1) in 2004, they extracted all the gold, and (2) the company is currently being sued by the Indonesian government for intentionally dumping poisonous waste, such as arsenic and mercury, into the Buyat Bay. This waste has poisoned the fish in the bay. This was, sadly, their main source of protein and economic livelihood. In addition, many people in this region have complained of headaches, breathing difficulty, and skin rashes and tumors. One newborn was born with birth defects and died at the age of 3 months. The company has denied any wrong doing and blames these symptoms and incidents on poor sanitation and nutrition.



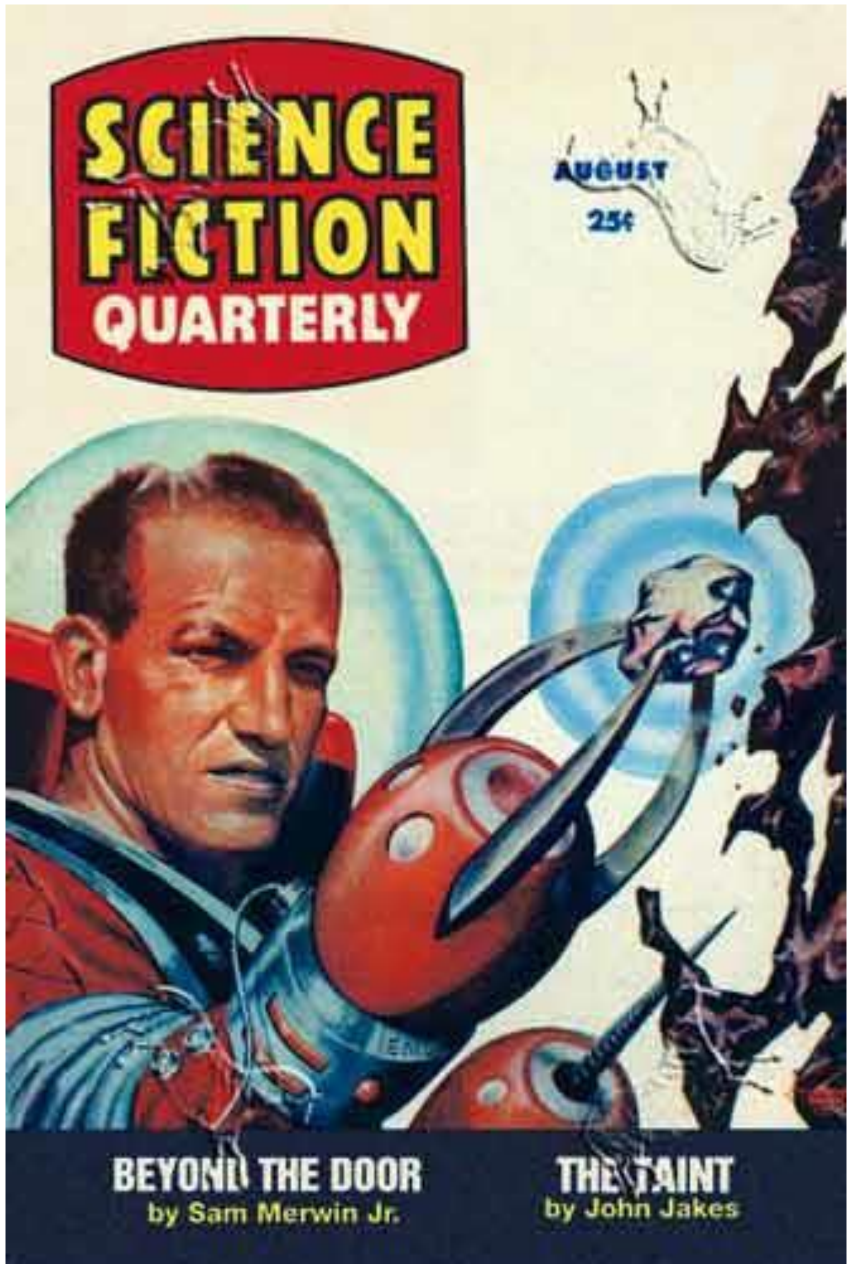
Where does mining occur?

Mining occurs in many places around the world, including the U.S. In South America, mining is particularly active in the Amazonia region, Guyana, Suriname, and other South American countries. In Central Africa, mining devastated a National Park called Kahuzi-Biega in the eastern Democratic Republic of Congo (DRC). South Africa is also very well known for mining diamonds. Mining also occurs in Indonesia and other S.E. Asian countries.

What if we run out?

Discuss the following with students: As we use more and more metals and the demand for them gets higher and higher, remember, the supply has a limit. What do we do if we run out? Guide the discussion so that students make the connection with meteors and suggest mining themselves.

The idea of mining the planets, Moon, asteroids, and comets for their valuable mineral resources is not new. Science fiction writers began weaving tales of space mines, worked by crusty, usually antisocial old prospectors, in the 1930s. Invariably, these difficult, dirty, lonely operations in the far frontiers of the solar system resembled the mines in a more familiar frontier situation—the nineteenth-century American Old West.



Not surprisingly, the Old West not part of the vision of the scientists who began discussing asteroid mining in the 1970s. The technological advances made during the U.S. space program had recently culminated in several successful manned Moon landings. And the experts became convinced that mining asteroids and perhaps comets too, would actually be feasible in the near future.

Since that time, scientists working for both NASA and private companies have been doing detailed studies of space mining. The general consensus is that most of the technology needed to begin modest mining operations on an asteroid already exists. The main ingredient still missing is the commitment of a large amount of money by a government, corporation, or group of private investors. The experts all agree that it is only a matter of time before humans begin exploiting the tremendous wealth of resources waiting for them in the solar system.

What can we get from an asteroid?

Two types of materials on asteroids appear to be attractive for mining - metals and volatiles. Both of these are essential for space travel. The cost of launching any material from the Earth is extremely high, so useful materials which are already in space can be very valuable.

Most of the asteroids are found in orbits between Mars and Jupiter. However, several hundred have orbits that bring them close to the Earth. Rocket trips to some of these “near-Earth” asteroids [NEAs] would use even less fuel than a trip to the Moon, though the travel time to an asteroid might be much longer.

- Metals - An asteroid of the composition of an ordinary chondrite could be processed to provide very pure iron and nickel. Valuable byproducts would include cobalt, platinum, gallium, germanium, and gold. These metals are basic to the production of steel and electronic equipment. Some metals from an asteroid mine might even prove valuable enough to be returned to Earth. Iron meteorites are high grade ores.
- Volatiles - Water, oxygen, and carbon compounds are useful in any space settlement, both for life support and for producing rocket fuel. These volatiles could be found in an asteroid that resembles a carbonaceous chondrite or the nucleus of a former comet. Water contents may range from 5-10% by weight for a chondrite to 60% by weight for a comet nucleus. In some asteroids large quantities of sulfur, chlorine and nitrogen may also be available.

The first questions that all potential investors ask, of course, are what is the nature of these abundant resources contained in asteroids and comets, and what are they worth? Scientists answer first that the asteroids are composed of iron, nickel, platinum, and other metals, as well as sulfur, aluminum oxide, carbon compounds, and other minerals. Many asteroids also contain smaller amounts of volatiles, aka fuels, including hydrogen, oxygen, and water.

As for the value of these materials to people on Earth, lets look at the example of the smallest known M-type asteroid—Amun. It is about 1.2 miles across and has a mass of about 30 billion tons. To put this large tonnage in perspective, have students imagine that the raw materials from the mining operation are loaded into a fleet of space shuttles like those presently in

NASA's fleet. The cargo bay of a typical shuttle holds about twenty-five tons, equivalent to 250 two-hundred-pound people. It would take four hundred shuttles (or four hundred trips by one shuttle), therefore, to haul ten thousand tons of asteroidal material; and it would take 1.2 billion shuttles (or 1.2 billion trips by one shuttle) to carry all of the materials mined from Amun.

Regarding the materials themselves, Amun's total tonnage breaks down into many different metals. The most abundant of these are iron and nickel, which alone would have a market value of about $8 trillion. (Keep in mind that a trillion is a million times a million.) Supplies of another metal, cobalt, on Amun would be worth perhaps $6 trillion. Then there are rarer metals such as platinum, iridium, osmium, and palladium, which together would add another $6 trillion to the investors' profits. The nonmetals, including carbon, nitrogen, sulfur, phosphorus, oxygen, hydrogen, and gallium, would be worth at least $2 trillion. If humans mined all of Amun, therefore (which would take many years), the gross profits would come to at least $22 trillion. It is difficult to estimate the upfront costs of such a mining operation. But even if they were as high as $1 trillion, the net profits would still be $21 trillion [USA + CHINA + JAPANs entire economic output for a year] , asteroid mining will be an extremely profitable business.

Remember also that all of the valuable resources and profits cited are from a single small asteroid. What would all of the asteroids in the asteroid belt together be worth? If we think about the asteroidal iron alone:

To raise the standard of living of the people of Earth to present-day North American, Japanese, or Western European levels, we need about 2 billion tons of iron and steel each year. With the asteroidal supplies of metal at hand, we could meet Earth's needs for the next four hundred million years. . . . Suppose that we were to extract all the iron in the belt and bring it back to Earth. Spreading this amount of iron uniformly over all the continents gives us a layer of iron . . . half a mile thick. . . . This is enough iron to cover all the continents with a steel frame building 8,000 stories (80,000 feet, or 15.2 miles) tall or build a huge space city. A metal sphere . . . 550 miles in diameter. Hollowed out into rooms with iron walls, like a gigantic city, it would make a spherical space structure over . . . 1,200 miles in diameter. . . . With a nine-foot ceiling, we could provide each family with a floor area of 3,000 square feet for private residential use and still set aside 3,000 square feet of public space per family. This artificial city/world would contain enough room to accommodate more than ten quadrillion [a million times a billion] people. Very simply, that is a million times the ultimate population capacity of Earth. whether they live on Earth or in space cities, people will naturally want to obtain cosmic resources as easily and cheaply as possible.

When one factors in the other metals available in the asteroid belt alone, along with the many nonmetals, the total resources could sustain a human population a million times larger than the present one for several thousand years. And this does not take into account the trillions of asteroids and comets in the Kuiper Belt and Oort Cloud. (The comets contain far fewer metals, but do have many minerals, as well as an abundance of volatiles that could be used for food production and making fuels.)

Supplies for Earth and the New Frontier

The discussion of the monetary worth of asteroids and comets must not divert attention from the other major reason to pursue the dream of mining these objects. Namely, the metals, minerals, and volatiles acquired in such operations would help conserve supplies of these materials on Earth. At present, these supplies are marginally sufficient to sustain the planet's present population. But that population will inevitably grow and supplies of a number of metals and other commodities will begin to run out.

Take a Stand!

Let’s poll a little public opinion

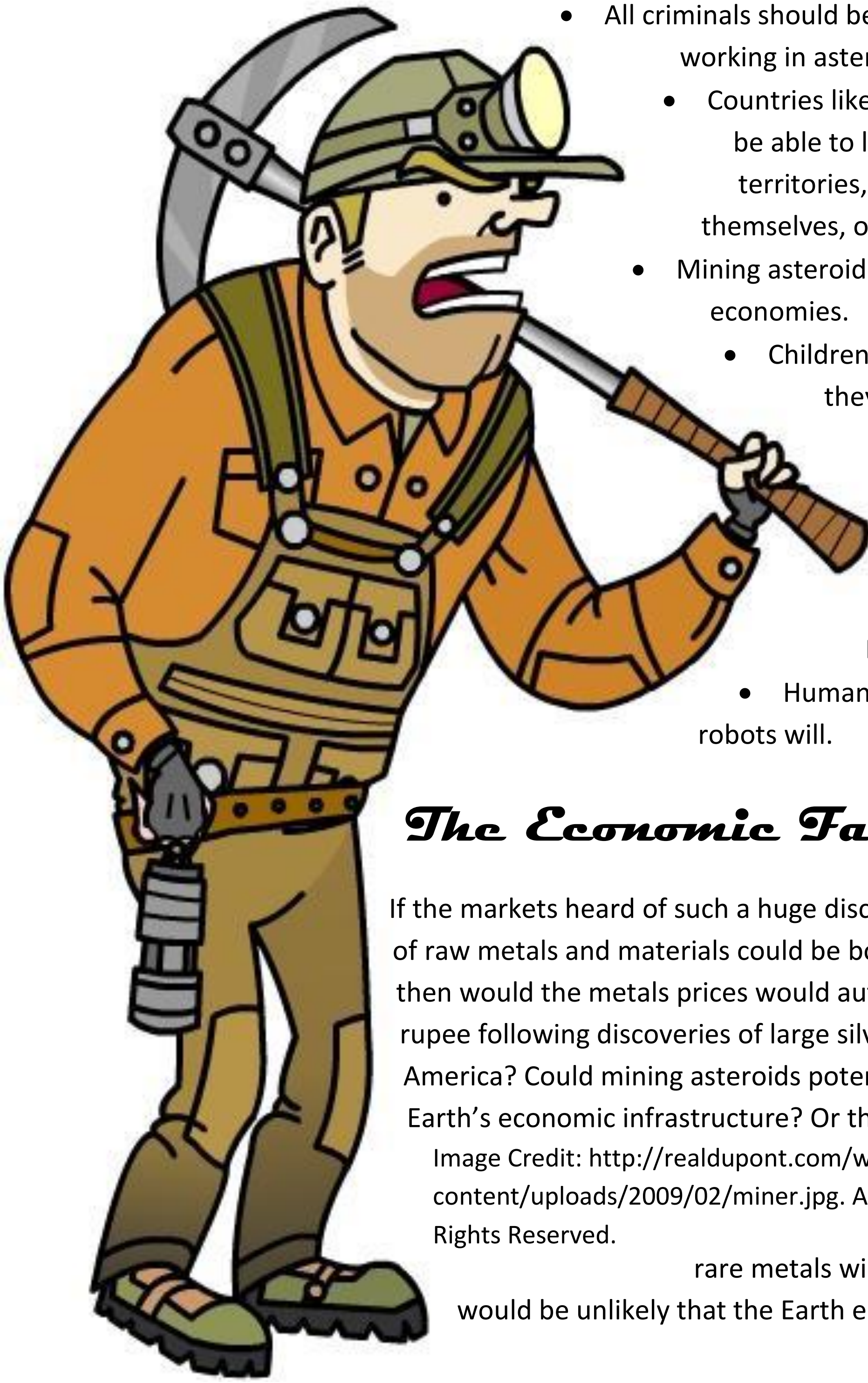
Materials:

- Four posters, each labeled in large letters with one of the following: Strongly Agree, Agree, Disagree, Strongly Disagree
- a teacher-generated list of statements about the various factors of asteroid mining
- writing paper and pencils at each corner.

Place a poster in each corner of the room. Then read a statement, and tell students to go to the corner that best describes how they feel about that statement.

Encourage students to voice their opinions from their respective corners. Then have each group gathered in response to a statement work together to write a clear statement explaining their position and be prepared to defend it.

Sample Statements:



- All criminals should be sentenced to serve their time working in asteroid mines.
- Countries like the USA, Russia, and China should be able to lay claim to asteroids, like new territories, and keep all resources for themselves, or sell as they choose.
- Mining asteroids will destroy the Earth's economies.
- Children should be used as asteroid miners, they are small, nimble, fast, eat less, weigh less, and are more quickly replaceable.
- Humans won't start trying to mine on asteroids until we have fully depleted Earth's resources.
- Humans won't go into space long term, robots will.

The Economic Factor:

If the markets heard of such a huge discovery and that such a large hoard of raw metals and materials could be bought down to earth profitably, then would the metals prices would automatically drop like the fall of the rupee following discoveries of large silver deposit in Mexico and South America? Could mining asteroids potentially be the downfall of the Earth's economic infrastructure? Or the salvation of it?

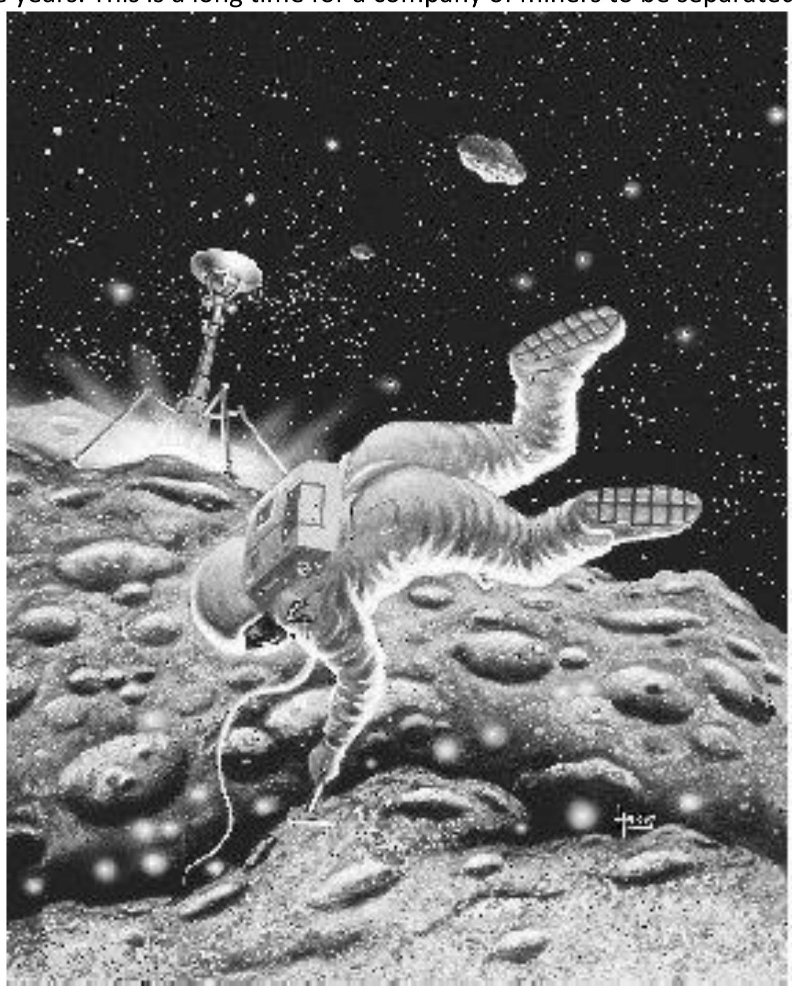
Image Credit: http://realdupont.com/wp-content/uploads/2009/02/miner.jpg. All Rights Reserved.

Some say that it is not likely anything other than extremely rare metals will be taken back to Earth, so it would be unlikely that the Earth economy would be affected, but is that really true?

The Human Factor

In a few decades a few critical resources will start to run out, mostly phosphorus needed for artificial fertilizers. This will cause prices to rise and create incentives to develop other sources. While some scientists find the idea of interplanetary mining very interesting, others find the idea of humans spending years of their lives drilling and the analogy of miners going off to an adventurous frontier a bit unlikely.

Others don’t. NASA, various groups of scientists, and some private companies have already begun drawing up plans for such space mining missions. They know that certain inherent difficulties and problems will have to be overcome, or at least planned for, to make this huge undertaking work. For example, even in the case of the closest asteroids, which will surely be the first targets for space miners, a typical round trip will be two to five years. This is a long time for a company of miners to be separated from family, friends, and society in general. Long periods of work in weightless conditions may also have a negative effect on the miners' health. Astronauts who have spent many months in weightless conditions in Earth's orbit have developed muscle weakness, loss of calcium and red blood cells, and other problems. And of course, such ventures will be extremely costly and require long-term financial and other commitments from governments, companies, and tens of thousands, if not millions, of individuals.



Some scientists believe It is more likely that no one will be doing manual labor in a spacesuit. Who might be doing it instead? What might be some problems with human miners? Some advantages? According to some, any project that requires humans in space is at least 10 times as expensive as a comparable project that that isn't.

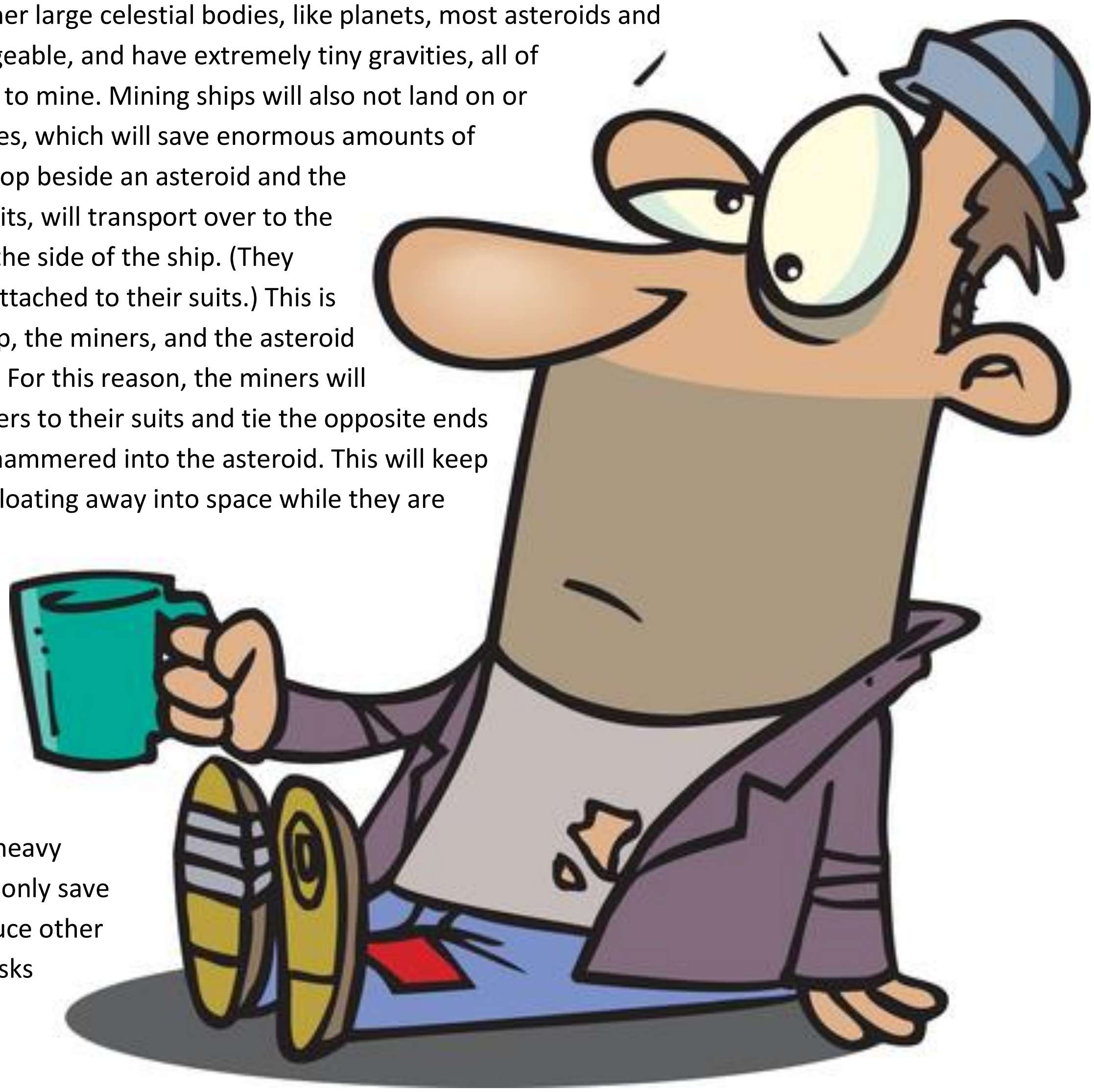
Some say what is more likely is **after** a well established space mining industry is accomplished; there might be administrators who oversee a large robotic mining operation if people decide to live nearby.

What might be some incentives for humans to live on barren asteroids?

- Life in space became very inexpensive
- Huge monetary gains
- The population problem is so bad that wide open and luxurious space habitats are a dime a dozen.
- Political and social reasons, if warfare becomes more frequent, and space real estate is almost free and attractive to pioneers.
- Refugees who decide living in a volatile political area is not worth it.
- Easier to get luxuries in space, and unlimited resources/housing space/higher quality of life.

The Zero-Gravity Factor

Unlike the moon and other large celestial bodies, like planets, most asteroids and comets are small, manageable, and have extremely tiny gravities, all of which make them easier to mine. Mining ships will also not land on or take off from these bodies, which will save enormous amounts of fuel. A typical ship will stop beside an asteroid and the miners, wearing spacesuits, will transport over to the worksite by pushing off the side of the ship. (They may also use small jets attached to their suits.) This is possible because the ship, the miners, and the asteroid are all nearly weightless. For this reason, the miners will need to attach long tethers to their suits and tie the opposite ends of the tethers to spikes hammered into the asteroid. This will keep them from accidentally floating away into space while they are working.



In addition, the mined materials in such a situation are, like the miners, nearly weightless, and will not need to be lifted off the asteroid's surface using heavy equipment. This will not only save fuel, but will greatly reduce other risks. There will be] no risks of crashes, no huge rockets. The gravity of the asteroids is very weak. A person can jump off any but the largest asteroids with leg power alone. Another advantage of mining asteroids, rather than the Moon, is that the asteroidal metals and minerals are concentrated in a small, easily accessible space and are much purer in content, they don't have as much space junk mixed in.

The Homeless Factor

During these mining operations, which could take months or years, depending on the size of the asteroid and the number of workers and machines, the miners will need somewhere to live. The quarters aboard the space ship itself will likely be too cramped for such a long stay; it would be like living in a tiny closet for years. So the miners could build a temporary habitat, which will use mostly on-site materials and thereby eliminate the need and cost of bringing them from Earth.

To some degree, the kinds of materials required to build and sustain a human habitat for such miners will dictate the type of asteroid the mining operation will target. Although M-types have more metals than other kinds of asteroids, probably a majority of the asteroids mined will be S-types or C-types. These bodies have larger supplies of oxygen, hydrogen, water (in the form of ice), and other volatiles that are essential to the habitats. If necessary, additional volatiles can be obtained from comets; storehouses of cometary volatiles could be positioned at various points in space for asteroid miners to draw from.

As for how these lighter materials will be converted, first the miners will melt the ices to produce water for drinking, cooking, and bathing. They will also extract oxygen and hydrogen from the ices and combine them with various minerals to make beams, walls, pipes, and other parts for their habitat. The miners can also employ the oxygen and hydrogen to make fuel, both to power the ship on its return voyage and to sell to companies or individuals in space cities or on Earth. This means that relatively little, if any, fuel will have to be brought from Earth, making space mines and habitats almost completely self-sufficient.

Indeed, nothing would be wasted during the mining operation. Even unprocessed soil could be used for shielding to protect miners and other astronauts on longer missions from cosmic rays and solar flares [dangerous radiation from the Sun]."

Challenges to the project:

- Convincing the general public that this is feasible stuff. Convince the populous that asteroid mining is the next natural step (which it is) and we'll be there in no time flat.
- Protecting astronauts from cosmic rays and solar flares [dangerous radiation from the Sun].

Assuming the necessary worldwide and human commitments materialized, the technical difficulties would actually be pretty minimal. Some scientists today believe that humans can reach and mine the asteroids and comets mostly using technology that exists or is presently in development. This technology will have to be applied on a much vaster scale but it could be doable. "This isn't Star Wars," say the Minor Planet Center researchers. "The asteroids aren't against us. It's really pretty simple stuff." People have already demonstrated the ability to travel and live in space, and according to scientists "the engineering factors that go into 'docking' with an asteroid are not difficult."

The biggest difficulty will rest in the human decision to begin the enormous enterprise of exploiting the riches of the solar system. Countries, peoples, and government s have to join together but people accomplishe d such large-scale goals before, as the Europeans did when they settled and transformed

Image Credit: Zero Gravity by ~Geironimo All Righs Reserved. Copyright 2012.
http://fc04.deviantart.net/fs45/f/2009/065/f/c/Zero_Gravity_by_Geironimo.jpg

North and South America or as the Americans did when they aimed for and reached the Moon in the 1960s. One thing is certain. While these prior goals were considered enormous in their own times and had innumerable unforeseen positive and negative consequences, their scale would be positively dwarfed by the adventure that awaits humanity in the asteroid belt and beyond.

Prospecting on Asteroids

This activity allows students to simulate a miniature mining expedition to an edible asteroid.

Materials:

This will make one large or two small "asteroids" for about 10 students (groups may take turns).

- Small package potting soil
- 1lb play dough or clay per asteroid
- 10-20 marbles (depends on size of marbles)
- 40 dried Great Northern beans, or equivalent
- Optional: Rice or other blend-ins.
- Large bowls
- apple corers, knives, or cork borers
- toothpicks
- small tabs for labels
- Student Worksheet
- metric ruler
- pens/pencils

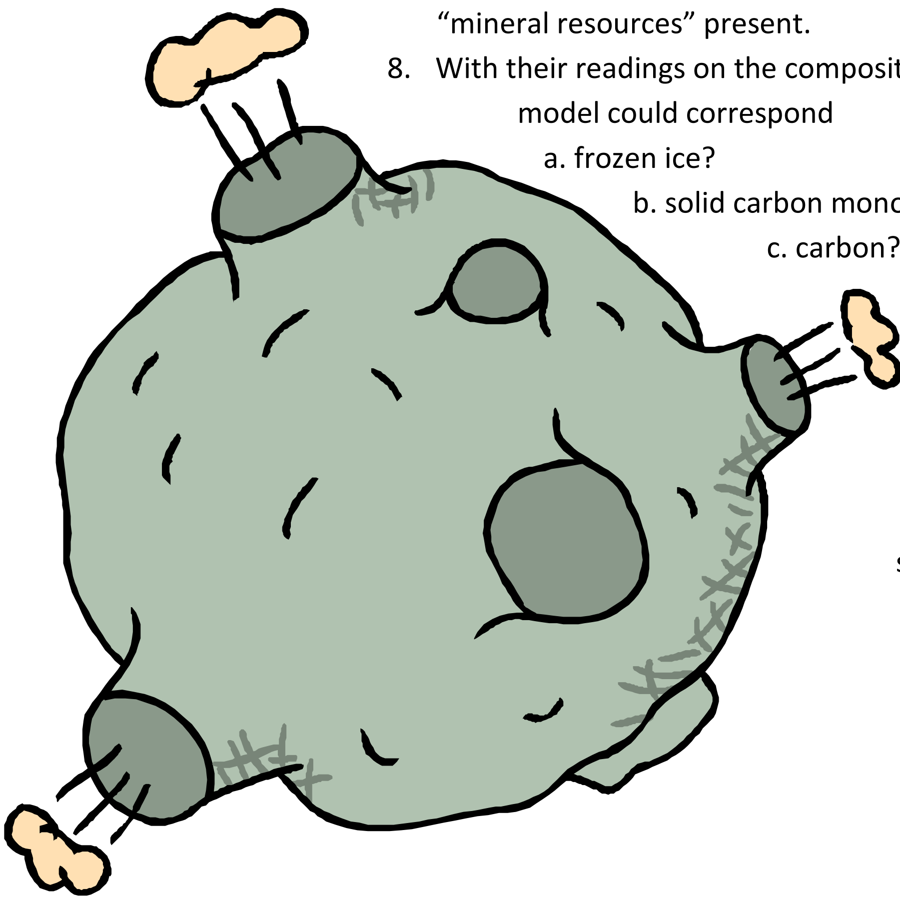
Assemble or assign materials.

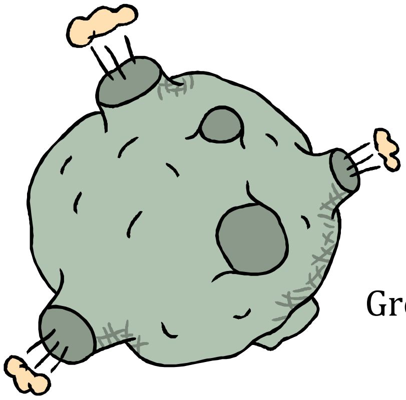
Review the background material and create asteroids.

Image Credit:
Brice Reignier, Freelance Illustrator.
http://breignier.blogspot.com/2011/01/alien-prospector.html.

Have them wash their hands before they start and remind them to not lick their fingers while they are working with their models. Students will make an "asteroid", and the class or team determines what the ingredients represent.

1. Have groups exchange "asteroids" with another team (to make the coring a discovery).
2. Name their "asteroid"
3. Draw or map/diagram the "asteroid" using the student worksheet; illustrate in detail.
4. Locate the best site for a core sample (a deep cylindrical hole) that will help determine the interior resources.
5. Mark the core location on the map, and on the "asteroid," using a small flag or toothpick.
6. Take one or more core samples using a sharp apple corer or knife.
7. Draw and describe the core on the Student Worksheet, noting the type and amount of "mineral resources" present.
8. With their readings on the composition of asteroids, which part of their model could correspond
   a. frozen ice?
   b. solid carbon monoxide?
   c. carbon?
   d. zinc?
   e. iron?
9. Write a brief report from their mine back to headquarters on Earth, describing the research, findings, and suggestions for further research.





Asteroid Mining Expedition

Group Members Names:

1. What is your asteroid's name? _______________________________
2. Where was it found? ______________________________________
3. Draw or map/diagram the "asteroid" using the back of this sheet; make sure to draw your asteroid will lots of detail.
4. Locate the best site for a core sample (a deep cylindrical hole) that will help you determine the interior resources.
5. Mark the core location on your map on the back of this sheet with an x, and on the "asteroid," using a small flag or toothpick.
6. Take one or more core samples using a sharp apple corer or knife.
7. Draw and describe the cores below. What type of "mineral resources" did you find? How much of each thing?
8. Write a brief report, on a separate sheet, from your mine back to headquarters on Earth, describing what you found, what you think should be done, and suggestions for further research.

Resource Type	Amount

The Project: Making it Mine

This is a group-participation simulation based on the premise that water and other resources from the asteroid belt are required for deep space exploration and to fulfill needs on Earth which are quickly running out. The class will brainstorm or investigate to identify useful resources, including water, that might be found on an asteroid. Teams of students are then tasked to take responsibility for planning various aspects of an asteroid prospecting expedition, considering many ideas and needs and to present the results of their planning.

Varying instruction: Elementary level classes should focus on the simplest aspects of vehicle design, hardware and personnel; advanced level classes should also consider financing for the mission, criteria for crew selection, Earth support teams, training, and maintenance, etc.

NASA, in cooperation with national and international space agencies, is planning for continued human exploration of the outer solar system. The intention is to send expeditions to the moons of Jupiter, Saturn, Uranus, and Neptune to explore, collect samples, and search for clues to the beginnings of the solar system. It has become increasingly impractical to send all the rocket fuel and consumables (drinking water, air, food) from the Earth because they are heavy, bulky items. Therefore, NASA is looking for sources of rocket fuel and consumables at an intermediate destination, the asteroid belt.

Asteroids are the source of many meteorites; therefore, it has been proposed that mines and manufacturing plants on asteroids would be able to supply or replenish needed consumables for deep space expeditions.

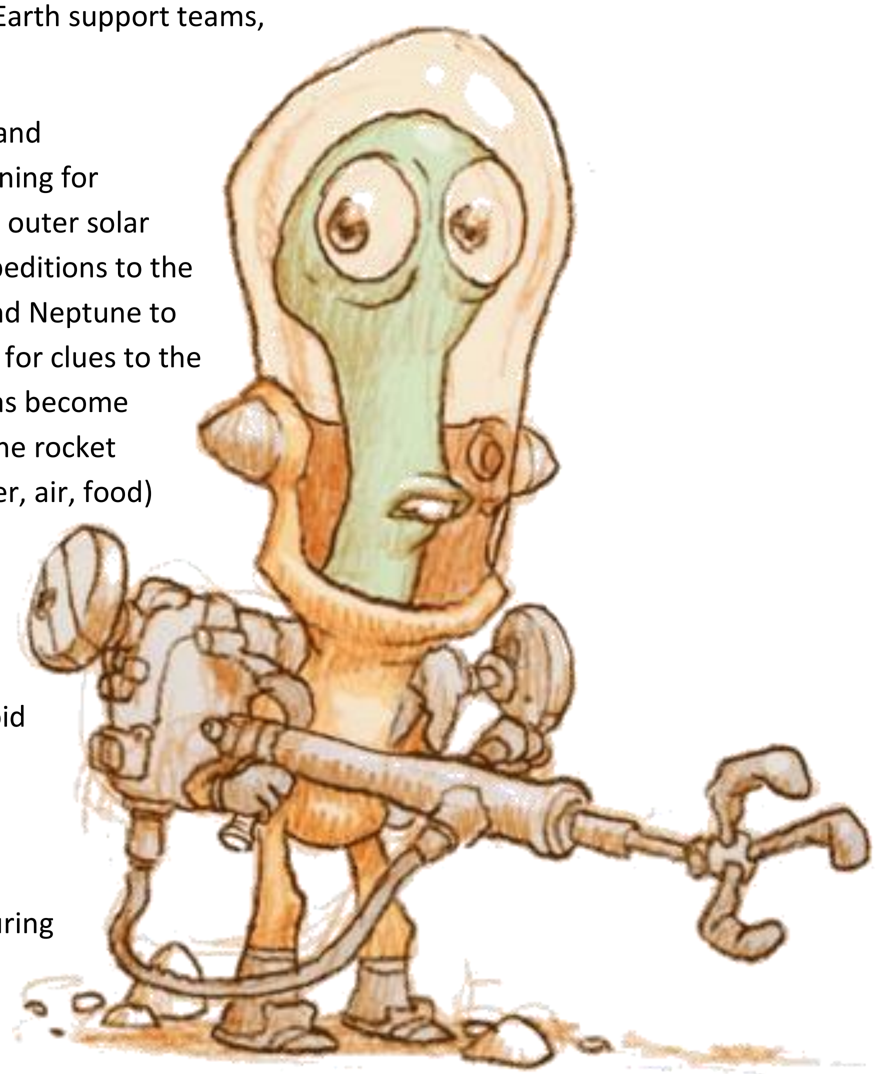


Image Credit: Jake Parker of Agent 44, an Art Blog by Jake Parker, illustrator. http://agent44.com/blog2/?p=23.

Remember, two main types of materials on asteroids appear to be attractive for mining - metals and volatiles. Both of these are essential for space travel. The cost of launching any material from the Earth is extremely high, so useful materials which are already in space can be very valuable.

Considering the Distances Involved

Most of the asteroids are found in orbits between Mars and Jupiter. However, several hundred have orbits that bring them close to the Earth. Rocket trips to some of these "near-Earth" asteroids would use even less fuel than a trip to the Moon, though the travel time to an asteroid might be much longer because the asteroid is not orbiting Earth.

Metals - An asteroid of the composition of an ordinary chondrite could be processed to provide very pure iron and nickel. Valuable byproducts would include cobalt, platinum, gallium and germanium. These metals are basic to the production of steel and electronic equipment. Some metals from an asteroid mine might even prove valuable enough to be returned to Earth. Iron meteorites are high grade ores.

Volatiles - Water, oxygen, and carbon compounds are useful in any space settlement, both for life support and for producing rocket fuel. These volatiles could be found in an asteroid that resembles a carbonaceous chondrite or the nucleus of a former comet. Water contents may range from 5-10% by weight for a chondrite to 60% by weight for a comet nucleus. In some asteroids large quantities of sulfur, chlorine and nitrogen may also be available.

Present background for the problem, and then brainstorm what facts about asteroids might be needed to prepare for a mission that would prospect for water, oxygen, or metals. Theorizing on the possible future of asteroid and comet mining, science projects can build models of the process of mining with additional charts to illustrate the profitability of such

Some of the resources of asteroids include, but are not limited to:

- Water - found in minerals in carbonaceous chondrites (could be used for life support or rocket fuel)
- Diamonds or platinum - found in ureilites (could be used for monetary or industrial value)
- Iron, nickel, cobalt, or gold - found in ordinary chondrites and irons (industrial value)
- Fine surface materials similar to soils - (could be used for nutrient or plant growth material, insulation, or building blocks)
- Gallium or germanium - found in ordinary chondrites (could be used for used for electronic circuitry)
- Oxygen - can be extracted from minerals (could be used for life support and rocket fuel)
- Carbon - found in carbonaceous chondrites (could be used for life support and manufacturing)

endeavors. For example, charts can be used to show the expected mineral content of an average asteroid or comet as compared to mining output on Earth.

Brainstorm the important components that must be designed or built to mount a prospecting expedition to an asteroid. Topics to be addressed may vary, depending upon the grade levels and skills of students, availability of information and materials, etc. They could include: propulsion (type of rocket), power, life support, communications, financing (including valuable things that could be mined on an asteroid and returned to Earth), crew selection (including human vs. robotic), ground support, vehicle design, maintenance, prospecting tools, and training.

Each team selects a topic from those suggested—all members of the team should reach consensus.

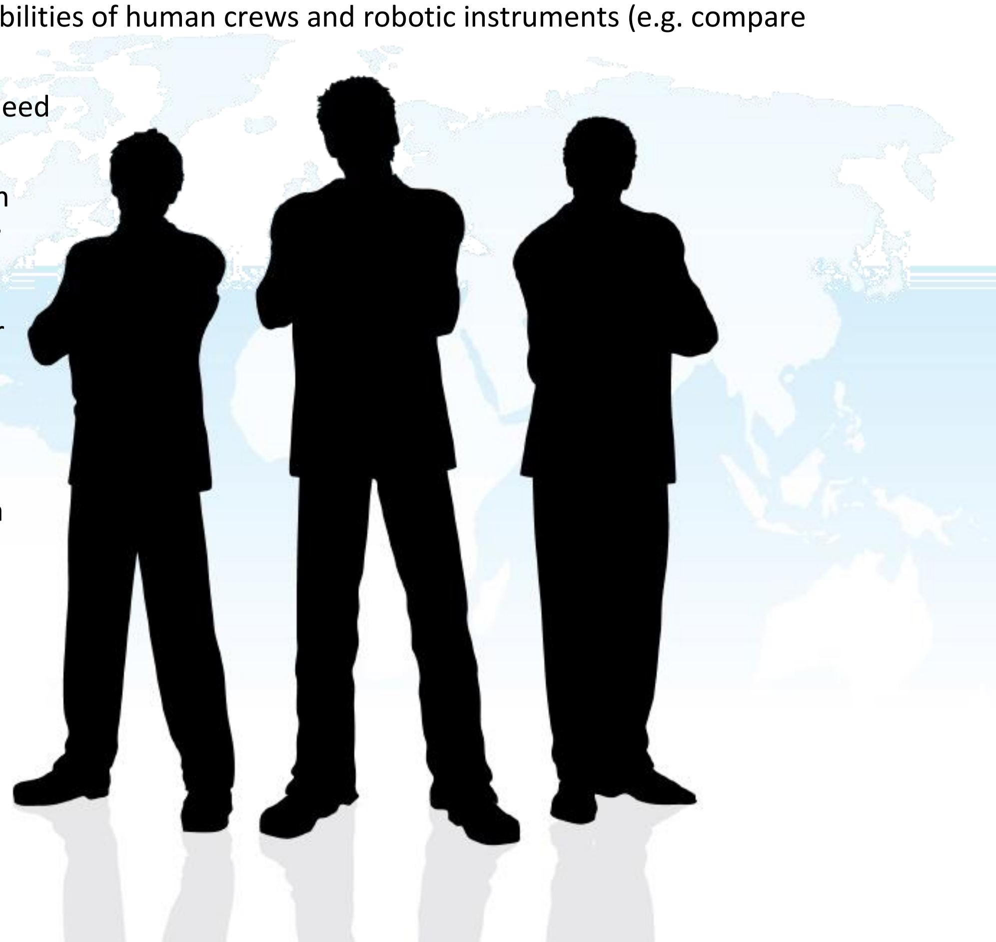
Teams will research and document their topic, keeping a log of sources investigated, relevant data found, relevant conversations, meetings, etc. The research should include a "major points" outline, visual aids, references used, and list of possible problems to be resolved through research.

Teams should also list "interfaces" with other aspects of the expedition design, (e.g., the electrical power team needs to know how large the crew is, how the life support system runs, and whether the prospecting tools require electricity).

Team results should include the basic questions or trade-offs for their part of the prospecting expedition, advantages and disadvantages for each option (e.g., power from solar cells versus power from a nuclear reactor), and a recommendation of which option is best for the expedition. Groups should present their results to the class and students should construct a prototype of a mining facility located on the planetary body of their choice.

Discussion Points:

1. Brainstorm the material needs of deep space travelers
2. Why would we want to go other places to mine?
3. If the resources of an asteroid are needed to support a deep space exploration mission, where would be a better place from which to launch a resource mining expedition: Earth, a space station, a lunar base, other? Why?
4. Where does the money for space exploration come from?
5. Might the money be spent better on the many problems on Earth?
6. What are possible economic benefits/disadvantages of space exploration?
7. Might a lunar base be cheaper to run than a space station in low-Earth orbit?
8. What are the advantages/disadvantages of gender-mixed crews?
9. What are the different abilities of human crews and robotic instruments (e.g. compare initiative, adaptability, spontaneity hardiness, need for life-support)? Have students debate "Human vs. Robotic Exploration."
10. What types of support teams (on Earth or other home base) are necessary to a mission? Consider human and/or robotic crews. Work as a group to create a web showing the interconnections of support personnel necessary to a mission
11. How does destination and crew selection affect vehicle design?



12. What skills/programming would astronauts/robots need during each phase of a mission?
13. Imagine some emergencies that might occur in flight. How might we plan to deal with them? Ex. What kinds of problems could not be fixed in a spacecraft millions of miles from home base?
14. Why do humans explore?

Luck of the draw

In this review and reinforcement game, negative scoring means that even the winners could lose! It's all in the luck of the draw.

Materials Needed

- cards containing game instructions
- prepared cards (or a prepared list) with questions for review and reinforcement

Before the Activity

1. Prepare two sets of cards in advance of the game:
2. Prepare a set of 25 "scoring cards." On each of those cards, write a different instruction, for example:
    - Earn 100 points
    - Lose a turn
    - Take 50 points from the other team
    - Earn 70 points
    - Double your total points
    - Take an extra turn
    - Earn 500 bonus points
    - Additional Ideas
3. On another set of blank cards, write 25 questions related to the topic or skill(s) you want to review and reinforce. (Note: Questions might be created in the list sheet rather than on cards.)

4. Introduce the stack of scoring cards to students. Shuffle the cards. Put the stack face down on a desk.

Alternative Format

Post the 25 scoring cards in random order on a bulletin board or chalkboard. Post the cards *with the blank side facing students and the scoring instructions hidden from view.*

Arrange students into two or more teams. Decide which team goes first, and then pose the first question to a member of that team. If the student answers correctly, he or she draws a scoring card from the stack (or removes one from the bulletin board or chalkboard). The score on the card determines the score the student earns for his or her team.

- If the team has 0 (zero) points and the card selected reads "Earn 50 points," the team has a total of 50 points.
- If the card reads, "Double your present score," the team doubles its score of 0, for a total of 0 points.
- If the card reads, "Deduct 50 points from your score," the team subtracts 50 from 0, for a score of -50.

If the student answers incorrectly, the first student on another team to raise his or her hand earns the right to "steal" the question. A correct answer earns that student the opportunity to choose a scoring card...

Of course, the scoring card could carry a negative message, so answering a question correctly is no guarantee that a team will earn points; as a matter of fact, the team could lose points! A team could conceivably answer all the questions correctly and lose the game. That's why the game is called "Luck of the Draw!"

Variations & Additional Twists

- You might have each student track the score for each team. Students track the team scores, on their own. At the end of the game, each student who correctly calculated each team's final score might earn 50 bonus points for his or her team.

- You might introduce another rule. Since no team member knows whether the scoring card he or she selects will earn or lose points, you might allow students the option of *not* selecting a card when they answer correctly. If the student thinks the next card in the stack might carry a negative scoring instruction, he or she is free to pass and earn (or lose) no points for the team. Students only learn whether that was a good move or not if the next student to choose a card reveals the scoring instruction on the card.

Question	Answer

Luck of the Draw

Luck of the Draw

Luck of the Draw

Give 1/3 of your points to the other team.

Luck of the Draw

Luck of the Draw

Take 10 points from the other team.

Luck of the Draw

Lose ½ of your points.

Luck of the Draw

Earn 100 points

Luck of the Draw

Lose a Turn

Luck of the Draw

Take 50 pts from the other team.

Luck of the Draw

Earn 70 pts.

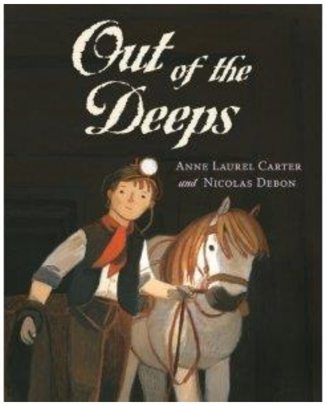
Luck of the Draw

Double your total points.

Luck of the Draw

Take another turn.

Coalfaces



You may want to introduce this project by reading a book related to mining with the students. Some examples, in children's literature, are *Out of the Deeps* by Anne Laurel Carter (Author), Nicholas Debon (Illustrator) or *Boy of the Deeps.*

The goal of this project is to put a human face on the energy issue by having students view photographs of coal miners. These monumental portraits reveal the human essence of the people within the work. Few students will ever have the chance to tour a mine or meet a miner, but through art and photography the many faces of coal mining can easily be seen. http://www.guardian.co.uk/artanddesign/gallery/2010/feb/13/photography-ukrainian-miners?intcmp=239 & http://www.glebkosorukov.com/These images form part of a series of 100 stunning portraits taken by photographer Gleb Kosorukov of Ukrainian miners as they finished a six-hour shift in the dark world underground.

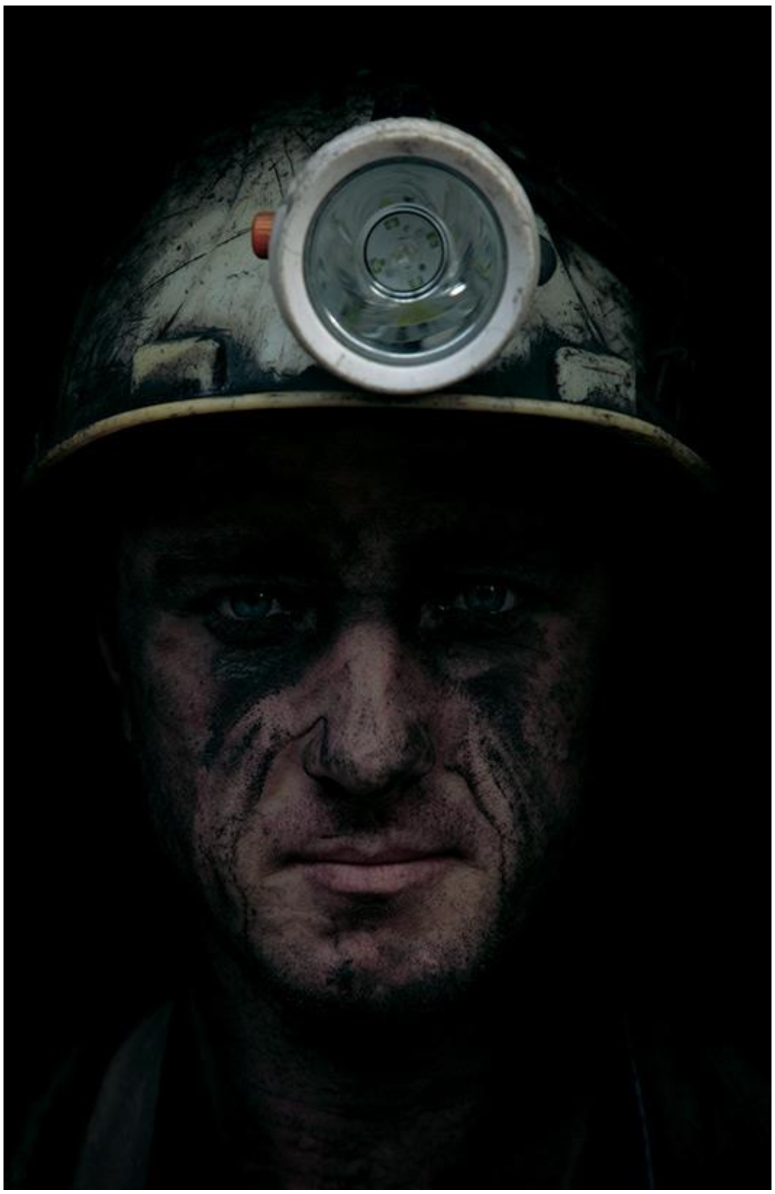
After viewing the images students will then create their own portraits, of themselves as a miner, or simply of a miner.

A portrait drawing of a coal miner should include a headlight and a coal-smudged face. A full body portrait may also include a jacket and tools.

There are several different mediums that will work well for this project and produce fantastic results, such as oil pastel, chalk pastel, or charcoal. Mediums can be combined for even more interesting results. The best medium might be chalk pastel or charcoal. Most children really seem to enjoy the process of "painting" with their fingers. Step out of your comfort zone and try mediums you may not think you like, kids don't care and they enjoy the process and it's rarely about the results. As it should be, right?

Sample, using charcoal and chalk or oil pastel

1. Pencil sketch first (guided drawing of miner's face and light)
2. Finish with charcoal on top of the pencil lines.
3. Have students use chalk or oil pastels to add color to their portrait's eyes
4. Protect the art by spraying it with a fixative or using sheet protectors



Drawing Portraits

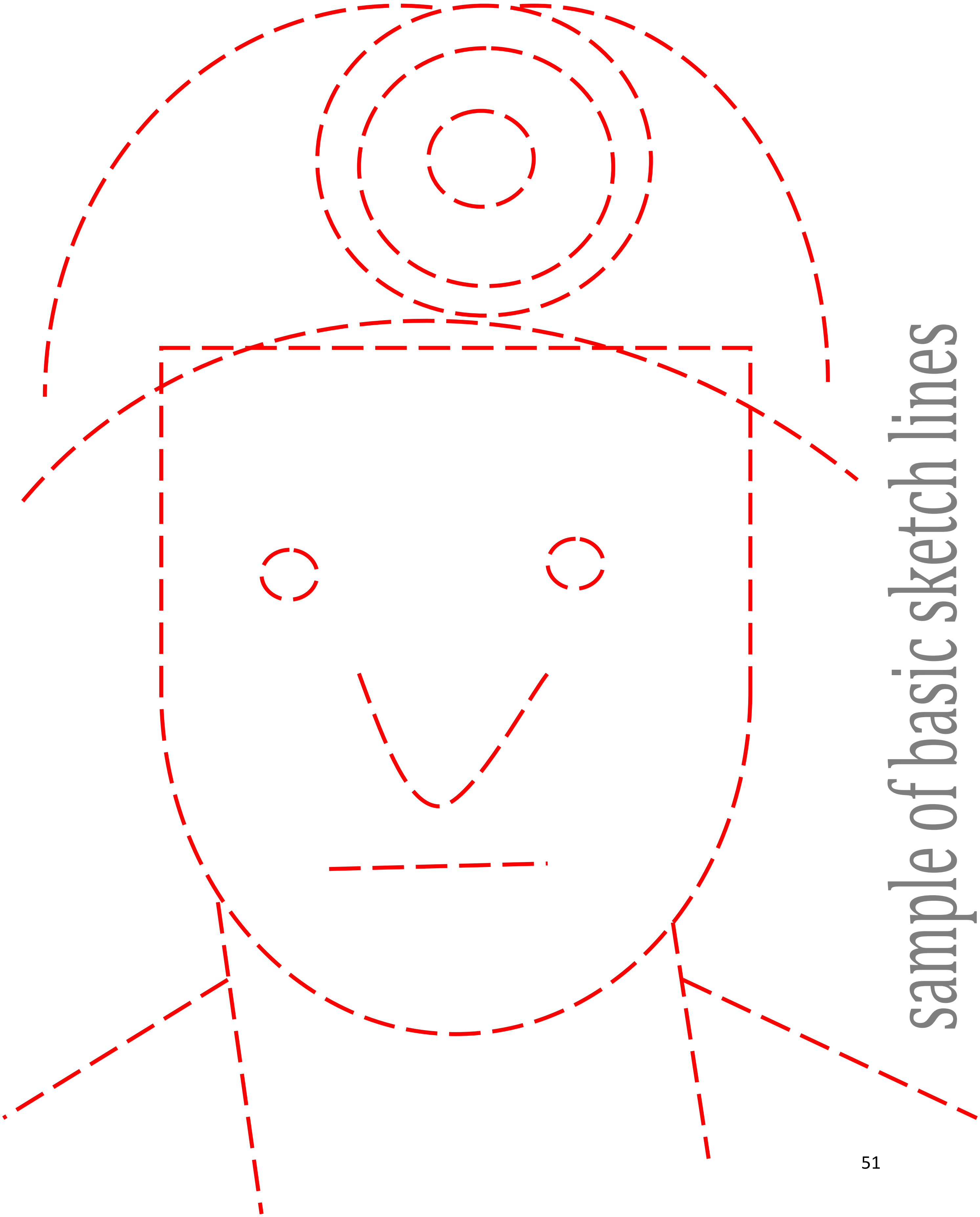
The letter "U" technique which works pretty well and has a 75% success rate. The other 25% drew their letter U's very small and required lots of one-on-one to fit their features into their heads. Cute, but it does take up a lot of teacher time.

The Mirror Option:

You don't have use mirrors for self-portraits with younger kids because it really isn't necessary to get the features exactly right. As you move towards upper grades, this becomes valuable. Though every age group the students usually have a blast looking at themselves and checking out their teeth, freckles, etc. You may want

Templates

Use templates with portrait lessons for Kinders and even first grade students. They establish a face on which every child can draw features. It eliminates frustration when a child draws his head too small. Little kids really do draw small and if they do, it makes it hard to paint or color or really do much else. Templates are fast and when you have limited time, there is no better way to speed things up than to use templates.



sample of basic sketch lines