EXTRACTION: SEPARATING USEFUL MINERALS FROM THE MATRIX

INTRODUCTION:

Some minerals in a sample of ore contain elements of interest, while other minerals are merely part of the rock. The minerals of interest need to be concentrated, usually by mechanical or chemical means.

PURPOSE:

Students will understand the basic concepts involved in extracting valuable minerals from the rock containing the mineral.

MATERIALS REQUIRED:

- 1-cup iron fortified cold cereal (Total)
- 2 cups hot water
- 1 clear drinking glass
- White magnet stirring bar or Popsicle stick with magnet strip glued to one side then painted with white epoxy paint.

ACTIVITY

PROCEDURE: (Teacher Tips, correlated with the Student instructions below)

1) Have a variety of cereals available for students so they can test their procedures on various “ores.”
   a) This models the situation where the extraction method works with differing efficiency for different ores.
   b) Use this first step up through step 3 without the extra testing and experimental design for students in lower grades.
2) On one type of cereal, have the students test the effect varying the temperature of the slurry water has on recovery of the iron.
   a) Test the effect of stirring time.
3) Have students propose and test changes in the variables, including the type of cereal, temperature and stirring times (as noted above), remembering to change only one variable at a time. By assigning various groups various values of the variables, the testing of several variables can be distributed throughout the class so the experiments will take less time.
4) Background information
   a) Cold cereals are fortified with vitamins and minerals for health.

b) Metallic iron is added to fortified cereal, and this form of iron is magnetic.
c) In this experiment the magnet collects the iron.
d) In other processing methods for non-magnetic metals (such as copper, uranium, and gold), acidic or caustic water, gravity separation, or flotation (see "Flotation and Separation") might be used to separate the element of interest from the waste rock.
    i) An example of gravity separation is gold panning.
        (1) When a gold pan is agitated, the heavier mineral drops to the bottom of the pan and the lighter rocks wash away.
e) The crushing of the cereal models the crushing of the ore rocks to make the grains that contain the element of interest accessible to the processing solutions.
f) Similarly, the stirring makes new parts of the ore accessible to the processing solution.
g) Changing the temperature of the added water could model the situation frequently encountered in the processing of actual ores in which the ore needs to be oxidized in order for the element of interest to be available for reaction with the processing solution. That step takes place in an autoclave in which the ore plus an extraction solution are heated. Oxidation does not take place in this cereal model.
h) Making use of the magnetic property of iron metal for separation reflects the general concept of extraction in which properties of the element or the mineral that contains that element are used for extraction. For example, in flotation (see "Flotation and Separation"), the sulfide mineral of the element of interest (often copper sulfide) is attracted to bubbles of a detergent and these bubbles are pushed off the top of the solution of crushed rock and flotation fluid.

PROCEDURE: (student directions)

1) Select a sample of cereal that is iron-fortified such as Total.
2) As a first most simple test, add water to make a slurry, stirring until the cereal is soggy.
3) After your selected stirring time, remove the magnetic stirrer and note the dark slivers of iron on the ends of the magnet. These are particles of metallic iron.
4) Quantify the recovery of iron by weighing the cereal sample before wetting it.
    a) After the iron is recovered, separate the iron filings from the magnet, dry the iron, and weigh the iron to determine the fraction of iron in the cereal.
        i) Dry the iron by separating the iron slivers from the magnet and letting the iron sit over night, or heating the sample in a warm oven.
        ii) The drying procedure and time depends on the humidity of the air

EVALUATION:

1) How is the iron removed from the cereal?
   a) What property about iron makes it possible that iron can be separated in this way?
2) Fine tune the extraction procedure by varying (one at a time) the conditions of extraction. Quantify all variables, repeat the same conditions more than once, and change the variables more than once.
   a) What effect does stirring have on separating the iron
      i) Is stirring necessary?
      ii) Is more iron recovered with longer stirring?
   b) Test the temperature of the water added to see if that makes a difference on the iron recovery.
   c) Test the amount of water added to see if that makes a difference on the iron recovery.
3) Relate the model of extraction of a metal from "ore" to the actual extraction.
   a) How is the cereal similar to actual ore?
   b) How are the variables in the model procedure similar to actual variables in metal extraction?
   c) How is the model different from real ore?
   d) How is the extraction method different from a real extraction method? Some research may be necessary here.

OPTIONS: (student directions)

1) What other fortified food product could be used instead of cold cereal?
   a) Try an iron fortified drink or cooked hot cereal.
2) Crush the cold cereal before adding the water.
   a) Does this improve the recovery time?
   b) Does it make a difference if the cereal is crushed in a separate container and then transferred to the drinking glass?
3) Weigh the recovered iron to make comparisons of recovery methods.
   a) Compare the recovered iron with the stated amount of iron added to the cereal.
4) How did people in earlier times, before there were "enriched" cereals, get the iron their bodies needed?