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ROCK CYCLE IN CHOCOLATE LAB

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This lab activity simulates the rock cycle with a piece of chocolate instead of actual rock. Students melt, crystallize, erode, lithify and metamorphose a single small block of chocolate. Along the way students complete questions and compare the products of each step with actual rocks.

This lab is intended for high school or undergraduate introductory Physical Geology lab students with little previous exposure to geology. Ideally students will have some previous exposure to the rock cycle, but this lab also serves as a comprehensive introduction and students require little to no background.

The lab is intended to be completed in a single 2-hour lab session (possibly a little longer for the final write up).

The content goals for this activity are based on a first-hand manipulation of the rock cycle.

- melting temperatures vs. composition
- melting and magma mixing
- plutonic vs. volcanic textures
- erosion
- lithification
- metamorphism
- distinguishing between igneous, metamorphic and sedimentary rocks

Students will also gain experience in the following:

- Formulation and testing of hypotheses
- Synthesis of ideas and concepts
- Working in groups
- Setting up experiments
- Evaluating experimental limitations

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Materials (for each group):
- Chocolate (dark and white)
- Aluminum foil
- Wax paper
- Hot plate
- Knife (doesn't need to be sharp)
- Piece of plutonic rock countertop (granite, gabbro, diorite, etc)
- Glass beaker with cold water (ideally sitting in an ice bath)
- Hand lens
- Small glass jar with lid
- Two Plexiglas sheets
- Clamp (for metamorphism)

Divide into groups of 2-5 (depending on how many set-ups for which you have materials). Each group will need materials to work through the following stations:

1. melting
2. crystallizing
3. erosion / weathering / sediment production / lithification
4. metamorphism
5. Short-circuiting the cycle
6. Comprehension

ROCK SAMPLE LIST:
A – Banded pumice or xenolithic rock
B – Aphyric basalt and/or vesicular basalt
C – Coarse-grained granite with obvious quartz crystals and other minerals
D – Medium-grained quartz sandstone
E – Quartzite
F – Folded gneiss or folded metamorphic rock (the fold is important)
G – Conglomerate with many lithologies (ideally all three major rock types)

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STAGE 1: MAKING CHOCOLATE **MAGMA**

1.1 Make a hypothesis. We are going to be putting white and dark chocolate on the hot plate. Do you think the two types of chocolate will melt in the same manner? Describe what you think will happen:

1.2 Test your hypothesis. Cover the surface of the hot plate with aluminum foil and turn the hotplate to ~2 (no hotter!). Place a small chunk (1 cm^3) of dark chocolate and a similar sized piece of white chocolate next to each other. You will need to use a stick or knife to smear the chocolate on the foil to help the entire chunk melt. **BE CAREFUL NOT TO TEAR THE FOIL WITH THE STICK** – we don't want to spill chocolate on the hot plate. Try to keep the white and dark chocolate separate. Remember to treat both samples the same (same amount of heat, smearing, time on the hot plate, etc).

1.3 Describe the results of your experiment. What happened to the chocolate? Describe how both types of chocolate melted. Did both types of chocolate melt the same? Be sure to include **viscosity** ("thickness" or "stickiness") and how much heat was required to melt each sample type.

1.4 Expand your conclusions. What does this experiment tell you about how substances melt? Can you extrapolate the information you just gathered to other systems (especially rocks)?

Before moving on to the next step, mix the white and dark chocolate together. As you are mixing these together, look at rock sample "A" in your tray. This is the result of two magmas mixing before they solidified, just like you are doing with your chocolate.

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STAGE 2: MAKING **IGNEOUS** CHOCOLATE

Turn off the burner and

2.1 Now that we have made chocolate "magma," it must cool to become an igneous "rock." We will cool the magma in two ways, fast and slow. What do you think will happen? What differences do you think will result?

2.2 Bring out the polished rock slab (countertop) or tile and the beaker of ice water. Pour a small amount (~ ¼ of your total sample) on the polished rock slab or tile. Take the rest of your sample and pour it into the ice water. Which will cool faster? Why?

2.3 While your samples are cooling, answer the following questions:

a. What geologic environment would allow magma to cool slowly? What environment would cause magma to quench (cool rapidly)?

b. Look at the slab of countertop on which your smaller sample is cooling. Then look at rock sample "B" in your tray. Describe the differences between these two igneous rocks. You can use the hand lens to look up close at each sample.

c. Which of these two rocks (the cooling slab or rock B) do you think cooled faster? What clues in the rock give it away?

2.4 Now look at your experimental samples. AVOID TOUCHING THE SAMPLES WITH YOUR FINGERS as our newly-formed chocolate will melt much faster than it did originally (this is why it is hard to make good chocolate). Using the knife or scoop, retrieve the sample from the ice water and place it on the slab next to the other sample. Using the knife, cut each of the samples in half.

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a. Using a hand lens, look closely at the textures of the two samples. Are there any differences?

b. Now the fun part. The texture differences can be pretty minor in these samples. It is easier to tell the differences using your teeth. Carefully grind a small piece of each sample in your teeth. Can you detect any differences now? Describe them.

2.5 Now look back at the countertop slab and rock sample B. What do you think caused the differences in texture between these two rocks?

2.6 The texture differences between the two rock samples are significantly greater than the chocolate samples. How do you explain this?

STAGE 3: MAKING CHOCOLATE **SEDIMENT**

At this stage, we're going to have to cheat a little because these processes are hard to duplicate in the lab (in fact, reproducing natural conditions in the lab is often one of the hardest parts of doing experiments!)

The formation of sediment requires processes that turn a few big objects into a lot of little objects. Use the knife to cut your igneous chocolate samples into small chunks. Use the knife to scrape flakes and chips of chocolate from the original block to increase the volume of your sample (see your TA for more chocolate if you don't already have some).

3.1 You now have a pile of a various types and compositions of material. In geology this is called sediment. What will it take to turn this pile of chocolate sediment into a cohesive mass (a rock)?

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3.2 Place all the sediment on a piece of aluminum foil and wrap the sediment in the foil. Place the foil envelope between the two pieces of Plexiglas and put the heaviest rock available on top of the Plexiglas. Why put the rock on top of the sample? What geologic process does this represent?

3.3 While the chocolate sample is sitting under a rock, use the hand lens (magnifying glass) to look up close at sample D. This is a sedimentary rock that formed from sediment produced from rocks like sample C. Describe the differences between rocks C and D.

3.4 The light-gray, almost transparent grains in rock C are quartz. Can you identify quartz in rock D? How is the quartz different in rocks C and D?

3.5 Estimate the percentage of sample C that is quartz. Do the same for sample D. Are there any other minerals present in either sample? Describe (or name) them. Assuming that sample D is formed the sediment from sample C, is anything missing in sample D? What happened to that material?

3.6 We've cheated here by manually creating sediment by breaking down the large piece of chocolate into shavings and chunks. How do you think this happens in nature with rocks? What processes do you think might be involved?

3.7 Take the knife and cut a few more shards of chocolate from the original piece. On the left side below (under "before"), draw one or two of the shards. Now put the shards in the small bottle and close the lid. Shake the jar vigorously for 1 minute. Look at the shards again. What has happened to them? Draw what the shards look like now on the right (under the word "after").

BEFORE	AFTER

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What would happen if you shook the jar for 5 minutes? An hour?

a. Compare the crystals in sample C and D. Do you see the results of this process in sample D? What geologic process causes this effect? Comparing the shape of the crystals in C and D, and considering that quartz is much harder than chocolate, estimate how long this process might have gone on.

3.8 Now remove the rock from the sample and unwrap the foil envelope. What has happened to the sediment? Is it hard? Is it soft? What are **<u>two</u>** things that would make this "rock" more cohesive?

In geology, this process is called **<u>lithification</u>**. This is how sediment is converted to sedimentary rock, and is an essential process in the formation of much of the Earth's crust and most of the rocks you see around you.

<u>**NOTE**: set aside a small portion of your sedimentary chocolate "rock" for later comparison</u>

STAGE 4: MAKING **<u>METAMORPHIC</u>** CHOCOLATE

Take the sedimentary rock you've just created and put it on <u>wax paper</u>. The rock may come off in pieces, so just stack the pieces on top of one another. Scrape or break some more chocolate on the sedimentary rock to increase the volume of your sample, and be sure to use different colors. <u>Wrap the chocolate in the wax paper to create as small and tight an envelope as you can.</u>

4.1 In order to make a sedimentary rock we used the weight of a rock on top of the sample. Predict what will happen if we apply more pressure. Consider what will happen on the scale of each grain and on the scale of the sample as a whole.

Place the envelope between the Plexiglas sheets and, using the clamp, squeeze the sample as tightly as you can. While it is pressing, answer the following questions:

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4.2 Why are we using a clamp now, rather than just adding another rock to the sedimentary apparatus? What does this say about the differences between the sedimentary and metamorphic environments?

4.3 Look at samples D and E. These rocks are composed of the same material and have the same composition. Using your hand lens, examine the details of rocks D and E. Describe the difference between them. Be sure to include the differences in the shape of the grains and how the grains contact one another.

a. Rock E is the metamorphosed version of rock D. What does that mean? Does this fit in with your hypothesis you described in question 4.1? Specifically, what matches your hypothesis? What doesn't?

4.4 Remove the clamp from your experimental sample and unwrap the wax paper envelope. What has happened to the sample? Compare this sample to the sedimentary sample you set aside, using **both words and a drawing**.

4.5 Now wrap up the sample in the *very small and tight* wax paper envelope again. This time set the envelope on its side between the Plexiglas sheets and apply ONLY MODERATE PRESSURE with the clamp (if you squeeze it too hard it will ruin the experiment). Predict what the resulting sample will look like.

a. What geologic process are we trying to replicate in this part of the experiment? Where (or in what context) might this type of event occur?

4.6 Release the clamp and carefully unwrap the envelope. What changes have occurred? Compare this sample to the first metamorphic sample you created (refer back to question 4.4 for your description of the first sample). **Use words and a drawing**.

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4.7 Look at rock F, another metamorphic rock. Consider how much additional pressure was required to form the metamorphic sample you just created over that required to create a sedimentary sample. With respect to depth, where do you think a rock like F might form?

4.8 We have used pressure to metamorphose this sample. Is there another tool we could use to change the shape and texture of the sample? What is it? How could we include that in our experimental design?

4.9 What do you think would happen if we added even more pressure to this sample? What if we used the tool you discussed in question 4.8? What would eventually happen?

STAGE 5: SHORT-CIRCUITING THE ROCK CYCLE

5.1 Imagine taking the metamorphic sample you just created and cutting it into small pieces (like you did with the igneous sample) and compress it with the weight of a rock. What type of rock would this represent?

a. Thinking geologically, how could this happen? What would need to occur in order for the metamorphic sample to be turned into sediment? Considering your response to question 4.7, and given that the rate of many geologic movements are in cm per year, how long do you think it might take for this to occur (give a rough estimate)?

5.2 What would happen if you took the igneous sample you created and squeezed it with the clamp? What type of “rock” would result? Would it look the same as the sample you created in the experiment?

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STAGE 6: THE STORY OF THE ROCKS

Examine rock G. In a concise paragraph (with proper sentences and grammar) write the “life story” of this rock in the context of the rock cycle. Ask your TA if you have trouble identifying parts of the rock.