**Lesson:** Geologic Composition of earth and plate tectonics with chocolate sandwich cookies

**Purpose:**

This lesson plan will help illustrate basic geology in terms of the rock cycle, changes in the Earth’s composition from crust to core, and the basics of plate tectonics

**Approximate lesson time:** 45 minutes

**What you will need:**

* Several chocolate sandwich cookies
	+ Like Oreos, Hydrox, or some other brand based on dietary restrictions
	+ Brands/varieties with extra crème filling work better for some concepts.

**Rock Cycle/ Rock Types:**

* Rock Types:
	+ Sedimentary Rocks: Discuss how sediments are deposited in horizontal layers like the flour and sugar of the cookies, a cementing agent, in the cookies case eggs, butter, etc. is incorporated between the particles allowing them to solidify with pressure. The cookie layers represent the layers of sedimentary rocks as they would appear if unearthed.
	+ Igneous Rocks: Discuss how rock materials will melt if enough heat is added. Have the student imagine the crème filling being warmed and melted, discuss how the melted crème could cool in a container (intrusive igneous) or be expelled onto a surface spreading and cooling uncontained (extrusive igneous). The crème in this scenario will represent the igneous rocks.
	+ Metamorphic Rocks: Discuss how rock materials may become malleable if heat is added and/or pressure is applied. Have the student imagine warming the cookie so the crème becomes soft but not liquid, they can then apply pressure to the external cookies to deform the internal crème filling. This same heat and/or pressure will be the process which alters the sedimentary or igneous rocks into metamorphic rocks like the now deformed filling.
* Rock Weathering:
	+ Mechanical Weathering: Discuss how there are no changes to the rocks other than changes in size with mechanical weathering. Have the student take a bite of the cookie and chew. As the cookie becomes smaller through chewing the student is performing mechanical weathering on the cookie.
	+ Chemical Weathering: Discuss how chemical weathering alters the chemical composition of the rocks’ exposed surfaces slowly eroding away the outside of the rock. Have the student take another bite of cookie, but this time do not chew the cookie allowing their saliva to soften the cookie, their saliva is altering the chemical composition of the cookie by adding water to break down the cookie. Have them repeat this process but this time take several bites breaking the cookie into several small pieces before allowing their saliva to go to work. They should notice that with the increased surface area their saliva will break down the cookie faster, follow this observation with a discussion about how surface area affects the rate of chemical weathering.
	+ Biological Weathering: Discuss with the student ways in which life can help aide both mechanical and chemical weathering (ex: roots growing in rock cracks, worms/moles exposing rocks to air/water by digging burrows). Compare these concepts to how they just performed chemical and mechanical weathering in their previous consumption of cookies.

**Earth’s Layers:**

* Chemical Composition:
	+ Crust, Mantle, & Core: Discuss the differences in the Earth’s Crust, Mantle, and Core and how each are defined by differences in chemistry with the least dense minerals and rocks arranging themselves near the surface and the heaviest arranging themselves near the core. These layers are similar to changes in the cookies with each layer having a different chemical composition of cookie or crème.
	+ Discontinuities: Discuss how there is a fast change in chemistry moving between the layers of the earth, these are called the Mohorovičić (crust to mantle) and Gutenberg (mantle to core) discontinuities. The student can think about this like the switch from cookie to crème, some crème may penetrate small spaces in the cookie but will be generally a division between the two layers.
* Mechanical Operation:
	+ - Note: you can attach the crème and one cookie to a second full cookie to create the full mechanical layers model in a single object or simply discuss the difference in reference to the cookie layers.
	+ Lithosphere: Introduce this as the fused crust and upper layer of the mantle which is rigid. Have the student think of this layer like the upper cookie.
	+ Asthenosphere: Introduce this as the semi solid plastic layer of the middle mantle that the lithosphere floats around on. Have the student think of this like the crème filling layer.
	+ Mesosphere: Introduce this as the more solid lower layer of the mantle due to increased pressures further down in the mantle. Have the student think of this like the lower (or middle cookie, if using 1.5 cookie model).
	+ Outer Core: Introduce this as the liquid layer due to high temperatures encompassing the outer portions of the core. Have the student think of this once again like the filling portions of the cookie but they should imagine it as less solid than the Asthenosphere. You can also add a discussion about how this layer is believed to provide the earth with its magnetic field.
	+ Inner Core: Introduce this as the solid inner portion of the core due to high pressures. Have the student picture this layer as the lower cookie.

Plate Tectonics:

* Plate Movements:
	+ Have the student remove one cookie from the filling. Now have them loosely reattach the cookie and apply horizontal pressure feeling the filling deform as the cookie slides along the surface. This is the general idea of the lithosphere moving over the asthenosphere.
* Evidence of Plate Tectonics:
	+ Have the student now break or cut the loose cookie in half and place back onto the filling fitting as best possible back together. Discuss how the same patterns are on both side of the cookie which is now in two (or more) pieces. Discuss how the same patterns are evident when the continents are thought of as the cookies and the fossils of plants and animals or the geology of mountains are the patterns from the original cookie.
* Plate Boundary Types:
	+ Transform Boundaries: Have the student push the two cookies halves laterally along each other. As the cookies slide along one another have them observe the friction as the uneven cookie edges grab at different points. You can discuss that this friction and release is the source of earthquakes as plate slide along one another sporadically which will be repeated in all the other boundary types.
	+ Divergent Boundaries: Have the student pull the cookie halves apart from each other creating a rift in the cookie surface. Discuss how this can occur for both oceanic crusts and continental crusts forming mid-oceanic ridges or continental rift valleys/proto-oceans in each respective lithosphere type. Use the idea of the crème rising to fill the new crack in the cookies as the replacement of mantle materials as the plates separate.
	+ Convergent Boundaries: Have the student push the cookie pieces together compressing the crack back together. Discuss how this can result in one cookie sinking under the other to relieve the stress as occurs with oceanic crusts. Then discuss how the two cookies could crumble and form a pile if neither plate sinks as would occur if to continental crust collide resulting in mountain building.