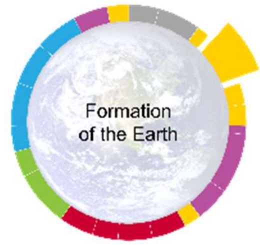
Formation of the Earth Learning Segment Table:
(approximately 10-13 traditional class days)



The model:

1. Earth formed when many small space rocks collided and came together.
2. When meteors (space rocks) combine, their masses add together.
3. Gravity increases when 1) the mass of an object increases and/or 2) when the distance between two objects decreases.
4. More gravitational attraction caused more collisions as proto-Earth gained mass.
5. As more and more nearby space rocks collided with the Earth, the number of nearby space rocks decreased.
6. Collisions of space rocks with planets and space rocks with space rocks convert kinetic energy into heat. Increases in the mass or velocity of the objects increases the heat generated during impact.
7. As proto-Earth was forming, there were so many collisions producing heat that the solid rocks melted into liquid.
8. The proto-Earth was a sphere of lava being constantly hit (and heated) by more space rocks.
9. As space rocks decreased in number, there were fewer collisions so the cold empty vacuum of space cooled proto-Earth down. The parts of Earth closest to the surface cooled down first, while the deepest center of earth remained molten rock.

Seg	**Model Move**	**Est Time** (min)	**Overview**	**What did we figure out?**	**Model Ideas Generated** (also ideas about impacts we might use to build our model)
1	P	80	We first consider what makes the Earth unique. How is it different from other planets? Through a couple of activities, we develop a list of ways in which the Earth is similar to the other planets of the inner solar system and ways in which it is different.	We've identified some ways in which the Earth is unique, and some ways in which it resembles neighboring planets. This sets us up to generate questions and to leverage our ideas about commonalities to develop a Driving Question.	
2	Q	30-55	We compile the questions we have. Instead of settling immediately on a broad Driving Question about the formation of the Earth, we engage in a short discussion about the commonalities among the inner planets (including Earth). We then decide to begin our exploration of an overall question about the formation of Earth by first focusing on the geosphere. How did Earth's rocky structure (the "geosphere") form?	We have both a broad Driving Question that asks how the Earth came to be as it appears to day, and a more immediate Driving Question that will carry us through this unit. How did the rocky Earth (the geosphere) form?	Earth shares a rocky structure and craters with the other planets of the inner solar system.

3	P	55-110	We explore one of the features we think Earth shares with other planets by looking more closely at a Barringer Crater in Arizona. In our exploration, we conclude that it, and other craters on Earth, were indeed caused by space rocks.	We've explored the crater in Arizona and have developed a pretty solid evidence-based argument for how a meteor impact could explain its origin. But we're still wondering what really happens during an impact and decide to first consider what happens to the all of the "stuff" (the matter)—the space rock and the ground.	Craters on Earth and other planets are likely the product of impacts with space rocks because: (a) There are still a lot of space rocks in the solar system. (b) Sometimes space rocks come close enough to Earth to either break up / burn up in our atmosphere or to hit the ground and leave an impact crater. (c) We see meteors enter the atmosphere regularly and have evidence of recent impacts.
4	Q→M	55	We explore what happens to matter during an impact by engaging in a lab and tracking the mass of the system both before and after a simulated event.	We see that mass is conserved in our lab simulation, but we wonder if this is what really happens in a high speed impact.	
5	P→M	20-30	We consider how realistic the lab might have been when compared to what actually happened at Barringer Crater or other impact sites. We engage in a Four Corners activity, debating our ideas about what might actually happen during an impact.	By problematizing the lab, we recognized that we might not yet understand what happens during an impact. We decide we have questions about both matter and energy. What happens with each when a space rock hits the Earth?	Mass is conserved during impacts. When a space rock hits the ground, it adds to the mass of the Earth.
6	P→M	30-55	We use a web-based simulation to consider how factors like velocity, density of the materials, etc. might affect the outcome of an impact. We also notice these parameters affect the energy involved, inspiring us to begin wondering how energy behaves during impacts.	We see that multiple factors change the outcome of impacts, but now we are more focused on wondering what happens with energy when a space rock hits the ground.	

7	Q→M	110	We explore how energy is involved in impacts through a lab and run some calculations that show us how much energy is released as heat.	We now see that beyond the movement of a lot of matter on the ground, the generation and deposition of heat is a huge consequence of impacts.	Energy is conserved during impacts, but it can be transformed. (a) Though some of the kinetic energy from a meteor is transferred to other rocks upon impact (and these rocks are ejected into the air) most of the energy is transformed into heat. (b) The heat is enough to melt rock. (c) How much rock is melted (and blasted into the air) depends on the mass and the velocity of the space rock (because that's what determines kinetic energy).
8	M	55	We finally step back to wonder how impact craters might help us understand how the Earth formed through an activity called "Rewind the Clock".	We've pulled together an accretion-based model of Earth's formation but have begun to wonder about the role of gravity.	All first-draft model statements about Formation of the Earth (the geosphere) are offered here. Ideas about gravity and cooling may be generated or revised in the ensuing learning segments.
9	M	30-55	We explore gravity and consider its role in Earth's formation.	We now have a fairly complete model for molten Earth.	Gravity increases when (1) the mass of an object increases and (2) the distance between objects decreases. More gravitational attraction caused more collisions as the proto-Earth gained mass.
10	M	55	We consider the final pieces of the model, and work to understand how Earth must have cooled enough to form an exterior crust.	Now that we've considered both the conditions necessary for cooling and the process of planetary cooling, we have a final model for how the Earth (the geosphere) formed.	The cold empty vacuum of space cooled proto-Earth down. The parts of earth closest to the surface cooled down first, while the deepest center of earth remained molten rock.