BUNDLE 1: CHANGES TO EARTH UNIT PLAN

This unit planning template was developed in alignment with Stroupe and Windschitl's (2015) framework for Ambitious Science Teaching that focuses on "1) planning a unit around a "big science idea", 2) eliciting and activating students' ideas about a puzzling phenomenon (for the purpose of adapting instruction), 3) helping students make sense of science activities, and 4) pressing students to construct evidence-based explanations" (p. 1). As such, each of these facets of AST are identified below.

Unit Authors:

Jacob Tourigny and Dan Lee

http://serendip.brynmawr.edu/exchange/files/CellularRespPhotoOverview.pdf

1. PLANNING A UNIT AROUND "BIG SCIENCE IDEAS"

Group Member Science Area Focus (e.g., Middle School Life Science, High School Chemistry):

High School Biology

What do you want to teach?

Disciplinary Core Idea(s) focus of Lesson: (Identify DCI at the bullet point(s) grade band progression)

ESS1.C: The History of Planet Earth Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.

ESS2.B: Plate Tectonics and Large-Scale System Interactions Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. (ESS2.B Grade 8 GBE) (secondary)

PS1.C: Nuclear Processes Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. (secondary)

ESS2.D: Weather and Climate Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.

ESS2.E Biogeology The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it.

What are the Performance Expectations that you are working toward?

Performance Expectation(s): (Search by DCI)
Students who demonstrate understanding can:

HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

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HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Why is/are this a core idea(s) in science?
Identify the DCI in Framework for K-12 Science Education using the following links:

Physical Science: https://www.nap.edu/read/13165/chapter/9
Life Science: https://www.nap.edu/read/13165/chapter/10
Earth and Space Science: https://www.nap.edu/read/13165/chapter/11
Engineering, Technology, & Applications of Science: https://www.nap.edu/read/13165/chapter/12

What does the Framework say about the core idea(s)?
Summary:
After reading through the specific DCI focus/foci of your unit, write a summary in your own words that describes why this is a/these are core idea(s) in science, along with what facets of this core idea(s) are most important for students to understand:

Summary: (example of unpacking)

The earth is made of large slabs of rock called crust that are constantly moving slowly over a sea of magma. There are two types of crust, oceanic and continental. Oceanic crust is formed at **mid ocean ridges (MOR)** when hot magma rises to the surface from inside of the earth and cools once it reaches the surface which produces new crust. As new crust is produced, the slabs on either side of the MOR move slightly away from the MOR in order to give space for the new crust to form. As the slabs continue to move they will eventually become continental crust, which we currently live on.

The rock that makes up the crust is formed of atoms some of which are stable and some of which are unstable. These unstable atoms have more or less neutrons than the number you would see when you look at the periodic table and are called isotopes. These isotopes will undergo reactions, known as nuclear reactions, which will change their chemical structure resulting in a new atom that is more stable. These atoms change or decay at standard rates which are called half-lives. A half-life is the amount of time it takes for half of a sample of radioactive (unstable) material to change into a more stable form. For example, if you have 1 gram of Ac-227 with a half life of 21.77 years , in 21.77 years only .5 grams of Ac-227 would be left as the other .5 grams became a more stable substance. We can use this method in order to determine the age of a substance depending on how much radioactive material is present. This then allows us to prove that continental crust is older than oceanic crust due to the fact that there is less radioactive material present in continental crust.

Similar to the earth's plates, the Earth's atmosphere was subject to change over time. There are many different gases that make up the atmosphere today such as oxygen, nitrogen and carbon dioxide. However, this was not always the case; before plants and other photosynthesizing organisms, the atmosphere was primarily carbon dioxide with little to no oxygen. As photosynthesizing organisms evolved, the atmosphere slowly changed from being primarily carbon dioxide to a homogenous mixture of numerous other gases. This has allowed organisms to develop more complex structures and evolve into the variety of life that exist today.

ANCHORING PHENOMENON

Identify a scientifically rich, complex phenomenon that students will require students to use multiple principles that are central to the DCI to explain (an occurrence or event that happens(ed) in the world)
[This will serve as the reason for engaging in the unit.] Resources for identifying anchoring phenomena (Phenomena, 2)

Why does the Earth look so different today than it did 4.4 billion years ago?

https://www.youtube.com/watch?v=oeM103KJ5x8

Identification of [Crosscutting Concept(s)] that can also be used to understand/explain the phenomenon: (explain this connection):

Crosscutting Concepts:

Patterns: Empirical evidence is needed to identify patterns.

Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

Stability and Change: Much of science deals with constructing explanations of how things change and how they remain stable.

Provide a Target Explanation of Phenomenon [Provide a written explanation of the phenomenon, being sure to consider how the role of the identified crosscutting concept(s) you identified above as part of the explanation] (Note: the explanation should identify how science principles are coordinated to explain the occurrence or event that happened in the world) (ex. target explanation for explaining ramps with models):

Billions of years ago earth was barren rock with no life to be found. There was no oxygen in this early earth's atmosphere which was composed primarily of gasses such as Carbon Dioxide and Methane. This atmosphere when exposed to various forms of energy lead to many random chemical interactions which resulted in the first simple organic molecules, monomers. These monomers accumulated in various locations around the earth. As these monomers were being bounced around and collided with other monomers they eventually produced more complex molecules, polymers. As these polymers continued to collide they ultimately resulted in the first life: simple, single-celled bacteria. Some of these bacteria developed the ability to use water and CO_2 in order to create energy (photosynthesis) and oxygen. These bacteria set in motion the changing of the earth's atmosphere thereby allowing more complex plants and animals to develop and grow complex structures in order to live in every types of environment found on the face of the earth. We can determine which organism came earliest by utilizing radioactive dating techniques in order to determine how much of a specific radioactive substance remains in the sample.

From your Target Explanation, identify principles within the explanation that are central to students explaining the phenomenon [this can serve as an early 'Gotta Have List' that you go into the lesson considering, while also serving as a guide for identifying science activities students can engage in as part of the unit after initial modeling to work on developing more sophisticated explanations of the phenomenon]:

Principle A: What is the earth made of and what processes have resulted in the way the earth looks today? (focus on the continents)

Principle B: How can we determine the age of the earth and organisms that have lived on it?

Principle C: Why was the early earth not able to support any form of life?

Principle D: What changed in order to allow the earth to support the various forms of life that exist?

For each science principle identified above, choose one activity, reading, video, simulation, or investigation that will help students understand this principle and begin to see its usefulness in explaining the anchoring phenomenon. Do this for each principle below: [possible resources **1**, **2**]

Principle A: What is the earth made of and what processes have resulted in the way the earth looks today? (focus on the continents)

https://news.uns.purdue.edu/html4ever/2005/050927.Lipschutz.meteorites.htm

Plate Tectonics Videos (on Youtube):

https://cptv.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.plateintro/plate-tectonics-an-introduction/#.WaauovOGOM8

Plate Tectonics Simulation:

https://phet.colorado.edu/services/download-servlet?filename=%2Factivities%2F3616%2Fphet-contribution-3616-6450.pdf
https://phet.colorado.edu/en/simulation/legacy/plate-tectonics

Convection Currents Lab:

http://webcache.googleusercontent.com/search?q=cache:QCHuXe5NGRcJ:www.daviesskyschools.org/userfiles/1822/Classes/20739/Convection%2520Currents%2520Lab.doc+&cd=5&hl=en&ct=clnk&gl=us

https://www.lsrhs.net/departments/science/faculty/brandesa/handouts3/PlateMovementLab.pdf

Principle B: How can we determine the age of the earth and organisms that have lived on it?

Radioactive Dating Game (https://phet.colorado.edu/en/simulation/legacy/radioactive-dating-game)

https://phet.colorado.edu/en/contributions/view/3254

http://www.nsta.org/images/news/legacy/scope/0604/jordanradiometrics.pdf

https://phet.colorado.edu/en/contributions/view/3534

Principle C: Why was the early earth not able to support any form of life?

www.kmajda.net/uploads/1/9/4/0/19408973/birth_of_earth_video_worksheet.pdf

Use this video instead: https://www.youtube.com/watch?v=cK1s4i4ckZc

Early Earth Atmosphere lab https://earthref.org/ERDA/1228/

http://www.earthsciweek.org/classroom-activities/geologic-time-scale-analogy

Principle D: What changes occurred which resulted in life being able to thrive on Earth?

https://www.khanacademy.org/science/biology/history-of-life-on-earth/history-life-on-earth/a/hypotheses-about-the-origins-of-life

http://www.bozemanscience.com/ngs-ess2e-biogeology/

https://serc.carleton.edu/marsforearthlings/examples/miller_urey_experiment_Mars.html

(Miller Urey Experiment Simulation)
http://www.wiley.com/college/trefil/0470118547/vdl/lab_miller_experiment/

Identify Ideas and Resources that might surface as students begin to reason about this phenomenon (use the AAAS Science Literacy Maps, NGSS Disciplinary Core Idea Progressions, and past experiences working with students around the principles (i.e., A, B, C…) above [these include ideas they may have learned previously or common ways students might think about one or more of these ideas]:

Identify Ideas and Reasoning:

Some common misconceptions about plate tectonics is that although plates move, it is perceivable to see the change in a person's lifetime. Although plates move a couple inches each year you actually cannot tell any change until vast amount of time has passed.

Plants were the first organisms to begin producing oxygen, not cyanobacteria

The earth's atmosphere has not changed since it was created.

2. ELICITING AND ACTIVATING STUDENTS' IDEAS ABOUT A PUZZLING PHENOMENON (FOR THE PURPOSE OF ADAPTING INSTRUCTION)

THE TALK SCIENCE GOALS AND TALK MOVES IS A RESOURCE FOR RESPONSIVENESS TO STUDENT THINKING THROUGHOUT THE UNIT . Additional resources are the Talk Science Primer and the Ambitious Science Teaching Discourse-Primer referenced next:

Eliciting students' initial scientific hypotheses in order to plan for further instruction. The goal of this discourse is to draw out students' understandings of a phenomenon (e.g. a bicycle rusting in the backyard) that is related to an important scientific idea (in this case chemical change or conservation of mass). After the lesson we *analyze students' ways of talking about it in order to adapt upcoming learning experiences (AST Discourse-Primer, 2015, p. 7.)*

Day 1: Outline how you plan to engage students in creating/sharing their initial models that explain the anchoring phenomenon. How will you introduce the phenomenon? What is your plan for eliciting student initial models (e.g. group sizes, directions to students including some introduction to what a model is and what you want to be sure students do as they share their initial ideas-be sure to include where and how you will use 'Gotta Have Lists' (taken from ambitiousscienceteaching.org) to help focus students reasoning during this process. Include any videos, templates, webresources, etc. you might want to use. Describe how students will share their initial models with peers in small group and whole group discussions/sharing: (Example Day 1)

Outline Day 1:

Initiation:

Students will begin by answering the question "What substances are necessary for life on earth?" and generating a list in their idea organizers. After all students have finished writing their answers they will share in small groups of 2-3 and will add new substances to their list. Once all of the groups have completed their discussion the class will generate a class master list on the front board with all the substances that the class deems necessary for life on earth (Teacher Reminder: make sure to encourage thought among the students when generating the master list. Whenever a student proposes a new substance then ask the class whether or not they believe that should be added to the board and why) **MAKE SURE TO SAVE THE LIST IN SOME FORM SO THAT STUDENTS CAN REFER BACK TO IT LATER IN THE UNIT.**

Lesson Development:

Show the phenomena video and have students write down their observations of early earth and how it compares to the modern earth that we live on in their idea organizers. Introduce the driving question to the students **(Why does the Earth look so different today than it did 4.4 billion years ago?)** and generate the Gotta Have List. Teacher Note: The Gotta Have List is all of the ideas that the students believe must be included in the final model for it to fully answer the question. This should incorporate students list of necessary substances. [Example Gotta Have list in page 27] At this time students should focus on what does the earth looked like when it was formed and compare it to what the earth looks like today. Play the video multiple times if necessary. After the video was played the necessary number of times introduce the main question of the unit **(Why does the Earth look so different today than it did 4.4 billion years ago?)**

Provide students with the starter kit and have students break up in groups of 3-4 and have them draw out on a whiteboard/piece of paper their reasoning for why the earth has changed over time (Modeling Example). Make sure that they refer back to their class list of necessary substances and incorporate them into their model.

Closure:

After all students have presented their models to the point where they are satisfied and do not believe they could add anything else have each group select a representative to present their model to the class. All other students should be in their seats, paying attention and asking questions. If time remains have the class discuss what differences and similarities that they have noticed among all of the models in the class. Lastly, refer back to the necessary substances list at the beginning of class and decide whether or not any of the substances should be added or removed. **MAKE SURE TO COLLECT THE MODELS AT THE END OF CLASS**

3. HELPING STUDENTS MAKE SENSE OF SCIENCE ACTIVITIES (WITH THE AIM OF USING SCIENCE PRINCIPLES BEHIND ACTIVITIES TO EXPLAIN ANCHORING PHENOMENON)

AST Discourse Strategies
• Making sense of data/information. The goal here is to help students recognize patterns in data, critique the quality of data, and to propose why these patterns exist. What, for example, is going on at the unobservable level that explains our observations?
• Connecting activities with big scientific ideas. The goal of this practice is to combine data-collection activities with readings and conversation in order to advance students' understanding of a broader natural phenomenon. This conversation is different from the previous one, in that students are not trying to explain the outcome of an activity, but to relate the activity to a bigger science idea or puzzle that the unit is framed around. (AST Discourse-Primer, 2015, p. 7.)

Day 2-5: [use more or less days as needed for engaging students in science activities depending on what might be needed to explain the anchoring phenomenon]

Identify how you will 'put on the table' science principles (i.e., you identified above that are central to explaining the anchoring phenomenon (i.e., Principle A, B, C...) using science activities you identified for each principle above (e.g., activity, reading, video, simulation, investigation) that prioritizes students engaging in science and engineering practices to develop an understanding of the principle that will be helpful in later stages of the unit in explaining the anchoring phenomenon. Describe how you will use 'Summary Tables [1, 2]' (taken from ambitiousscienceteaching.org) across these days/activities to help students keep a record of activities, ideas, and evidences that will be used to later in the unit to revise their initial models of the anchoring phenomenon. (Example Days 2-5)

Outline Day 2-5:

Day 2:

Initiation: Briefly go over the student's models that they created from the previous day to keep what they had created in mind as they learn new material. Possibly give students time to look over their models as well. It is important to always refer back to models and see if there are any changes in the way their initial thoughts.

Lesson Development: Describe how you will develop the lesson, what you will do to model or guide practice, and the learning activities students will be engaged in order to gain the key knowledge and skills identified in the student learning objective(s).

Give the students the article from Purdue and include the worksheet (WORKSHEET) (ANSWERS). Go over the questions and try to discuss any misconceptions that students may have.

Show the video from PBS about plate tectonics and give the students a related worksheet (WORKSHEET) (Answers). Let the students see the video as many times as needed in order to answer the questions.

Next, have students be on computers/laptops or other such devices that can utilize JAVA for the simulation and give them the worksheet. Give students ample time to play around and experiment with the simulation for plate tectonics. If there aren't enough computers/laptops then divide the students into working groups.

Closure: The last couple minutes of the period should be used to come together as a class and discuss/fill out the summary table using evidence or facts from the activities. Try to point the discussion back towards the phenomena

Day 3

Initiation: Show a lava lamp or a video of it, and have the students write why do they think the liquid moves up and down inside of the lava lamp. Don't discuss the answer but tell the students to keep the lava lamp in mind as they do the lab.

Lesson Development: For the class set up the Plate Movement lab before class. Give a demonstration of how to perform the lab, and be sure to go over safety precautions as there will be hot liquids involved. Have the students read the purpose, introduction and the procedure together so that everyone is on the same page. Divide the students into groups of 4-5 students (Can vary based on number of students in class) and start the lab. When they are finished with the lab then let students start the conclusion questions. Discuss (Using Talk Moves) (found on pg.13) the lab and the mechanics that were involved that might have allowed the liquid to cycle through the container.

Closure: Following the lab have students revisit their original explanation of how the lava lamp works and alter their explanation to incorporate their new data. **COLLECT THIS AND USE IT AS A FORMATIVE ASSESSMENT** Afterwards fill out the section in the summary table set aside for this activity

Day 4

Initiation: Pose the question to the classroom "How can we determine the age of any substance on earth (i.e. a rock, a plant, a fossil etc.) Students will write down their answer and then turn to the person next to them and share their reasoning and compare it to their partners. Afterwards they will hand in the

Lesson Development: The students will select a computer/laptop and work in groups of 2-3. Students will go to the Radioactive Dating Game simulation and fill out the lab worksheet [Lab Worksheet Answer Key]. When they are finished with the lab the students should answer all questions found on the sheet and compare. The teacher will then go over the answers with the class and answer any questions asked by the students.

Closure: Fill out the appropriate section of the summary table with the students. Make sure to focus on how on how understanding of radioactive dating could help us to develop a timeline of events that have happened on earth and shaped how it looks today

Day 5

Initiation: For the beginning of class have students take out their models and go over it one more time. Make sure that every member of their group has a good understanding of the model and would be able to explain it to another person.

Lesson Development: Assign one person in the group to hold onto the model, or whoever can explain the model the best. Then let the other members travel to another group so that everyone is with new people. The purpose of this is to allow the person who was assigned to explain the model to a new group of people. After the model is explain it is the job of the new members to ask questions, notice patterns, clarifications, etc. using the crosscutting concept cards. Every member must come up with at least one response for every new model they see. Keep switching until every group has seen everyone else's models. Let students go back to their original group and give them time to read the comments and/or revise anything they want to change.

Round Robin Sheet for Audience

Round Robin Sheet for Presenter

Closure: In the last part of class have students do a reading based on the article with the questions at the end of the article. Have students share their answer to question number 4. If it is not done in class then it is for homework.

Day 6

Initiation: Start class with a discussion on the reading that they completed yesterday for homework. The students will provide a summary of the reading highlighting the points that they deem to be important. The teacher will then pose the question where did early life come from

Lesson Development: The students will form groups and work on the computers in order to complete the Miller Experiment virtual lab. Students will work together in order to complete the experiment and fill out the lab report (Answer Key)which will be handed in upon completion. After students have completed their work and handed it in they will read the articles How the First Plant Came to Be and When Did Life Appear on Earth? and answer the questions on the worksheet provided about each reading. (WORKSHEET When Did Life Appear) (ANSWERS)

(WORKSHEET How the First Plant Came to Be)

Closure: Students will write a paragraph describing how it is the the first living organism was created and how the creation of that organism lead to the first plants and animals and Hand it in. Spend the remainder of the time in class filling out the section in the summary table for this particular lab.

Day 7

Initiation: Have students write a paragraph on what they believe the earth looked like about 4 billion years ago. Students will hold on to this so that it can be revisited later in the class

Lesson Development: Show the video and have students fill out the worksheet which is to be collected at the end of class. Press them to pay attention to the most important characteristics of early earth that are different

Closure: Have students revisit their paragraph that they wrote at the beginning or class and add or remove any information that they believe to be important or no longer valid. If there is time have them share these with their partners. Fill out the section in the summary table for this assignment

Day 8

Initiation: Watch [Bozeman Science Video on Biogeology] (Stop at 2:14 and play multiple times if needed). Have the students work in groups in order to come up with at least 3 ways the the earth and life interact with each other

Lesson Development: Students will pick one of their 3 examples of Biogeology and present them to the teacher. If the teacher accepts their example they will begin to research their example and answer the questions on the Biogeology Research Sheet. **NO TWO GROUPS CAN RESEARCH THE SAME EXAMPLE.** After the students have answered all the questions on their sheet they will make a poster containing all the information that they have gained from their research. Each group will present their poster to the class. The students who are not presenting will be attentive and ask questions.

Example Interactions:

- Burning fossil fuels
- Cyanobacteria
- Interactions that could lead to evolution ex. Peppered Moths

Closure: Each student will write a paragraph writing about one thing that they personally do that affects the geosphere (the earth). Lastly, Fill out the section in the summary table for this assignment/

4. PRESSING STUDENTS TO CONSTRUCT EVIDENCE-BASED EXPLANATIONS

AST Discourse Strategies
• Pressing students for evidence-based explanations. This discourse is designed to happen near the end of a unit, but elements of this conversation can also happen any time the teacher is trying to get students to talk about evidence. The goal of this discourse is to assist students in using multiple forms of evidence, gathered during a unit, to construct comprehensive explanations for a phenomenon that has been the focus of the unit.

Day 9:

Part 1. In this part of the unit, students will engage in revisiting and negotiating (with the teacher) the Gotta Have List to be sure that it represents what they think should be included in the final models. Additionally, students should engage in refining their initial models by both referring to the finalized 'Gotta Have List' and 'Summary Table' that was developed across the unit. You might also consider having groups of students comment on other groups' initial models with 'Sticky Notes' prior to students making final revisions to their group models (see 'Sticky Notes [1, 2]' taken from ambitiousscienceteaching.org). Once students are ready to revise their models based on what they learned across the unit, be sure to identify how you will ensure that they use the Gotta Have Lists and Summary Tables as resources for supporting their final revisions. Be sure to include your complete plan for supporting student groups in revisiting their initial models (e.g. directions to students. Include any templates or resources you will use). (Example Days 6-7)

Day 9:

For the first portion of class have students look back at the summary tables they have done over the unit. Let this be a framework as they try to revise and make a final "Gotta Have List." As a class go over the initial list again and see if there is anything they would like to add/remove from the list.

Next, break the students into their initial modelling groups to create their final model. This model should only include things from the final Gotta Have List. When students share their final models have the entire group go up to the front of the room to the white board and place it high for everyone to see. Every student in the group should participate in the explanation of their final model that should answer the driving question.
Then as a class discuss with the group that is sharing what they notice about their model such as what they agree/disagree on. Perhaps set a minimum of two for every student in order to get more participation if it is low. It is often an easier way to start the discussion if you start off with what you agree on the model.

(There is also an article on how to create academically productive talk.)

As disagreements arise, DO NOT write them off or try to fix it right away, instead, use those discrepancies as a discussion point. Before the group ends their sharing time, try to guide the discussion back to the anchoring phenomena if it has not yet been discussed.

Part 2. Individual Student Evidence-Based Explanation. As a final summative assessment of the unit, consider asking students to develop a written evidence-based explanation of the anchoring phenomenon. In this, consider asking them to ensure they include reference to all important ideas included in the final class Gotta Have List and Summary Table. And, consider asking them to ensure they use all evidence chronicled in the rows of the summary tables (e.g., patterns and explanations for patterns) in their written explanations.

Plan for individual student evidence-based explanation:

Day 10:

Each student will be responsible for a 1-2 page paper (depends on class) where they will answer the question posed at the beginning of the unit: Why does the Earth look so different today than it did 4.4 billion years ago? Students will have to reference labs and activities that they have completed in class in order to provide evidence to support their claim

Final Assessment Assignment and Rubric

Refer to the target explanation of phenomena (on page 3) when grading the quality of explanation

Resource-Rubric EXAMPLE as Possible Resource for Summative Assessment of Group Consensus Models or Individual Student Evidence-Based Explanations. This rubric was developed by using the principles identified above that were important for explaining the anchoring phenomenon and using these as indicators for the rows. The levels of each indicator is then assessed by considering the extent to which students or groups models or explanations are useful in explaining the anchoring phenomenon using the principle of each row.

References

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