Oakland Schools Science Scope

High School Earth Systems Science

Unit 2 – Earth's Place in the Universe

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About Our Scope Unit/Lesson Template

This template is designed to serve several teaching and learning principles considered as staples of state-of-the-art science instruction. Here are the key principles in summary:

- It's critical to **elicit prior knowledge** as a unit or lesson begins.
- **Key questions** should drive student explorations and investigations.
- **Activity Before Concept** – Student inquiry-based explorations which give personal experience with phenomena and ideas should precede a presentation of science ideas.
- **Evidence is the heart of the scientific enterprise.** Students generate evidence and analyze patterns in data that help to construct scientific explanations around key questions.
- **Concept Before Vocabulary** – Attaching science vocabulary to concepts developed by student investigations yields more success than beginning a unit or lesson with a list of science vocabulary.
- **Talk, argument and writing** are central to scientific practice and are among the most important activities that develop understanding.
- **Application** of the ideas provides review, extends understanding, and reveals relevance of important ideas.
- **Assessment** of knowledge, skill, and reasoning should involve students throughout the learning process and be well aligned to the main objectives and activities of the unit.

The Scope Science template is designed to put these principles into practice through the design of the ***SCOPE LEARNING CYCLE FOR SCIENCE***. Each unit has at least one cycle. The components are listed below:

The Key Question for the Unit	Each unit has one open-ended Focus Question that relates to all the content and skills of the unit. The Key Question is presented at the opening of the unit and revisited at the unit's conclusion.
Engage and Elicit	Each unit begins with an activity designed to elicit and reveal student understanding and skill prior to instruction. Teachers are to probe students for detailed and specific information while maintaining a non-evaluative stance. They also can record and manage student understanding, which may change as instruction proceeds.
Explore	A sequence of activities provides opportunities to explore phenomena and relationships related to the Key Question of the unit. Students will <u>develop</u> their ideas about the topic of the unit and the Key Question as they proceed through the Explore stage of the learning cycle. Each of the activities may have its own Key Question or central task that will be more focused than the unit question. The heart of these activities will be scientific investigations of various sorts. The results, data and patterns will be the topic of classroom discourse and/or student writing. A key goal of the teacher is to reference the Key Question of the unit, the Engage and Elicit ideas of the students, and to build a consensus especially on the results of the investigations.
Explain	Each unit has at least one activity in the Explain portion of the unit when students reconcile ideas with the consensus ideas of science. Teachers ensure that students have had ample opportunity to fully express their ideas and then to make sure accurate and comprehensible representations of the scientific explanations are presented. A teacher lecture, reading of science text, or video would be appropriate ways to convey the consensus ideas of science. Relevant vocabulary, formal definitions and explanations are provided. It's critical that the activity and supporting assessments develop a consensus around the Key Questions and concepts central to the unit.
Elaborate	Each unit cycle has at least one activity or project where students discover the power of scientific ideas. Knowledge and skill in science are put to use in a variety of types of applications. They can be used to understand other scientific concepts or in societal applications of technology, engineering or problem solving. Some units may have a modest Elaborate stage where students explore the application of ideas by studying a research project over the course of a day or two. Other units may have more robust projects that take a few weeks.
Evaluation	While assessment of student learning occurs throughout the unit as formative assessment, each unit will have a summative assessment. Summative assessments are posted in a separate document.

Grade 9-12

Unit 2 – Earth's Place in the Universe

Contents

Unit 2 – Earth's Place in the Universe

Unit Introduction

This unit attends to the Michigan High School Content Expectations as they are gathered in Unit 2 of the Michigan Department of Education Science Companion Document. Topically, the unit addresses concepts related to Earth's place in the universe. To organize the content of this unit, the Oakland Schools Science Scope has established three learning cycles:

Cycle 1: Movements and Models
Cycle 2: The Earth-Star Connection
Cycle 3: Exploring Our Universe

The resources and opportunities to address these topics are of such abundance and quality that the unit has the tremendous potential to be a highly relevant, real-world and investigation-rich experience for students. As teachers look for ways to have students use real-world data, apply interactive technology to real-world questions, and foster meaningful tasks for reading, writing, argumentation and mathematics, and framed by the Common Core Curriculum Standards, the issues here provide abundant opportunity. The main limitation is the class time available given other content demands.

On the Common Core State Standards for English Language Arts and Literacy in Science

All science teachers will find the Common Core State Standards of ELA a tremendous asset for reaching learning objectives in science education. Reading, writing, argumentation and discourse are central proficiencies necessary for success in science. All teachers should become fluent with the document and will likely find it validating.

http://www.corestandards.org/assets/CCSSI_ELA%20Standards.pdf

These standards are best reached with science instruction that connects content to real-world problems and experiments, complimented with scientific writing, challenging questions, processes for classroom discussion and debate, and use of scientific text.

It is recommended that teachers require students to use an interactive Astronomy notebook to support learning in this unit. Here are some features and policies to consider:

- Use a bound notebook – cut and paste some other materials into it.
- The right-facing page is for teacher content (ex. notes, questions) and student work; the left is for student reflection.
- Leave four pages for a table of contents.
- Leave the notebooks in the room.

Learning Cycle 1: Movements and Models

Introduction

In Cycle 1, “Movements and Models,” students will first get a sense of the incredible distances and scales within our solar system, and subsequently begin to categorize and differentiate between the solar system objects, and finally will discuss and draw conclusions about the efficacy and probability of space travel, leading to questions of life on this planet and possibly elsewhere.

Learning Objectives

Students will be able to:

- Interpret the movements and the scale of the solar system using models and scales.
- Identify the key shaping and moving force (gravity) of the solar system and the universe.
- Explain strategies and difficulties in interplanetary exploration and travel.
- Expain the possibility of life outside of Earth.

Key Question: How can the movements and models be used to study and explore the solar system?

Engage and Elicit

Activity 1 – How Big is the Solar System?

Purpose
To understand the scale of our solar system in distance.

Activity Description
Visualizing the scale of the solar system is a difficult task. This activity allows the students to discover the varied separations between the planets and the extreme distances of the outer planets compared to the inner planets. Using printed planet cards, students will first predict where they think the planets will be positioned in relation to each other and the sun along a roll of toilet paper or adding machine paper taped to the floor. Then they will compare their predictions to the actual distances. (Optional: The team that comes closest wins a prize!)

Focus Questions
How big is the solar system? How far away are the planets relative to each other?

Duration
Half a class period

Materials
- Planet picture cutouts
  http://cse.ssl.berkeley.edu/AtHomeAstronomy/activity_10.html
- Calculators
- Tape measure or meter sticks
- Colored paper, scissors
- Prizes (optional)
- A pre-measured "example roll" created in advance to use as the master solar system distance scale
- Scale calculator (this website offers a good one):
  http://www.exploratorium.edu/ronh/solar_system/index.html

Teacher Preparation
1. Gather several rolls of toilet paper (or adding machine tape) for classes. If you teach more than one class, you might want backup rolls.
2. Print out planet pictures from website.
3. If you print out sets on differently colored paper, you can easily see each team's prediction. You can store the sets in baggies to distribute to each team. You can also laminate them for longevity.
4. You will want to use a space for this activity that sets the boundaries for the solar system. For example, use a hallway that just about fits your pre-made model of the solar system distances, so students will have a ballpark idea of how much space to use for their solar system.

Classroom Procedure

1. After establishing small groups have students predict distances of planets by laying down their planet pictures (in order!) along a hallway or outside. Discussion may take place about the order of the planets. Don't forget "My Very Educated Mother Just Served Us Nachos" or any other cute way to remember the order of the planets. (First letters of the words are the same as the first letter of each planet.) Pluto is not included in this activity.
2. In the spirit of competition and peer discussion, you may offer hints to students and allow changes of mind, especially if fun prizes are at stake!
3. Remind students that light takes eight minutes to reach us from the sun, and signals take about a half hour to reach us from Mars. You can continue with hints like these. Usually students don't spread the planets out enough, especially the outer ones.
4. You can show the students the actual distances by having volunteers measure with a roll of toilet paper according to the scale given on the website.
5. Another option is to let students volunteer to be planets, holding a planet picture in their hands, and have them each measure how far away they are from the sun according to the "master roll" you have previously created, or some other scale measure.
6. Be sure to draw the students' attention to the ever-widening gap between the planets, and talk about the idea that distances are not linear, and that the spaces between the planets increase as they get farther from the sun. You may even want to have the students graph the distances if they are familiar with linear and non-linear relationships. This would be a great activity for them to do in their Astronomy Notebooks.
7. Students will make reflections in their Astronomy Notebooks about the distances to the planets. What were their predictions? How accurate were they? What was most surprising about the activity?

Engage and Elicit

Activity 2 – Sizing up the Solar System

Purpose
To explore the relative sizes of solar system objects. After completing the previous activity, students should be able to gain a more accurate sense of scale of the solar system.

Activity Description
This is a visual activity comparing the sizes of various objects both within the solar system and ouside of it. Students will view a short dramatic video of comparisons of the sizes of planets and stars. Then they will reflect on the topic in their Astronomy Notebooks, using some questions to guide their reflections.

Focus Question
What are the relative sizes of the planets and stars?

Duration
Half a class period

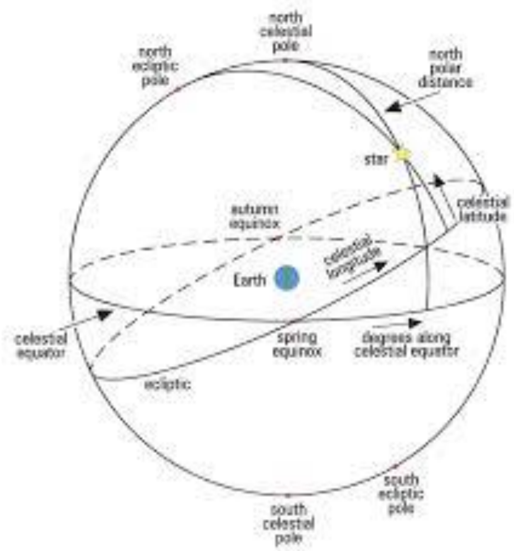
Materials
- Interesting and dramatic video of size comparisons: http://www.youtube.com/watch?v=HEheh1BH34Q
- Another video comparison: http://sizeofworldse.ytmnd.com/
- An interactive database for comparisons: http://sciencenetlinks.com/interactives/messenger/psc/PlanetSize.html
- Astronomy Notebooks
- NOAO webpage with good ideas for comparing household items as analogies http://www.noao.edu/education/peppercorn/pcmain.html

Teacher Preparation
1. Review the websites and video to be able to lead a guided discussion and answer questions/comments that will come up.
2. For the discussion about what household objects might represent the solar system objects, explore the NOAO webpage.

Classroom Procedure
1. Explain to the students that they will be viewing a short video showing the size comparison of planets to stars, and small stars to larger stars.
2. Students will answer a few questions in their journals:
   Which are the smallest planets? The biggest? Is there a relationship between where the small and big planets occur in the solar system? How big are the planets with respect to the sun? How big is the sun with respect to other stars? Can you think of everyday objects that could model the differences in sizes? (See the following link: http://www.noao.edu/education/peppercorn/pcmain.html.)

3. This activity can be followed with a traditional modeling activity where students make a physical model of the solar system, though many have done this in previous school experiences.
4. Possibly a more useful discussion to conduct is why it is nearly impossible to make a model of the solar system that represents both size and distance scale accurately.

Explore



Activity 3 – Where Things Are

Purpose
Students will practice using abstract constructs of models of the sky and celestial sphere to reach an understanding of motions and positions of objects in the solar system.

Activity Description
In this activity, students are asked to recall what we see in the sky on a daily and yearly basis. They also will practice constructing a mental model of what motions and objects look like from space. Using a handout and aided by props and whiteboards, students will work through conceptual three-dimensional scenarios of space, both from an earth view and a space view. This is an activity specifically targeted at moving students from concrete thinking to more abstract ideas so they can have a useful model of the celestial movements and relationships to be explored in coming activities.

Focus Question
How can we understand where things are and how they move in the solar system using what we see in the sky as evidence?

Duration
One class period

Materials
- "Where Things Are" document: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/WhereThingsAre.doc
- Props such as globes and Celestial Globes. The latter can be purchased from science supply stores such as Frey for $100-$200
- Whiteboards

Teacher Preparation
1. Print out handouts for students.
2. Break students into groups. Have whiteboards available to facilitate groups' sketches and discussion. Whiteboards are handy tools for students to draw/discuss their ideas in small-group format, so students can give each other feedback and come to conclusions. Students may find talking about their ideas and discussing how they visualize space to be challenging. The more they practice, the easier it will get; any activity involving discourse will benefit this process.
3. Have models ready, such as a globe, and if possible a Celestial Globe.

Classroom Procedure

1. Distribute "Where Things Are" handout to students.
2. The teacher can facilitate discussion as students work through the questions. As they work through the activity, they will use language and drawings to make decisions about how things move in the solar system and on Earth. This activity can be used as a group discussion led by the teacher, with students discussing their answers aloud and defending the reasons for their answers either on whiteboards or on their papers.
3. Have students turn in their handout for comments/assessment so they get feedback on their ideas.

Explore

Activity 4 – Blogging the Planets

Purpose
To allow students to discover interesting facts about the planets with an emphasis on exploration and create a blog about the planets to share with classmates.

Activity Description
This activity encourages creativity and sharing of scientific information. Students will use a blog entry to answer questions and describe aspects of their planet. They will also update the blog's audience with the latest information and research. This is a longer-term activity – with a learning curve at the front end – that can be used for many different topics once the students are comfortable with the format. It provides an excellent use of technology to allow students to do research and interact with each other on topic questions.

Focus Questions
What are the interesting characteristics of the assigned planet? How has it been explored? What is the latest information about the planet and from what data collector does it come?

Duration
Three class sessions, or homework as needed

Materials
- A blog or website for students to use, teacher moderated:
  - Weebly: http://www.weebly.com/weebly/main.php
  - Edublogs: http://edublogs.org/
  - Blogger: http://www.blogger.com/home
  - Classblogmeister: http://www.classblogmeister.com/
  - A blogging rubric: http://www2.uwstout.edu/content/profdev/rubrics/blogrubric.html
  - Blogging teacher tips: http://digitallyspeaking.pbworks.com/f/Handout_TeacherTipsBloggingProjects.pdf
- Research websites:
  - http://www.nasm.si.edu/etp/
  - http://solarsystem.nasa.gov/planets/index.cfm
  - http://solarsystem.nasa.gov/educ/howweexplore.cfm
- Computer access for several days

Teacher Preparation
1. Set up a website or blog for student use. Use the above sites as resources.
2. Once blog/website is set up, ground rules and procedures for blogging should be created. All students should be using the same blog. Students should be reminded of appropriate use of electronic media and any school rules about consequences of inappropriate uses. (This may seem time consuming, but once the blogs and the guidelines are set they are powerful tools in the classroom and can be used for many diverse topics.)

Classroom Procedure

1. Introduce the idea of blogging and have students log into the blog/website.
2. Present any helpful techniques or guides to help students with the activity. Here are some ideas for guidelines:
   - Determine length of blog entry, such as 5-7 paragraphs.
   - Include at least three images in your entry.
   - Make sure you tag and catagorize your post.
   - Include at least two links to other scholarly websites.
   - Include all sources at the end of the post.
3. Assign students a planets or have them choose a planet of our solar system to research. They should answer some primary questions about their planet, such as:
   - When was the planet discovered?
   - Does the planet have an atmosphere?
   - Does it have a surface? What are the temperatures?
   - Has the planet been explored by robotic spacecraft? If so, which spacecraft and when?
   - What were the major findings of the spacecraft?
   - Was there ever a question of life on the planet or any of its moons? Why or why not?
4. Students will share their blogs with each other and comment on their planets. One requirement might be that each student must comment on at least three other blogs with scholarly comments. Teacher can easily check this as an assessment.

Explore

Activity 5 – The Physics of Orbiting

Purpose
To explore the relationship between gravity, velocity, and the process of orbiting.

Activity Description
One of the most challenging concepts to explore in astronomy is the idea of gravity and how it affects objects. Many students have pre-conceptions and incomplete information about how gravity affects objects, specifically about how bodies in the solar system must obey the Universal Law of Gravity as conceived by Newton. Some students ascribe more power to gravity than it deserves, especially in the case of orbits. In this activity, students will explore the role of a planet's velocity in the making of an orbit, as well as the important but incomplete role of gravity. They will use a computer simulation to model orbits. The simulation can be downloaded ahead of time if you don't have an Internet connection during class. Using the C-E-R framework ("Claim, Evidence, and Reasoning"), students will come to conclusions about the roles of velocity and gravity in the process of orbiting.

Focus Question
What is the relationship between gravity, velocity, and a planet's orbit?

Duration
One class session; possibly more if discussions run long

Materials
- Computer access for pairs or small groups of students
- Access to the PhET simulation, *My Solar System*: http://phet.colorado.edu/en/simulation/my-solar-system
- Whiteboards, pens
- Astronomy notebooks

Teacher Preparation
1. You may want to download the simulation onto the computers beforehand if there will be no access to the Internet during class. Otherwise the simulation can be run from the website.
2. Prepare parameters and questions in advance to expedite the lesson. Parameters include:
    - mass
    - position
    - velocity
3. Prepare for a "board meeting" class format by arranging desk/chairs in a circular or square shape. A board meeting is a technique that allows students to share information efficiently, critique their own and others work, and communicate general trends across the data sets. For details, see Step 8 below.

Classroom Procedure

1. As an introduction to this activity, you may want to begin a discussion about why planets are “held” in orbit, or why the moon orbits the earth. This would be a good brainstorming activity to begin with, perhaps prompting student discussion with a demonstration of dropping a rock to the earth and asking why the moon doesn’t fall to the earth. When Alexander the Great asked his teacher Aristotle this question, Aristotle responded that if the moon were heavier than air, then it of course would fall. His conclusion was that the moon was made of something lighter than air. Do students agree with Aristotle’s conclusion? What could explain the moon’s orbit? Wouldn’t gravity pull it down just like it pulls a rock down?
2. As discussion wraps up, guide the students to explore the parameters that will allow a low-mass object (a planet) to orbit a higher-mass object (the sun.) This should be the guiding question to their explorations.
3. Allow student teams to explore the parameters and controls. A beginning activity might be to bring their attention to the **Initial Settings area.** Notice that the parameters not only include mass, which is directly related to gravity, but also position and velocity. Why velocity? Direct students to the velocity of the lower mass body, and make it 0,0. That means the orbiting body has no velocity. What happens when there’s no velocity?
4. On their whiteboards, teams can write the parameters they will use: mass, position and velocity. The default simulation should model the sun and a planet like Earth. To make the simulation model the sun and Earth, make the minimum mass of the higher mass object 2000 kg, and the minimum mass of the “satellite” 20 kg.
5. Allow the students to experiment with the parameters, keeping the mass minimums described above in mind.
6. Teams should gather their data on the whiteboard, in a chart form, or some other organizational form.
7. The chart should include the constants and the change of parameters. Remind students that they should only change one variable at a time.
8. After gathering data, teams will share with each other in a “board meeting” where students are gathered in a circle to comment on and share each other’s work. They can refer to their whiteboard charts and compare the different parameters they explored. Discussion should focus on which parameters allow a planet to orbit rather than crash or fly off into space.
9. During the board meeting, draw out the differences in the shapes of orbits depending on the parameters.
10. After sharing the general patterns and trends from the varied parameters, teams will choose one parameter to explore in depth. They should make a claim for which they can find evidence. One team could explore how changing mass of the central body affects orbits; another could explore how the velocity needed for a circular orbit changes with the distance from the central body. The teams can organize their whiteboards with their claim, their constants and changing parameters underneath, their evidence (their data set), and their reasoning for their conclusions (C-E-R).
11. Form a board meeting again and allow the students to share their results. A conclusion that might be drawn is the a delicate balance between gravity and the velocity of the orbiting body. Ensure that students talk about how velocity is involved with gravity to create an orbit, and that it is not gravity alone that keeps the moon or planets in orbit.

12. Students should write up their claims-evidence and resoning (C-E-R) notes from their whiteboard in their Astronomy Notebook. Class discussion and conclusions should be included.

Explore

Activity 6a – Motion in the Solar System

Purpose
To understand the physical relationships between objects that describe their motion in the solar system.

Activity Description
This activity uses Jupiter and its moons as a model for the physics of motion in the solar system by introducing Kepler's Third Law of Motion, which applies not only to planets but to moons as well. In this activity, students will use data from Jupiter moon positions to derive a relationship between the period of a moon and its distance from Jupiter. From this relationship, students will calculate the distance of a moon once the period is known. Since they can actually detect this motion within a few nights of observation, this activity ties together observation and physical laws of the universe.

Focus Question
What is the relationship between how long a moon/planet takes to orbit an object and its distance from the object it is orbiting?

Duration
One to two class sessions. Evening sessions if possible for Jupiter observations.

Materials
- Orbits of Jupiters Moons Activity Guide
  http://kepler.nasa.gov/files/mws/OrbitsOfJupitersMoons.pdf
- Atlas url:
- Copies for students in groups of 3-4, one per group, or enough for individual copies
- Calculators
- Copies of the 19-day chart of Jupiter's moons for each student
- Colored pencils (optional)
- Jupiter-moon orbit demonstrator: paper plate with a bead or ball affixed to the rim to represent a moon, and a pencil inserted through the center into a larger ball representing Jupiter. The moon can be made to orbit Jupiter by rotating the pencil. (See PDF link above for an image of the device.)

Teacher Preparation
1. Prepare materials for students. If possible, teacher may want to schedule a viewing evening of Jupiter with binoculars or small telescopes.
2. Prepare the Jupiter-moon orbit demonstrator ahead of time.
3. Thoroughly review the materials and go through calculations beforehand.

Classroom Procedure
1. As an introduction, you may want to use the Jupiter-moon orbit demonstrator as described above.

2. Have the students work through the activity. This activity will be a guided trip through the physics of planetary motion. Each student will pick one of Jupiter's four largest moons to study, but make sure there are at least three students to work on each moon. If they work in teams of four, each team member should have a different moon.
3. Have students work through the activity.
4. Observation sessions will greatly enrich and bring alive the experience for the students. If possible, team up with a local amateur astronomy club and meet your students at one of their observation sessions. The next activity will incorporate the observations of Jupiter, so you might want to do these two activities concurrently.

Explore

Activity 6b – Motion in the Solar System

Purpose
To understand the physical relationships between objects that describe their motion in the solar system.

Activity Description
This activity has multiple parts. In the first part, students are asked to think about their ideas of the planets and moons, and answer questions related to the possibility of life and/or travel to them, Jupiter in particular. In the second part, they will use a simulation on computers to understand Kepler's Third Law. This activity builds on the ideas from the previous activity, and also gives a practical relationship to the results from Activity 5. Students will use Kepler's relationship to calculate the distance from the sun to Jupiter. In the third part, students will be observing Jupiter's moons with the Harvard MicroObservatory online telescope. However, Jupiter's moon are fairly easy to see with even binoculars on a steady tripod and actual observations are recommended. Galileoscopes (inexpensive student telescopes) are also fun for this activity. Nighttime observation is best done over the course of several evenings because Jupiter's moons move visibly from night to night. In the fourth part, students synthesize information from their experiences in observation and in the physical aspects of their work. In the last part, they will draw conclusions about their work.

Focus Question
How do objects move in our solar system?

Duration
Three to five class sessions; evening sessions if possible for Jupiter observations

Materials
- Document: What are Jupiter and its Moons Like?
  http://www.cfa.harvard.edu/webscope/activities/pdfs/jupiter.pdf
  Atlas url:
- Copies for students in groups of 3-4, one per group
- Calculators, rulers
- Online Orbit Simulator
  http://cfa-www.harvard.edu/webscope/inter/jupiter
- Optional: using the Harvard Microobservatory
  http://mo-www.cfa.harvard.edu/OWN/training.html

Teacher Preparation
1. Prepare materials for students. Copy worksheets from part 1 or use whiteboards to elicit ideas. Copy worksheets for Part 2. Copy worksheets for part 3 and 4.
2. If possible, schedule a viewing evening of Jupiter with binoculars or small telescopes.
3. Thoroughly review the materials in the packet and go through calculations beforehand.

4. If you plan on using the MicroObservatory, spend some time on the website familiarizing yourself with it to expedite activities with the students. It must be downloaded, and using it involves a learning curve. It is not difficult, but will take preparation. A manual is included in the download. Images must be taken in real time, so one option is to make real-time observation a home project. Otherwise, stored images can be accessed here: http://mo-www.harvard.edu/jsp/servlet/MO.ID.ImageDirectory.
5. If using Galileoscopes or binoculars, make sure tripods are also available. It is very frustrating to observe objects in a telescope or binoculars without a steady view (https://www.galileoscope.org/gs/products). Again, preparation and trial is very important- but once you are familiar with how the telescopes work and how students interact with them, you will be able to have real discussions with them about what they see.

Classroom Procedure

This activity will be a guided trip through the physics of planetary motion. The activity will work best for small groups, with teacher oversight and interaction. Students can work both or one of the activities in *What are Jupiter and its Moons Like* document depending on skill levels and time contraints.

Part 1: Use worksheets or whiteboards to elicit ideas from students about planets and moons. Use the questions listed on the worksheet as a jumping off point for a rich discussion with students about the possibility of life elsewhere and the evidence you would need to claim that a planet has life.

Part 2: Use the worksheets on the website to guide the students through the inquiry, "is Jupiter or Europa suitable for exploration?" This is the part that uses the Orbit Simulator. Students will need access to computers with the program downloaded. They will work through the instructions on the worksheet to answer the questions about the physics of planetary exploration.

Part 3: Observation sessions will greatly enrich and bring alive the experience for the students. If possible, team up with a local amateur astronomy club and meet your students at one of their observation sessions. The online observation can be a great project to incorporate into the lessons. Students will need to observe Jupiter and its moons, then they make a movie and do calculations to determine which moon is Europa.

Part 4: If using the MicroObservatory, students will do the calculations of orbital period of Europa and size of Jupiter. They will answer questions about density, weight, and surface features.

Part 5: Students write their report as they create a "portrait" of Europa. Projects can be shared with class, or made into a protfolio shared on the internet.

There are additional projects at the end for extensions of the lessons.

Explain

Activity 7 – Interplanetary Travel

Purpose
To gain an understanding of what humans have accomplished and our limitations with space exploration.

Activity Description
This activity allows student to think and reason about the difficulty of space travel. With a background of ideas about planetary motion, gravity, and velocity from previous activities, students can begin to visualize what it takes to travel in space. They will work through a series of questions in this tutorial to guide them through the ideas of planetary travel. Working in small groups, they will find that the easiest way to get to another planet is NOT a straight line!

Focus Question
How is traveling to planets accomplished?

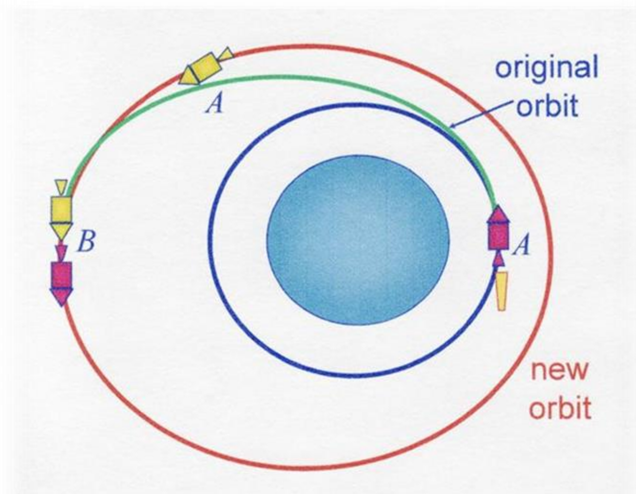
Duration
One class session

Materials
- Interplanetary Travel Activity Guide
  Atlas URL:
- Short NASA Voyager video
  http://www.youtube.com/watch?v=GAysmcZ7DZg&feature=related
- Video of Juno's trajectory to Jupiter
  http://www.youtube.com/watch?feature=endscreen&v=sYp5p2oL51g&NR=1

Teacher Preparation
1. Print out and copy the student worksheets from the PDF link, enough copies for small groups with 3-4 students per group.
2. Ensure students are familiar with Kepler's Third Law of Planetary Motion. This relationship is the period of a planet squared is equal to the cube of the distance to the sun (see Activity 6a).
3. Have the video clips ready to use during the introduction.

Classroom Procedure
1. Introduce the lesson with this question: "Assuming we are using rockets and have worked out the vehicles to take us to the planets, what is the best way to get there?" This will help focus the lesson on the idea of the Hohmann Transfer Orbit.
2. Pass out worksheet copies to students, and allow them to work in table groups or as partners to complete the worksheets. As they work in small groups, there should be discussion among them, especially when they tackle the debate questions. To facilitate this, show the video clips as a visual guide to the questions that students will be answering.

3. Students may have trouble at first visualizing how spacecrafts travel most efficiently from one planet to the next. You may want to have them model this physically. Have students form a little solar system, having the planets stand in a line from the sun, and simultaneously take one step at a time in their orbit. Teacher may want to beat a drum or make asound to indicate when to take a step. Have one student act as **a spacecraft** and stand next to the earth; taking one step at a time, the spacecraft student has to hand a pencil or some object to the planet farther out. How will the student get to the next planet, one step at a time? Students may think a straight line is the shortest route from one planet to another, but they should quickly see that this is not the case. A straight line will miss the planet. They have just made a Hohmann Transfer Orbit.



Explain

Activity 8 – Are We There Yet?

Purpose
To read about the trials and difficulties of interplanetary space travel.

Activity Description
The article in this activity allows student to think and reason about the difficulty of space travel. They will work through a series of questions to guide them through the article titled "Are We There Yet?" Written in a modern and engaging style, the article details an experiment done to study the effects of long-term isolation on humans, simulating what it would be like to travel to Mars.

Focus Question
What are some primary and important issues associated with travel between planets?

Duration
One class session

Materials
- Article: "Are We There Yet?": http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Are%20We%20There%20Yet.doc
- Student question set: "Interplanetary Space Travel": http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Interplanetary%20Space%20Travel.doc
- Reading strategies:
  http://spedlit.k12.hi.us/Strategies/Say_Some.htm
  http://www.readingrockets.org/strategies/anticipation_guide/

Teacher Preparation
1. Print out and copy Interplanetry Space Travel. These include the article and the question set.

Classroom Procedure
1. Pass out copies to students. Because it is a fairly engrossing reading dealing with the psychology of humans in isolation, high school students generally find it interesting and are motivated to read it.
2. If the level of reading is high for some struggling readers, a reading technique like Anticipation Guides or "Say Something" could be used. (See above link.)
3. This reading might be used as homework after the previous class activity, or it could be used to initiate class discussion. The reading could be assigned in class with the expectation of discussion afterwards, and the questions could be asked verbally.

Explain

Activity 9 – Patterns in the Solar System

Purpose
To recognize and catagorize patterns in the solar system.

Activity Description
Students will work with physical data of the planets to answer questions and use graphs and charts to classify the planets. They will analyze characteristics of the planets and contrast and compare them.

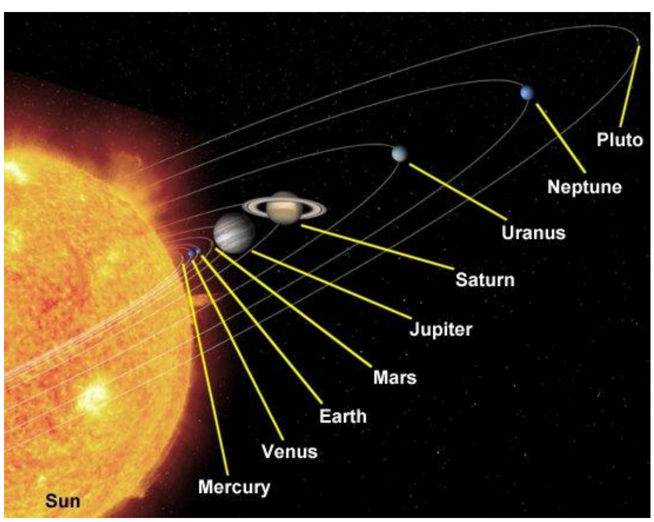
Focus Question
What are some recognizeable patterns and systems within our solar system?

Duration
One class session

Materials
- Copies of "Patterns in the Solar System" packet, one per student: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/ESS%20Unit%201/PatternsintheSS.doc

Teacher Preparation
1. Make copies of the packet (one per student), "Patterns in the Solar System."

Classroom Procedure
1. Hand out the packet to students.
2. Students should understand and recognize the difference between terrestrial planets and jovian planets, and especially understand what they refer to.
3. Teacher may want to go over tables and graphs in the packet with students to explain the data charts and what the information refers to.



Elaborate

Activity 10 – Exploring the Moon, Past and Future

Purpose
To read and answer questions about a scholarly historical account of the moon.

Activity Description
Student will read a set of articles on the exploration of the moon and answer a question set about the reading. Reading strategies are recommended for struggling readers and students who may be below the reading level.

Focus Question
How has the moon been explored by humans? What are future plans for exploration?

Duration
One class session, or out-of-class assignment

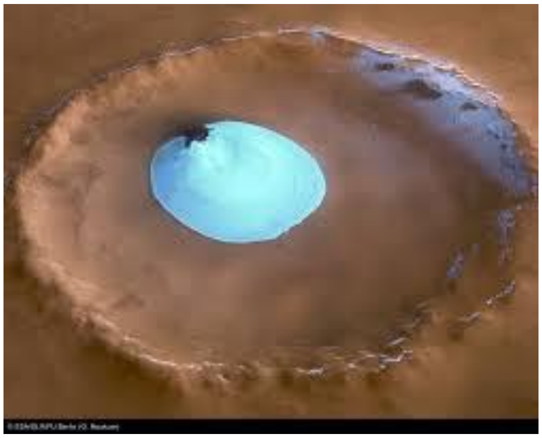
Materials
- "Exploring the Moon, Past and Future" (one per student) http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Exploring%20the%20Moonreading.doc
- Question set (one per student) http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Exploring%20the%20Moon.doc
- Background website: http://airandspace.si.edu/exhibitions/space-race/
- NASA description of Apollo 11: http://www.nasa.gov/mission_pages/apollo/missions/apollo11.html
- Reading Strategies http://www.readingrockets.org/strategies/

Teacher Preparation
1. Make copies of readings and question set, one copy per student.
2. If desired, give a little historical background or pictoral examples of the 60s and 70s in American history. Option: have some music and/or video clips handy to set the scene for moon exploration.

Classroom Procedure
1. Teacher may want to enrich readings with short video clips or historical and anecdotal stories about the late 60s and early 70s. Students may recall learning about this time in a history class, and a pre-reading discussion would be helpful to set the scene and put the reading in cultural and historical context.
2. Hand out readings and questions to students. Either assign as classwork or homework.

3. If struggling readers have been identified, use some of the strategies recommended in the materials list.
4. As a follow up, students may want to make their own presentations on the historical context of the Lunar Landing program.

Elaborate



Activity 11 – Mars Image Analysis

Purpose
Students acting as planetary scientists reach conclusions about the geology of Mars.

Activity Description
This NASA Triad Activity follows the 5 E format to allow a rich and deep experience for students to study images from Mars and analyze them. Students will be looking at actual orbiting spacecraft images to identify features and learn their names.

Focus Question
How can we reconstruct geological events using empirical evidence?

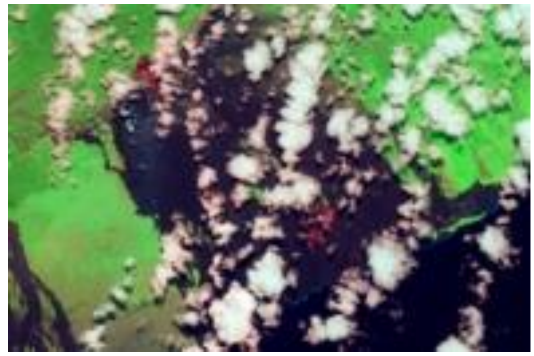
Duration
Two or more class sessions

Materials
- Student Activity Guide: Mars Image Analysis
  http://www.agiweb.org/education/NASA/tr/invest/activities/MARS_IMAGE_ANALYSIS_12_2012.pdf
  Atlas URL:

Teacher Preparation
1. This is a very image-intensive activity, and high-quality prints should be made and laminated for continued use.
2. Make copies of materials.
3. Become familiar with the materials and print out the necessary materials from the PDF link. The PDF contains detailed instructions for each part of the lesson.

Classroom Procedure
1. Hand out materials to students, follow lesson plans on the PDF.
2. Part 1 – Engage: What can you tell from this picture? Students will examine images from THEMIS and feature ID charts to begin to identify features on Mars.
3. Part 2 – Explore: Image analysis. Students begin to identify and list the exact features in their THEMIS image of Mars.
4. Part 3 – Explain: Discussion and sharing. Students will discuss and share their ideas about relative ages and sizes of features on their image.
5. Part 4 – Elaborate: Compare Earth to Mars. Students engage in research of a topic using background knowledge and their observations.
6. Part 5 – Evaluate: Evaluate proposed solutions using criteria. The students' work is evaluated with a rubric.

Elaborate



Activity 12 – Blue Marble Matches

Purpose
This activity uses earth features to identify common planetary features across the solar system.

Activity Description
This NASA Triad activity introduces students to geologic processes on Earth and how to identify these features in images. They will study many different images and identify features from the familiar Earth and then the less familiar planets. This lesson connects the shape of Earth's surface (and the names of the features that correspond to those shapes and textures) to the processes that form them. It will also introduce students to how scientists use Earth to gain a better understanding of other planetary bodies in the solar system. There are five parts to this lesson, based on the 5 E's.

Focus Question
Can we identify geological processes on other planets by recognizing them on our own?

Duration
Several class sessions

Materials
- Student Activity Guide: Blue Marble Matches
  http://www.agiweb.org/education/NASA/tr/invest/activities/BlueMarbleMatches_3-12.pdf
  Atlas url:
- For projection, images from Blue Marble Matches (to be projected)

Teacher Preparation
1. Make copies of materials. This may take some time, as it is a 5-part activity featuring beautiful color images necessary for the activities. Several sets of the cards (number of students in class divided by four) should be printed out on a color printer.
2. Become familiar with the materials and print out the necessary materials from the PDF. Materials can be modified for classes as needed.
3. General time recommendations are listed on the activities; keep these in mind as you plan the unit.

Classroom Procedure
1. Refer to the PDF for detailed descriptions and lesson plans.
2. Part 1 – Engage: Observations and Descriptions. This part requires students to work in groups to identify shapes and names of features on Earth. Students will share their work in a large group setting or a whole-class discussion.
3. Part 2 – Explore: Identification Criteria. Students will use identification criteria to identify common characteristics helpful to identify features.

4. Part 3 – Explain: Feature Recognition and Review. Students discuss their identification criteria and review them. They may come to consensus or not, just like real scientists.
5. Part 4 – Elaborate: Using Earth for Planetary Comparisons. Students now use their identifying characteristics on other planets. They will compare features from Earth to those on Mars, the moon, Venus, Mercury and Jupiter's largest moons.
6. Part 5 – Evaluate: Observations, Interpretations, and Drawing Conclusions. Students now synthesize what they have learned and draw conclusions in the table provided.

Elaborate

Activity 13 – Water on the Moon?

Purpose
To explore the question of water on the moon.

Activity Description
Students will read a short article about water on the moon and answer related questions. There has been debate about what water on the moon could mean for human exploration of the moon.

Focus Question
Is there water on the moon? How do we know? What will we do about it?

Duration
One class session

Materials
- Copies of article and questions for each student Atlas URL:

Teacher Preparation
1. Make copies of the article.
2. You may want to familiarize yourself with recent lunar discussions and the countries that are interested in going back to the moon.
   http://news.discovery.com/space/this-moon-was-made-for-mining-helium-3.html
   http://www.nss.org/adastra/volume23/lunarresources.html

Classroom Procedure
1. Hand out article to students, and have them answer questions.
2. You may want to conduct a class discussion with this article. Students may exhibit surface apathy about the idea of going back to the moon, but with an open discussion, some students may express ideas about the usefulness of exploring planets and moons, and some may express concerns. Classroom discussion on this topic can be quite rich and enlightening with a little prompting and perseverance.

Learning Cycle 2: The Earth-Star Connection

Introduction

Cycle 2 of Earth's Place in the Universe focuses on stars as the building blocks of the universe and understanding where we came from by understanding the sun and other stars.

Learning Objectives

Students will be able to:

- Describe the process that makes stars shine.
- Compare the life cycles of stars depending on their masses.
- Identify the information gained from the spectra of stars.
- Plot and interpret a relationship between star color, temperature, luminosity, and magnitude.
- Explain the end states of stars and how they populate the universe with important elements.
- Assess the importance of the sun on our lives and our energy sources.

Key Questions: How do stars shine? What information can we get from starlight? What does it tell us about stars? What is the energy source of the sun? How does it affect the earth?

Engage and Elicit

Activity 1 – How Does a Star Shine?

Purpose
To understand the source of our energy.

Activity Description
The teacher facilitates brainstorming of sources of energy on Earth. Students will use energy cards from the NEED website to map the flow of energy of various sources. (NEED is the National Energy Education Development Project.) All materials come from the website link below.

Focus Questions
Where do our sources of energy come from? How does the sun fit into the cycle of energy flow?

Duration
One class period

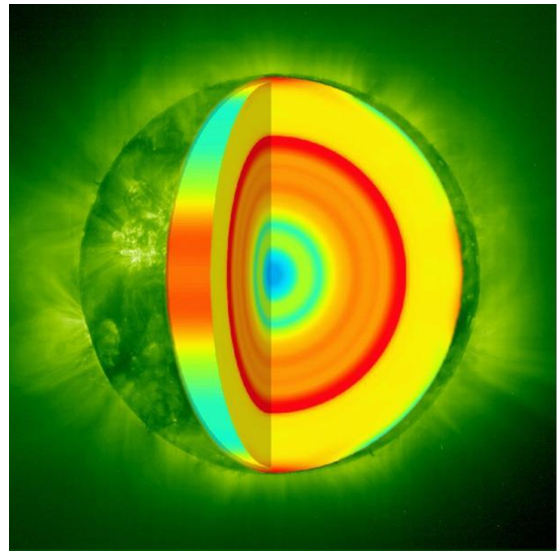
Materials
- Activity Guide: Energy Flows (from NEEDS project)
- http://www.need.org/needpdf/Energy%20Flows.pdf
  ATLAS URL
- Materials for NEED activity (wooden match, flashlight, printed cards from website)
- various examples of energy sources: chunk of coal, petroleum oil, piece of solar panel (from calculator), match, wood, candy bar, rubber band, pictures of windmills, nuclear power plants, etc.
- Projection technology for illustrations in the Activity Guide.

Teacher Preparation
1. Gather examples of energy sources to use as visual cues to students to facilitate brainstorming.
2. Print out materials from NEED website and have materials ready. Read the materials and preparation list on the website itself.

Classroom Procedure
1. Introduce the cycle by telling the students they will be investigating the energy sources that we use every day to discover the source of the energy. They will discover many connections between the earth and our energy sources and the sun, our star.
2. To orient students to the topic, display the examples of energy sources listed on the website without explanation.
3. Have students list all the sources of energy they can think of; write them on a whiteboard, and have students record in their notebooks.
4. Go through the list after student ideas are exhausted and prompt with visual cues if needed until the list seems complete.

5. Carefully lead students to search through the list for underlying source for the energy, and help them trace them back to the sun. The concluding idea is that all energy ultimately comes from our star, the sun.
6. Students will use the cards as directed on the NEED website for the activity.

Explore



Activity 2 – Looking Inside a Star

Purpose
To explore the structure of a star, the sun.

Activity Description
This activity is a defining and note-taking activity using Internet or textbook sources, or a teacher presentation. Students will use all available resources to gather information and refine knowledge about the interior of a star like the sun. Included below is a link to an informational PowerPoint about the sun that can be used. Students will use their astronomy journals to collects notes and information about the sun using the resources listed below or others.

Focus Question
What does the interior of a star like the sun contain?

Duration
Up to one class session; can be used in conjunction with previous lesson

Materials
- If using Internet resources, here are some useful sites:
  http://solarscience.msfc.nasa.gov/interior.shtml
  http://www.windows2universe.org/sun/solar_interior_new.html
  http://sohowww.nascom.nasa.gov/explore/
- If students don't have access to computers, you could print out the text and questions from this website:
  http://www.bsin.k12.nm.us/Curriculum/CAP/completed%20files/astronomy/completed%20files/nuclearpowersun.html
- If using class textbook or the PowerPoint (link below), ensure they are available.
- "The Sun Our Star" PowerPoint
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/The%20Sun%20Our%20Star.ppt
- "Basic Structure of the Sun" notesheet:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Basic%20Structure%20Of%20The%20Sun.doc
- Notesheet key:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Basic%20Structure%20Of%20The%20Sun%20Key.doc

Teacher Preparation

1. Thoroughly review the teacher PowerPoint presentation, textbook, or Internet resource.
2. Secure time in the library/media center if using resources/computers there.
3. Students will collect information in their journals; remind them to bring their journals with them.

Classroom Procedure

1. If following up from the previous activity's brainstorming session, use the idea that all our energy comes from the sun to introduce the notion that the sun is producing energy.
2. Students will then use available resources to investigate the source of the sun's energy. The guiding question is "What is inside the sun?" In the process, students will map out the interior of the sun using their own sketches in their notebooks or the included template.
3. To guide the students, you may want to draw an image of the sun on the main board in the classroom. The drawing can include the three inner layers and the three outer layers of the sun so that students have a template for their own drawings. The labels of these layers should be checked at the end with whiteboarding; students will quickly sketch their sun layers and compare with each other for accuracy.

Explore

Activity 3 – Biography of a Star

Purpose
To develop an understanding of how the sun, as an average star, has a life cycle.

Activity Description
This activity encourages literacy in scientific reading by exposing students to a scholarly but accessible reading on the sun. The question set guides students through the reading and provides a formative assessment for the topic.

Focus Question
What is the life cycle of a star like our sun?

Duration
One class session or use as homework

Materials
- Reading "Biography of a Star": http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Biography%20of%20a%20Star%20article.doc
- Question set: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Biography%20of%20a%20Star%20questions.doc
- Walter Lewin's MIT lecture on the life and death of stars (optional): http://mitworld.mit.edu/video/158

Teacher Preparation
1. Print out and copy the reading and attach the question set.
2. If needed, provide some reading strategies, highlighting techniques, or literacy techniques to help students glean information from the reading.
3. If the reading is used as homework, the lecture from Walter Lewin may be used during class, or assigned as homework if the reading is classwork.

Classroom Procedure
1. Hand out the reading and question set to the students.
2. Present any helpful techniques or guides to help students with the activity.
3. Show the video for background information if time allows.

Explore

Activity 4 – Space Weather Broadcasts

Purpose
To study and communicate space weather to other students and the entire school.

Activity Description
Students will gather information from space weather websites and use a visual communication program like Adobe to broadcast information on a daily, weekly, or bi-weekly basis. This is a longer-term, ongoing project of which students can take ownership. To show the product to the school, many outlets can be explored, starting with the school announcements/weekly news broadcast if it exists. If the community has a cable channel, students might like to include a weekly space weather clip.

Focus Questions
What is the weather like in space? How does it affect us?

Duration
Ongoing throughout the cycle

Materials
- Adobe Visual Communicator or a similar software program, such as the free http://www.xsplit.com/ or a live Twitter broadcast from http://twitcam.livestream.com/
- Space weather websites:
  http://www.spaceweather.com/
  http://www.swpc.noaa.gov/SWN/
  http://www.agu.org/journals/sw/

Teacher Preparation
1. Purchase or download software that allows students to broadcast their "space weather report."
2. Have students survey the websites and assign different groups of 3-4 students each week or other time frame to write and produce a script for a space weather broadcast.
3. Get together with the school technical director-A/V director to see how student broadcasts could be incorporated into the school announcements or website.

Classroom Procedure
1. Introduce the broadcast idea to students by showing them the websites listed above.
2. Some of the more tech-savvy students may want to volunteer to use the software and create the first space weather broadcast. This may work best as teams; not everyone will want to be in front of the camera, but there are writing and editing jobs, image gathering and editing, and production tasks to be fulfilled.
3. Responsibilities should be shared for the broadcast. This can be an ongoing task through the semester, or the entire year if able. The broadcasts don't need to be long, and visual props from APOD (http://apod.nasa.gov/apod/) could also liven up the presentations. The

focus should be on the earth-sun connection, however, and how the sun directly affects the earth and our daily lives.

Explore

Activity 5 – Solar Stormwatch

Purpose
To develop an understanding of how the sun affects the earth.

Activity Description
Students will use the “citizen science” *Solar Stormwatch* website to learn about how the sun affects the earth, and then use the website to contribute real data to solar science. This is a project that students can use on their own long after they learn how to use it in class. It is part of a constellation of citizen science programs where the casual science enthusiast can contribute to the body of science knowledge by analyzing the vast collection of data.

Focus Questions
How does the sun affect the earth? What happens on the sun that affects the earth directly?

Duration
One or two class sessions

Materials
- *Solar Stormwatch* website: http://www.solarstormwatch.com/
- Computers for each student
- Solar Stormwatch Activity Guide and Student Questions: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/ESS%20Unit%201/Solar%20Stormwatch.doc

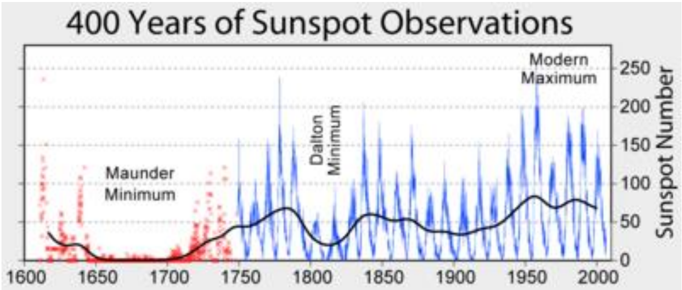
Teacher Preparation
1. Print out and copy the question set.
2. Teacher may want to make an account for the class in advance; the data that students will create can be saved to the class account. Some students may want to carry on with the research even after the class is over to contribute to the data set.
3. Teacher may also want to print out little slips with the web address and password on it, or put it on a whiteboard if one is available.
4. Ensure each student will have a computer connected to the Internet.

Classroom Procedure
1. Hand out the web address for the website and question set to the students.
2. Students should work through the questions in the introductory activity called “Mission Briefing” (the link is on the question page). Once this is completed

and the questions are answered, students should go on to “Spot Training” and start processing some data. Another class period could be used if students need more time or express a desire to do more data collecting.

3. Students can keep track of their progress in their notebooks. Incentives may be offered for further work on the *Solar Stormwatch* website.

Explore



Activity 6 – Determining the Sunspot Cycle

Purpose
To develop an understanding of why the sun has a sunspot cycle and to determine what it is.

Activity Description
Students will examine real data from historical records of sunspot data and analyze the data to find an average sunspot cycle. The data has been collected from many different sources, including tree ring data in the pre-modern eras. Students will learn the patterns and cycle periods well as the effects of the solar cycle in this activity.

Focus Questions
What is the sunspot cycle of our sun? What does it mean to us?

Duration
One class session, or use as homework

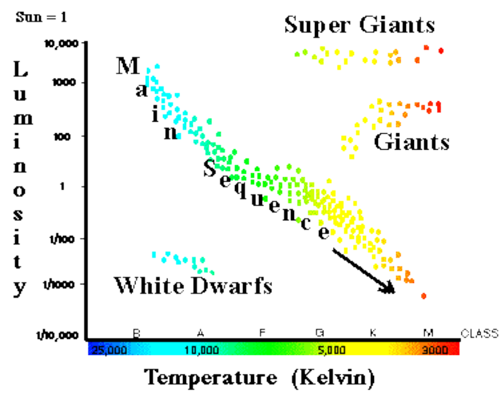
Materials
- Graphs of sunspot numbers and butterfly diagram
- Atlas URL: Sunspot Graphs
- Question set *Determining the Sunspot Number*: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Determining%20The%20Sunspot%20Cycle%2012.doc
- Sunspot graphs: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Sunspot%20Graphs.doc
- Reading: *Magnetic Fields:* http://oaklandk12.rubiconatlas.org/links/Earth_Systems_Science/ESS%20Unit%201/Magnetic%20fields%20of%20stars.doc
- *Earthsky* website (provides more information): http://earthsky.org/space/nasas-three-minute-solar-cycle-primer

Teacher Preparation
1. Print out and copy the data from Sunspot Graphs and attach the question set, *Determining the Sunspot Number*.

Classroom Procedure
1. Hand out the data and question set to the students.
2. Allow them time to analyze the data; they may need help understanding the procedure for interpreting the data.

3. As the students analyze the data, they may need clarification on what a short-term trend is (one solar cycle) versus a long-term trend (decades' or dozens of decades' worth of data) and what the difference is. Short-term data shows a fairly regular pattern of low and high numbers of sunspots, but long-term data can show effects to climate, such as the Maunder Minimum (http://solarscience.msfc.nasa.gov/SunspotCycle.shtml).
4. To answer questions about why the sun has sunspots, the *Magnetic Fields* reading should be consulted. A short video of the magnetic carpet of the sun is available here: http://umbra.nascom.nasa.gov/ssu/magnetic_carpet.html.

Explore



Activity 7 – The H-R Diagram

Purpose

To plot and analyze the sun's ranking among the stars of our galaxy.

Activity Description

This is a physical activity during which students plot a number of stars on a large board, preferably magnetic (classroom whiteboards are often magnetic). The stars can be made magnetic so that the whiteboard can be turned into a giant Hertzprung-Russel (H-R) diagram. As students plot the stars on the whiteboard, the H-R pattern emerges, and they can draw conclusions about size, temperature, brightness, and age from this one graph.

Focus Questions

How does our sun compare with other stars? Is it big or small? Bright or dim compared to other stars?

Duration

One class session

Materials

- Templates of stars:
  http://www.middleschoolscience.com/startemplates.pdf
  Atlas URL:
- Large magnetic whiteboard or similar tool
- Magnetic tape or regular tape
- Colored pencils or markers to color stars
- H-R diagram worksheet:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/H-R%20Diagram%20Worksheet.doc

Teacher Preparation

1. Prepare star cut-outs from templates. Teacher may want to laminate them and use magnetic tape on the back if using a magnetic whiteboard. Otherwise, regular or duct tape will work on the back of the stars. You may want to make round stars rather than the pointy ones on the website.
2. Draw the axes of the H-R diagram on the whiteboard. Plot temperature on the x-axis and brightness on the y-axis. The increments will not increase linearly. Consult a reliable H-R diagram to get a sense of the scale.

Classroom Procedure

1. Students will be plotting a giant relationship between the temperature of a star and its brightness. They should be familiar with direct relationships and indirect or inverse relationships on a graph.
2. Depending on the number of students, pass out the stars so everyone has at least one. If you wish, have students color their stars, and then plot them on the big graph/whiteboard.
3. When all the stars have been plotted, the relationship between brightness (luminosity) and temperature should be identified. The sun's position on the graph should also be identified.
4. As a follow-up to this activity, students can plot their own H-R diagram on the worksheet provided.

Explain

Activity 8 – Presentation: Life of a Star

Purpose
To reinforce ideas of stellar evolution and to allow students to use their talents and creativity to present their new understanding of a star's life cycle.

Activity Description
This activity will reinforce student understanding of the concepts related to the previous activities. Students will choose a type of star and present its life and death to the class. Students can use a PowerPoint and/or a notesheet for notes, but they should also use the Internet or other resources for their presentations. This activity allows for a lot of creativity with presentations.

Focus Question
What is the life cycle of a star?

Duration
Two or three class periods

Materials
- Computer access, and any materials you may wish to provide. Helpful websites:
  http://map.gsfc.nasa.gov/universe/rel_stars.html
  http://www.discoveryspace.net/up/files/04_Birth.ppt
- Instructions and rubric for grading:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Life%20of%20a%20Star.doc
- PowerPoint for notes: *Life Cycle of a Star*:
  http://oaklandk12.rubiconatlas.org/links/Earth_Systems_Science/ESS%20Unit%201/LifeCycleofAStar.ppt
- Notesheet for notes:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Life%20Cycle%20of%20a%20Star%20ws.doc

Teacher Preparation
1. You may have materials on hand for students, but usually students will come up with their own (posterboard, colored paper, scissors, etc.).
2. Make sure students check with you after picking a star and after deciding what form their presentation will take. Options for presentations include: posterboards, PowerPoints, songs, children's storybooks, cartoons, food-related presentations with a verbal component, or videos and movies. Creativity is encouraged!

Classroom Procedure

1. Introduce the project/presentation by handing out the grading rubric and showing examples of stars. Students can choose famous named stars or others but be sure they can find information on their star. Make sure they understand they must include an H-R diagram and their star's place on it in their presentation.
2. Students may take one or two class periods to work on their presentation. Working in teams of two is best, but they can work alone or in groups of no more than three. The project can also be assigned over a weekend or as an end-of-the-week project.
3. Presentations may take up to two days depending on class size. Collect the rubrics back from the student teams with their names on them and use them to assess the presentation. Rules of good audience behavior may be reviewed before and during presentations.

Elaborate

Activity 9 – Using the Sloan Digital Sky Survey (SDSS) to create an H-R diagram.

Purpose

To use a powerful collection of data to create a data-driven Hertzsprung-Russell (H-R) chart.

Activity Description

In this project, students will make their own Hertzsprung-Russell diagrams using the powerful SDSS website and data. The SDSS contains a vast collection of images and three-dimensional maps of the sky. Students and educators have access to this powerful resource. The website also has nicely developed activities for the classroom, which include paperless notebooks and Excel spreadsheets so that the lesson is self-contained on the website.

Focus Questions

How are stars classified? How is an H-R diagram made with star data?

Duration

Two to four class sessions

Materials

- Computer access for all students
- Sloan Digital Sky Survey Website: http://cas.sdss.org/dr7/en/proj/advanced/hr/

Teacher Preparation

1. Review the entire activity in advance, using the online graphing or Excel program to record data. You will want to decide of how far you'd like to go in the activity. There are several stopping points; depth will be at the teacher's discretion.
2. Decide if you want to print out information such as the Excel chart.

Classroom Procedure

1. Have students find the SDSS site with the web address provided.
2. Walk them through the first page and show them various key points. They will answer the questions in red in their notebooks. They can make the H-R diagram in Excel or on graph paper at your discretion.
3. Students will work for as long as time permits or as far as teacher directs.
4. At the end of the activity, the class should come back together and talk about the answers to the questions from their notebooks. Discussion could include comparing this real-data H-R diagram with the one they made on the whiteboard and the worksheet plot. Are they the same? What might be different about them?

Learning Cycle 3: Exploring Our Universe

Learning Cycle 3, “Exploring Our Universe,” introduces students to the big ideas of science. Teachers will develop consensus within the class using sound scientific processes, such as gathering evidence, modeling physical phenomenon, and using text for discussion and debate.

Learning Objectives

Students will be able to:

- Define and explain our current model of how the universe began based on how it looks today.
- Identify and understand the key pieces of evidence for the current model of the universe.
- Explain different conflicting theories of how the universe began and be able to debate different sides of the issues.
- Relate what we see today to how it must have looked in the past (“running the movie backwards”) to reach consensus about what the early universe was like.

Key Question: How does our current view of the universe inform our model of what the universe is and how it began?

Engage and Elicit

Activity 1 – What Do We Know About the Universe?

Purpose
To elicit ideas about what we know about the universe, and how we can study it.

Activity Description
Students often have strong ideas about how the universe might have begun and what it is, based on religion, TV programs, and stories and ideas they have heard from adults and their peers. The beginning of this unit is an excellent time to whiteboard or brainstorm ideas that students have and discuss them in an open and non-judgmental way.

Focus Question
What do we really know about the universe?

Duration
One class session

Materials
- Whiteboards or some method of sharing ideas, and markers
- Images of the night sky, galaxies, star clusters, and galaxy clusters:
  http://science.nationalgeographic.com/science/photos/galaxies-gallery/
  http://www.ugcs.caltech.edu/~yukimoon/BigBang/BigBang.htm
- PowerPoint *Expanding Universe*:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/ExpandingUniverse.ppt

Teacher Preparation
1. Gather images that represent large, medium, and smaller-scale structures in the universe. Large = galaxy clusters, galaxies. Medium = star groups, star clusters. Small = planets, comets, moon, solar system images.
2. Make sure you have enough whiteboards or posterboards for groups of 3-4 to work in small-group settings.
3. Prepare questions to probe students' thinking on their understanding of what comprises the universe, such as "Can you think of anything that is not part of the universe" or "What do you think the edge of the universe is like," or start by having them organize the objects you have available.
4. Plan for small groups of 3-4 to use their whiteboards to generate ideas about the universe, including what we really know about it and what it contains. After group sharing and the teacher occasionally checking in, hold a whole-group discussion and catalog student understanding on a number of key concepts relevant to this unit. The discussion has the potential to be emotional, and it's important to set some ground rules. Suggestions for discussion rules: Listen while others are talking rather than just wait to speak. Raise your hand and wait to be called on. Avoid statements such as "That's wrong!" or "That's dumb!".

Classroom Procedure

1. Begin by introducing the idea of humans' search for what comprises the universe and how it began. The PowerPoint linked above can be used as a whole or in parts to introduce ancient ideas of the universe.
2. Allow 10 or 15 minutes for students to explore and discuss ideas about their understanding of what comprises the universe and how it came about. Suggest they use drawings and diagrams in their explanations. Each student can use a corner of their whiteboard for their own interpretation, but they all should contribute to a larger central image or group of words to describe their ideas of the universe.
3. Prompt students to share their stories with you as you walk around the room. You may want to help them bring out their ideas so they can clarify them. Sometimes students have trouble putting their thoughts into words, especially if the thoughts are vague. Drawings can help with that.
4. Bring the whole group together to share the whiteboards but direct the conversation so that it emphasizes student thought about the universe and what we know it contains. Rather than correcting their thoughts, allow students to debate with one another (see suggestions in Teacher Prep for discussion).
5. Record some of the students' notions on a class whiteboard. See if the class can come to a consensus about their story of the universe. This activity can also be done as a closure assessment to the cycle to compare and contrast their pre- and post-cycle ideas.

Explore

Activity 2 – A Cosmic Survey

Purpose
To introduce the concepts of the structure and evolution of the universe.

Activity Description
Many people, adults and students alike, are familiar with the names of objects in space, but they have an incomplete mental model of where those objects are positioned in space, their relative size and scale, and how they fit into the cosmic scheme of things. Understanding the sizes and distances of celestial objects can be tricky because in our everyday experience the stars all seem the same distance away, and the moon can appear close or far away depending on whether you observe it near the horizon or higher in the sky. Most people's knowledge of dim and distant objects such as nebulae and galaxies comes mainly from images in books, where all the images are about the same size with no indication of scale.

In this activity, a three-part questionnaire launches students on discussions about where objects in space are located, and when they formed. By physically manipulating images of objects in space, students represent their own mental models of space and time.

As the teacher leads discussions with students, it's important to keep in mind that ideas and insights about the three-dimensional organization of the universe develop gradually. Getting the "right answer" is not as important as developing critical thinking skills from confronting questions that arise as students struggle with their mental models of the universe.

This survey can serve as a great assessment activity for teachers to find out how students think about the universe, and it can be used to help design follow-up activities to improve their understanding.

Focus Question
What are your ideas about the universe?

Duration
One class session

Materials
- Cosmic Survey: Teacher notes, Student Questions, Images. https://www.cfa.harvard.edu/seuforum/CosmicSurvey/survey.htm
- Prints and copies of the cosmic survey images, either large or small, from the PDF link.

Teacher Preparation
1. Print and make enough copies of the cosmic survey images for teams or small groups to work on. This activity is the first one in the PDF link, though there are other great activities in it as well. You will have to cut them out individually. They do not need to be in color.

2. Print and copy the three student worksheets for the survey called “How Big?” “How Far?” and “How Old?”
3. Read the information on the scale and discussions to have with the class.

Classroom Procedure

Part 1: What are your ideas?

1. Hand out copies of the three data sheets and the sets of seven images. Have students cut the images apart so they can physically manipulate them as they fill out their data sheets. They should answer the survey questions in the following order: How Big? How Far? How Old? (This order represents increasing levels of conceptual difficulty for most students.) Collect the students’ papers so you can look over their ideas.
2. Organize the class into discussion groups of 3-5 students. Give each group a set of survey data sheets. Explain that each team is to discuss the three survey questions and come to an agreement, if possible, on the best order of images for each question. One member of each team should record questions that arise as they order the images.
3. Circulate among the groups of students, encouraging them to discuss any disagreements fully and to write down arguments in support of their answers.

Part 2: Discussion

1. Lead the class in a discussion about the three different survey questions. Play the role of moderator, requiring each group to explain why they chose that order. (Ensure that students are also comfortable saying, “We really didn’t know about these objects.”) See the discussion notes for “correct” answers and frequent student ideas.
2. After discussing each question, poll the students on the alternative orders of images suggested. Do not announce the correct order at this time; students should be encouraged to think for themselves.
3. After obtaining a class consensus on all three questions, let students know the correct answers and observations of astronomers.
4. Try this activity again with your students after a visit to the Cosmic Questions exhibit or as a post-astronomy unit assessment to see whether their ideas and understanding have changed.

Explore

Activity 3 – What Does Starlight Tell Us?

Purpose

To identify different elements by their spectral lines, and to interpret motion from spectral line shifting.

Activity Description

This lab activity introduces students to spectral analysis by using gas tubes and diffraction gratings or spectroscopes. If students have already been exposed to the gas tubes in chemistry, the teacher can focus more on the idea that the shifted spectral lines indicates motion. Spectral anaylsis has been extremely useful in astronomy, since most of the information we gain from the cosmos comes in the form of electromagnetic radiation. When students learn to "read" this information, they can begin to understand how we know what stars are made of and how they move. In the first part, students will view the glowing gases and their spectra and draw them. By drawing them, they will begin to be able to identify the spectral fingerprints of different gases. Then they will learn about how motion changes spectra, the ways it changes, and what it indicates about motion.

Focus Question

What can we learn from starlight?

Duration

Two class sessions

Materials

- Set of gas tubes and power supply from a science supply store (or Phet simulations)
- Class set of diffraction gratings or spectroscopes
  https://phet.colorado.edu/en/simulation/discharge-lamps
  https://phet.colorado.edu/sims/blackbody-spectrum/blackbody-spectrum_en.html
- Student notebooks
- Colored pencils
- Two Slinkys, or as many as you can acquire for the class
- PowerPoint from previous lesson which contains material pertinent to this lesson.
- PowerPoint with spectra to be identified:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Spectroscopy%20lab.ppt
- Lab document:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Spectroscopy%20Lab.doc
- Spectra Practice worksheet:
  http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Spectra%20Practice%20WS.doc
- Short video of Doppler shift with sound and light:
  http://science.discovery.com/videos/time-doppler-effect.html
- Video of students modeling redshift and blueshift:
  http://www.nationalstemcentre.org.uk/elibrary/resource/5408/redshift

Teacher Preparation

Day One

1. Have the gas tubes and diffraction gratings/spectroscopes ready for the class.
2. Make sure the room can get fairly dark, and plan to arrange the students so they are close enough to the glowing gas tubes to be able see the spectra.
3. Have the worksheet for the lab on hand for students.
4. The PowerPoint can be used as a check or formative assessment as students try to identify the spectra from what they have seen in lab.

Day Two

5. Use Slinkys to demonstrate stretching and compression of light waves.
6. Use Spectra Practice worksheet to review Day One lesson and move on to motion. Make a copy of the worksheet for each student.

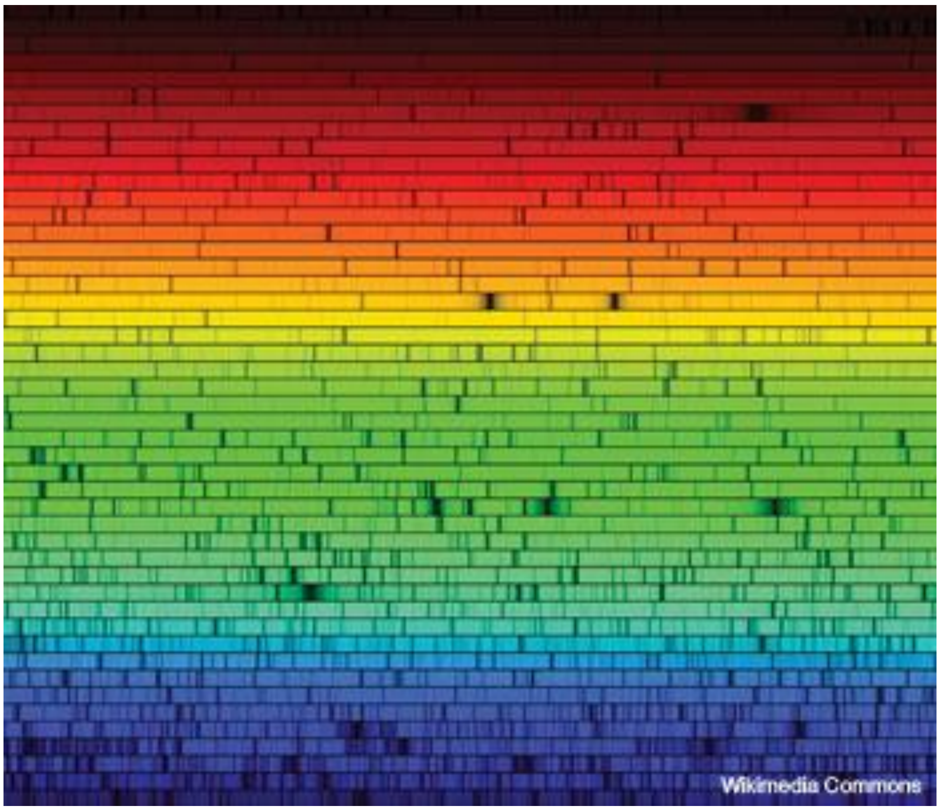
Classroom Procedure

1. Introduce the idea that more information can be gained from light than just brightness. Students will be familiar with the rainbow, so remind them that the colors of visible light are ROY G BV and that each color has a different wavelength, red being the longest and violet the shortest of visible light wavelengths.
2. Have students look at the lights in the room with the spectroscope. Follow the worksheet for the order of light sources. Teacher may adapt the lab to fit what is on hand.
3. Have students use colored pencils to draw spectral lines at the corresponding wavelengths in their notebooks or on the lab sheet. They can draw boxes and then use colored pencils to draw spectral lines.
4. The teacher may use discretion for which or how many gases to use, but hydrogen, helium, neon, argon, and mercury vapor are usually easy to see and draw.
5. Once gas tubes are shown and drawn, you may use some spectra in the PowerPoint or with the actual gas tubes to quiz the students to identify the elements in an informal game.
6. During the next class session, use Slinkys to represent light waves. Have three students stand in a line at the front of the class facing to one side. The student in the middle will hold both Slinkys, one in front and one behind. The student in front of him will take the end of the Slinky and walk a few steps away so the Slinky is moderately stretched, and the student behind will do the same thing, so the three students are equidistant and the Slinkys are stretched between them in a line. The two end students will remain stationary while the middle student starts moving toward the student in front of him, slowly so the class can see that the slinky in front is less stretched, and the one behind is more stretched. Show videos to help clarify concepts.
7. Have the class predict what will happen to the light that was stretched versus the light that was compressed. If they don’t make the connection, prompt them to remember which color has longer wavelengths versus shorter. You can introduce the idea of “redshift” versus “blueshift” when looking at spectra from stars and galaxies. Students will often confuse the idea that when spectral lines are shifted to the left or right (red or blue end of the spectrum) it means the star or galaxy is literally moving to the right or left. Be sure to

reinforce that the motion is either toward or away from the viewer. Refer back to the Slinky activity or have students repeat it in small groups.

8. If time permits, show students actual spectral data and have them identify motion in their notebooks.

Spectra of the Sun:



Explore

Activity 4 – Analyzing the Spectra of Galaxies

Purpose
To categorize and identify spectra from many different galaxies with the intent of understanding the general motion of galaxies.

Activity Description
Once students have been introduced to the information that spectra can give us, they will be ready to interpret spectral data and to draw some conclusions about the data. By using actual data in an elegant interactive project called the Sloan Digital Sky Survey (SDSS), students will be given many spectra to analyze and classify. They will keep track of the spectra and analyze possible motion in their notebooks and come to a conclusion about the general motion of galaxies on their own.

Focus Question
How can we use observable spectra from galaxies to understand their motion?

Duration
One class session

Materials
- Spectra: gather various galactic spectra from the website Sloan Digital Sky Survey (You can either have students work on the website on computers or print off enough for the class to use without computers)
- Actual Spectra of stars and galaxies from the Sloan Digital Sky Survey: http://cas.sdss.org/dr3/en/proj/basic/universe/redshifts.asp
- Student notebooks to record results

Teacher Preparation
1. If using the online Sloan Digital Sky Survey, familiarize yourself with how it works and how to get students to the spectra. Take some time to explore the website; it is rich and can be time consuming to explore. You may want to start here: http://cas.sdss.org/dr3/en/proj/teachers/basic/galaxies/.
2. If using printed spectra, number them and have enough copies so that each small group of students has at least 10 galaxies to classify and study.
3. Have a reference available, perhaps in the front of the room, to remind students of the difference between redshift motion and blueshift.

Classroom Procedure
1. Introduce the activity to the students with a brief overview and explanation:
   - Explain the difference between redshift and blueshift, and have the students recall what motion each indicates.
   - Introduce the SDSS website and go to the link you provide (given above).

- Remind students to keep track of which galaxy they are studying and have them compile the information in their notebooks. They will want to make a table. Example:

Galaxy	Blue shift	Red shift	Motion
1. Andromeda	x		toward
2. Whirlpool		x	away

2. Students will draw a conclusion based on their data of the general motion of the observed galaxies and their spectral line shifts. They will record this conclusion in their notebooks.
3. Have students draw in their notebooks what the motion? might look like. For example they might want to sketch our galaxy, the Milky Way, in the center of the page, and then draw other galaxies relative to the Milky Way, with arrows indicating their motion.
4. Have the students draw their sketches on the whiteboard and share and compare them as a class.

Explore

Activity 5 – Galaxy Crash Lab

Purpose
To model the interaction of galaxies.

Activity Description
As with many objects in space, real-time study of galaxies is limited by the enormous lifetimes and distances of these celestial objects. In this activity, students will use a powerful computer program to collide galaxies to study their gravitational and frictional interactions. They will need to use previously attained skills such as graph analysis, interpolation, and estimation in this activity, and they will be learning vocabulary as they read and research at the beginning of the activity.

Focus Question
What happens when galaxies collide?

Duration
Two class sessions

Materials
- Website for *Galaxy Crash*: http://burro.cwru.edu/JavaLab/GalCrashWeb/
- *Galaxy Crash* Lab: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Galaxy%20Crash%20Lab.doc

Teacher Preparation
1. Ensure Internet access for students. They can work in pairs or alone.
2. Make copies of the lab for each lab group.
3. Review the website thoroughly. The introductory information explains the phenomenon of galactic interaction in detail. The applet is easy to use but users will need to spend a few minutes familiarizing themselves with the different parameters available and what they mean.

Classroom Procedure
1. Students will begin by answering questions about vocabulary and artifacts of collision.
2. Have them enter the simulation where they will work through the instructions to simulate different parameters in galactic collision. Usually at this point students become involved in the pretty outcomes of collision and tend to want to play. Keep them on track.
3. As students go through the lab, they may have questions about different parameters. They may need help with velocity and time parameters. They can keep track of the pink and blue graphs for information about passing time and relative velocities. This task requires reading graphs, interpolation, and estimation.

Explain

Activity 6 – Understanding the Cosmic Microwave Background (CMB)

Purpose
To understand that the universe has an average temperature, and that the temperature is a measure of how much energy the universe has over its volume. Temperature provides a line of evidence for the expanding universe.

Activity Description
Students are always curious about how the universe began and how it is changing. The Cosmic Microwave Background (CMB) is pivotal to exploring those questions. Students will be able to describe how the CMB is evidence of the Big Bang Theory and that the slight variations in temperature (color) are the seeds of the large-scale structures that evolved over cosmic time. Students will be able to state the rule that decreasing temperature increases density and that denser areas have larger gravity and therefore attract more matter. Students will also be able to describe that these low-temperature, high-density areas in the CMB are the starting points of structure formation in the universe.

Focus Question
What is the Cosmic Microwave Background and what does it tell us about the universe?

Duration
One or two class sessions

Materials
- Student notebooks
- "Understanding the Cosmic Microwave Background" activity http://bccp.berkeley.edu/o/Academy/workshop08/08%20PDFs/CMB_Kerrigan.pdf
- Several student worksheets to be copied from the PDF link above.
- Alternative CMB activity from American Museum of Natural History. Video near top of page is excellent. PDF file of activity is posted at the bottom of the page. http://www.amnh.org/explore/science-bulletins/astro/documentaries/the-cmb-a-new-view-from-the-south-pole/educator-resources/classroom-discussion-activity/

Teacher Preparation
1. Read the teacher background materials and lesson plan from the PDF to familiarize yourself with the lessons.
2. Make sure to have all materials printed and copied.
3. For one part of the lesson, students will need access to the website listed above. They can use laptops or smartphones for this. If the Internet is not available, you can print out copies of the text for students to read or show it on a larger screen and have them take turns reading out loud.

Classroom Procedure
1. Distribute the document to students.
2. Follow the classroom procedures listed in the PDF.

Explain

Activity 7 – The Expanding Rubberverse

Purpose
To model the dynamics of the expanding universe with a rubber band.

Activity Description
Students will model the expanding universe using materials at hand. They will draw galaxies on thick rubber bands and measure the unstretched versus stretched distances between the galaxies. This is a model of the expanding universe. Students will make a graph that shows the relationship between distance and speed of galaxies, and from this graph will draw conclusions about the expansion of the universe.

Focus Question
What are some possible ways to model the universe based on scientific evidence?

Duration
One class session

Materials
- Thick rubber bands, as thick (wide) as you can find
- Felt-tip pens for making galaxies
- Lab worksheet *The Expanding Rubberverse*: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/The%20Expanding%20Rubberverse.doc
- Rulers, stopwatch

Teacher Preparation
1. Review the following website for a step-by-step overview of the activity: http://cas.sdss.org/dr7/en/proj/basic/universe/expanding.asp.
2. Gather materials.
3. Set up material stations in the classroom so that small groups can use materials to develop their models.

Classroom Procedure
1. Begin by passing out the rubber bands.
2. Students will use rulers to measure the unstretched distance between the galaxies drawn on their rubber bands, and then they will measure the stretched distance.
3. Challenge students to time their stretching, but if it's too hard, they can just use a time of two seconds in their equations.
4. Have students fill out the questions in the lab.
5. As they work on the lab, ask students questions about the wisdom of using a drawn galaxy on the rubber band. Do galaxies expand as the universe expands? (No!) What might be a better model? Thumbtacks? Paper clips? Staples? Students can come up with some ideas and try them if you have extra rubber bands.

Elaborate

Activity 8 – The Universe Project

Purpose
To investigate current models and updates of the Big Bang Theory.

Activity Description
Students research current evidence of what we know about the universe. The ideas they uncover should include dark energy, dark matter, the Inflation Theory, and the idea that the universe is expanding faster as time goes by. Students create a display or exhibit to show what they have learned and what is yet to be discovered.

Focus Question
What evidence supports the current theory of how the universe began?

Duration
Four class sessions

Materials
- Display and exhibit-making materials
- Rubric for Universe Project: http://oaklandk12.rubiconatlas.org/links/ESS%20-%20Earth's%20Place%20in%20the%20Universe/Universe%20Project.doc
- Websites on cosmology, such as:
  http://www.umich.edu/~gs265/bigbang.htm
  http://cosmology.berkeley.edu/Education/IUP/Big_Bang_Primer.html
  http://map.gsfc.nasa.gov/universe/bb_cosmo.html
- WMAP Universe (the article is an excellent description of the structure of the universe): http://oaklandk12.rubiconatlas.org/links/Earth_Systems_Science/ESS%20Unit%201/WMAP_Universe.pdf

Teacher Preparation
1. Secure a spot in the school for a display/exhibit, such as a display window, bulletin board, or a space in the library or a classroom.
2. Develop a process for student teams to determine what parts of the story they will research. Give some guidelines and examples of what the exhibit/display might include or the form it might take. The above rubric might help in this process.
3. Set criteria/rubric for student posters/displays or use the one above. Some elements worth considering: History of Big Bang Theory, Elements of the Theory, Model of the Theory, Problems with the Theory, New evidence/updates on the Theory. A flowchart or map of the exhibit would be very helpful in the creation process, so students should check with their teacher and show their ideas before going too far into project.
4. Schedule a computer lab or gather resources for the student research. Direct them to the websites above and provide the addresses for them.

5. Gather exhibit-making materials such as posterboard, markers, colored paper and scissors, glue, and some the materials from the modeling session, etc.
6. Determine a method for a class display session. Perhaps other science classes could visit the display, like a mini science fair. Or perhaps the school offers a display area that can be used to display high-quality projects. Students may assemble the whole exhibit in the classroom, arranging by topic so that it becomes a cohesive whole. Then they can take it to the exhibit area and re-assemble.

Classroom Procedure

1. Present the project to the students by describing the product and processes.
2. Provide two class periods for students to conduct their research. Provide a day for students to assemble their display elements, and another for the making of the exhibit. The project could also be done as a home assignment.

Oakland Schools Scope on Atlas Rubicon Curriculum Manager
http://oaklandk12.rubiconatlas.org/public

Oakland Schools: http://www.oakland.k12.mi.us/