JOURNAL OF THE STARS

Performance Standard 12F/11A.G

Students will apply the processes of scientific inquiry to explore the galaxy accordingly:

- *Knowledge*: Identify the principles and variables in the star life cycle.
- *Application*: Design a graphic representation of the variables associated with the star life cycle.
- *Communication*: Explain the comparisons of graphic displays to generate alternative explanations for study.

Procedures

1. ***In order to know and apply the concepts that describe the composition and structure of the universe and Earth's place in it (12F), the concepts, principles and processes of scientific inquiry (11A) and apply the accepted practices of science (13A),*** students should experience sufficient learning opportunities to develop the following:
   - Generate questions and strategies to test astronomic concepts using critical and creative thinking.
   - Generate an if-then, cause-and-effect premise about star life cycles.
   - Differentiate qualitative and quantitative data and their applicability.
   - Use conceptual/mathematical or physical models.
   - Review research about life cycle, age, composition and energy output of stars.
   - Determine choice of variables and data-collecting format.
   - Conduct modeling investigation.
   - Collect and manipulate data from investigation.
   - Observe trends within data sets.
   - Communicate the findings to explain the life cycle correlations.
   - Generate additional questions to investigate about the life cycle of galactic components.

   Note to teacher: This activity relates to knowledge associated with standard 12F, while addressing the performance descriptors for stage G within standard 11A. Applying scientific habits of mind in standard 13A are foundational.
2. Have students review and discuss the assessment task and how the rubric will be used to evaluate their work.
3. Introduce the way stars come into being and produce energy by asking students why stars shine. Ask if all stars are the same. Generate a list of variables between stars (mass, color, heat, life cycle, etc.). The attached activity illustrates how these differences in stars' characteristics are related.
4. Pass out balloons to students so that 45% have red, 25% yellow, 15% white and 10% blue and 5% dark blue/purple, telling them the approximate mass of their star as they are receiving them. (In a class of 20, this means 9 red, 5 yellow, 3 white, 2 light blue and 1 dark blue or purple). Read the attached timeline "script" for "Life Cycles of the Stars" as directions for each kind of star. At each step, read aloud the current age of the stars and the directions for each type of star. Chart results on the overhead. Students must record the appropriate data for their assigned star on the provided tables. It is important to emphasize that students should record their data accurately. Students will need to plot their data from their table on a line graph. The challenge of this activity is to determine which variables can be graphed and how. They may decide to research resources which provide information about the temperatures, composition, relative volumes, etc. Students should determine groupings for different variable combinations, such as Color vs. Time, Color vs. Volume, Color vs. Temperature, Mass vs. Temperatures, Volumes vs. Temperatures, etc. Within each group, have students create transparencies which display their combinations. Generalize the results of all of the investigations and the final line graphs. Generate additional questions which can be researched, such as: Which star died first and last, the fate of yellow stars like our Sun, how rare is becoming a black hole, what will become of the stuff in the recycle box, etc. An important objective to realize is that this is the way that scientists really work---they may not know what the questions are or what the data represents or how it correlates to other data. Emphasize scientist strategies to use critical and creative thinking.
5. Evaluate each student's work using the Science Rubric as follows and add the scores to determine the performance level:
   Knowledge: The identification of the variables and principles of star life cycles was complete and accurate.
   Application: The graphic representation of selected variables was accurate and complete.
   Communication: The comparisons between graphic displays and ensuing questions were well-reasoned and accurate.

Examples of Student Work not available

Time Requirements
- 1 class period for initial questions and modeling activity; 1 class period for graphing; 1 class period for graphing comparisons and after-questions.

Life Cycle of Stars Activity by Kyle and Heather Cudworth, University of Chicago, Yerkes Observatory, Williams Bay, WI. Permission granted for non commercial reproduction.

Resources
- Red, Yellow, White, Blue and Dark Blue/Purple balloons
- White, Black and Blue beads
- Pin to pop balloons
- Red markers for writing on balloons
- Recycle box for popped balloons
- Life Cycle of Stars Information Chart (provided)

Preparation
Place 1 white bead inside each yellow and white balloon, 1 blue bead inside each blue balloon, 1 black bead inside each dark blue/purple balloon

Life Cycles of Stars

Age of Stars	Red Balloons	Yellow Balloons	White Balloons	Light Blue Balloons	Dark Blue/Purple
	0.4 Solar Mass (2/5 times the mass of the sun**)** **Red Stars**	**1 Solar Mass** The mass of the sun **Yellow Stars**	**3 Solar Masses** (3 times the mass of the sun): **White Stars**	**10 Solar Masses** (10 times the mass of the sun) **Blue Stars**	**40 Solar Masses** (40 times the mass of the sun): **Very Blue Stars**
START	Blow up the star to about 3 inches diameter	Blow up the star to about 3 inches diameter	Blow up the star to about 3 inches diameter	Blow up the star to about 3 inches diameter	Blow up the star to about 3 inches diameter
1 Million Years	Wait – do not change size of balloon	Wait – do not change size of balloon	Wait – do not change size of balloon	Blow slightly More air into the balloon	Blow up balloon rapidly and then pop it: **Supernova!** Bead inside becomes a **black hole.** Put balloon pieces into recycle box**.**

30 Million Years	Wait	Wait	Blow slightly more air into the balloon	Blow up balloon rapidly and then pop it: **Supernova!** Bead inside becomes a neutron star. Put balloon pieces into recycle box.	Still a black hole.
500 Million Years	Wait	Wait (Note that Planets are forming)	Blow more air into balloon and color it red. Explain that gas is rapidly flowing off the outer surface of the star but star grows in size.	Still a Neutron Star	Still a Black Hole
1 Billion Years	Wait	Blow slightly more air into the balloon	Blow more into balloon. Deflate balloon and cut up the pieces (these are a planetary nebula). Bead inside becomes a **white dwarf**.	Still a Neutron Star	Still a Black Hole

8 Billion Years	Wait	Blow slightly more air into the balloon.	Still a white dwarf. Put nebula pieces in the recycle box.	Still a Neutron Star	Still a Black Hole
10 Billion Years	Wait	Blow more air into balloon and color it red. Deflate balloon and cut up the pieces) these are a planetary nebula) Bead inside becomes a **white dwarf**.	Still a white dwarf. Getting cooler.	Still a Neutron Star	Still a Black Hole
15 Billion Years. Current estimate of the age of the Universe)	Wait	Still a white dwarf. Put nebula pieces in the recycle box	Still a white dwarf. Getting cooler.	Still a Neutron Star	Still a Black Hole