MYSTAR

THE EDUCATOR'S GUIDE

Draft, 11.02.10
James Harold, harold@spacescience.org

LEARNING STELLAR AND PLANETARY EVOLUTION WITH YOUR OWN PERSONAL SOLAR SYSTEM

Summary: MyStar is an online, multi-user, stellar and planetary evolution game. The game is closely aligned with the national science standards and is designed to introduce visitors to the basic concepts of stellar and planetary evolution: stars are born, live, and die, and their lives are controlled by their initial mass. Players can form their own star, build planets, attempt to initiate life, and observe as the system evolves in scaled real time (a million years per minute). Over the course of days or weeks, players can receive email or text message prompts as their star and accompanying planetary system enter new phases. Perhaps life will arise; perhaps not. If the system includes a giant planet it might clear the debris from the solar system and save the inhabitants from destruction by bombardment or, if positioned poorly, the giant planet might simply eject the terrestrial planet. In the end, the system will meet a fate determined by the mass of the star: either the planets will be overwhelmed by the envelope of the red giant, or be obliterated by the searing heat and gamma ray blast of a supernova.

Learning Goals: Depending on the amount of time spent in the game, students can discover that:

- The galaxy has "habitable zones" where planetary formation and/or life are more likely;
- Stars are born and die, and their life cycle is controlled by their initial mass;
- The time scale for stellar evolution is on the order of billions of years;
- Solar systems have "habitable zones", inside which planets can support life;
- Life begins to form relatively quickly after the early "heavy bombardment" period, but takes billions of years to reach complex stages;
- Various events can interfere with the progress of life, including stellar encounters, asteroid impacts, and "gamma ray bursters".

Game Play: The game framework uses the "sporadic play" model typical of some Facebook games and incorporates a currency system that lets players earn funds to be invested in more stars, the seeding of life, etc., while they attempt to complete various "feats".

This takes time: It's important to note that this is not a quick game that can be played in a single session. It will take at least several days to successfully generate life on a planet. It does not require a significant amount of actual playing time (a few minutes a day is sufficient), but it does take long periods of game time for the systems to evolve.

Target Age: The learning goals for the activity map most closely to late middle school, early high school standards concerning the structure and evolution of the solar system and galaxy.

Suggested Use: Given the time scales of the game, this is probably most appropriate as an at-home assignment that spans the time when the matching concepts will be covered in class.

Credits, Funding: The game was designed by James Harold, Dean Hines, and Evaldas Vidugiris at the Space Science Institute (www.spacescience.org). The project was funded through the Space Telescope Science Institute (STScI) and the Space Science Institute's (SSI's) "*Alien Earths*" project.

KEY GAME ELEMENTS: BUILD STARS. CREATE LIFE. PROFIT!

Persistency: the game runs on a server in the background so that systems can evolve while the player is offline.

Time Scales: Events occur on a timescale of one million years per minute. Giant worlds can be built in a few minutes; terrestrial worlds a few minutes after that. Single cell life can arise within an hour, but complex life can require several hours. Star lifetimes can range from seconds (for supergiants) to weeks (for sun-like stars).

Currency: Players begin with enough Starbux to create a star and a world. Each star generates income over time: stars with planets earn more; if the planets have life they earn even more.

Achievements: The game encourages certain actions through "Feats": accomplishing each task earns badges and titles.

Customization: Planets can be patterned and colored. The color pallets are a function of the planet type and its distance from the sun (e.g., distant giant worlds will be shades of methane blue).

Relation to Standards and Benchmarkds: the structure of the game lets us directly address stellar lifecycles; their dependence on initial mass; their relative timescales; as well as some conditions relating to life including both galactic and stellar "habitable zones." See Appendix 1 for a summary of the relevant Project 2061 Benchmarks.

DETAILS, DETAILS

Players begin with a small number of Starbux, the game currency. This is sufficient to build a star which can begin the process of generating currency. You can expect it to take at least a day before you can build up enough currency to start a star with a terrestrial planet.

WHERE TO BUILD

The galaxy, like solar systems, has "habitable zones". Some areas lack the metals necessary to build stars and planets. Others are so dense with stars that the ensuing radiation, combined with the odds of local supernovas, gamma rays bursters, or simply near collisions, will make it difficult for life to form and survive.

WHAT TO BUILD: STARS

A key learning goal of the game is that stars have life cycles which are determined primarily by their initial mass. Players can choose the mass of their star: large stars will supernova quickly; small stars will live long enough to support planets.

WHAT TO BUILD: PLANETS

Opportunities to build planets come in specific windows during the life of the star. Giant worlds come first: these can't support life, but they can help shield planets from asteroids and comets that could lead to extinction events. Terrestrial planets come next: these can support life, but only if they're placed in the star's habitable zone, which is a function of the star mass. Note that the game checks for solar system stability: if a giant world is placed in the habitable zone it's unlikely you'll be able to place a terrestrial planet there as well.

LIFE

The window for generating life only appears after the "heavy bombardment period" for the system has ended; prior to that the planets are regularly sterilized by impacts. Life is broken up in to multiple stages, and each must be successfully completed in turn. The difficulty of each stage is modeled after our understanding of the evolution of life on Earth: simple life appeared very early on, immediately (on geologic time scales) after the end of the bombardment. The transition to multi-cellular life took much longer, and which point life evolved rapidly.

NOTHING LASTS FOREVER

Eventually stars will reach end of life, with the ultimate fate depending on the stars initial mass. But players can continue to build as many stars as they like, assuming they have sufficient funds.

QUESTIONS?

If you have any comments, questions, or suggestions, feel free to contact James Harold at harold@spacescience.org. Thanks!

APPENDIX: SUMMARY OF THE "UNIVERSE" STANDARDS FROM THE 2061 BENCHMARKS

http://www.project2061.org/publications/bsl/online/index.php?chapter=4

BY THE END OF THE 2ND GRADE, STUDENTS SHOULD KNOW THAT

- There are more stars in the sky than anyone can easily count, but they are not scattered evenly, and they are not all the same in brightness or color. 4A/P1
- The sun can be seen only in the daytime, but the moon can be seen sometimes at night and sometimes during the day. The sun, moon, and stars all appear to move slowly across the sky. 4A/P2
- The moon looks a little different every day but looks the same again about every four weeks. 4A/P3

BY THE END OF THE 5TH GRADE, STUDENTS SHOULD KNOW THAT

- The patterns of stars in the sky stay the same, although they appear to move across the sky nightly, and different stars can be seen in different seasons. 4A/E1
- Telescopes magnify the appearance of some distant objects in the sky, including the moon and the planets. The number of stars that can be seen through telescopes is dramatically greater than can be seen by the unaided eye. 4A/E2
- Planets change their positions against the background of stars. 4A/E3
- The earth is one of several planets that orbit the sun, and the moon orbits around the earth. 4A/E4
- Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. 4A/E5
- A large light source at a great distance looks like a small light source that is much closer. 4A/E6** (BSL)

BY THE END OF THE 8TH GRADE, STUDENTS SHOULD KNOW THAT

- The sun is a medium-sized star located near the edge of a disc-shaped galaxy of stars, part of which can be seen as a glowing band of light that spans the sky on a very clear night. 4A/M1a
- The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. 4A/M1bc
- The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. 4A/M2abc
- Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past. 4A/M2de
- Nine planets of very different size, composition, and surface features move around the sun in nearly circular orbits. Some planets have a variety of moons and even flat

rings of rock and ice particles orbiting around them. Some of these planets and moons show evidence of geologic activity. The earth is orbited by one moon, many artificial satellites, and debris. 4A/M3

BY THE END OF THE 12TH GRADE, STUDENTS SHOULD KNOW THAT

- The stars differ from each other in size, temperature, and age, but they appear to be made up of the same elements found on earth and behave according to the same physical principles. 4A/H1a
- Unlike the sun, most stars are in systems of two or more stars orbiting around one another. 4A/H1b
- On the basis of scientific evidence, the universe is estimated to be over ten billion years old. The current theory is that its entire contents expanded explosively from a hot, dense, chaotic mass. 4A/H2ab
- Stars condensed by gravity out of clouds of molecules of the lightest elements until nuclear fusion of the light elements into heavier ones began to occur. Fusion released great amounts of energy over millions of years. 4A/H2cd
- Eventually, some stars exploded, producing clouds containing heavy elements from which other stars and planets orbiting them could later condense. The process of star formation and destruction continues. 4A/H2ef
- Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and X-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle data and complicated computations to interpret them; space probes send back data and materials from remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. 4A/H3
- Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe. 4A/H4