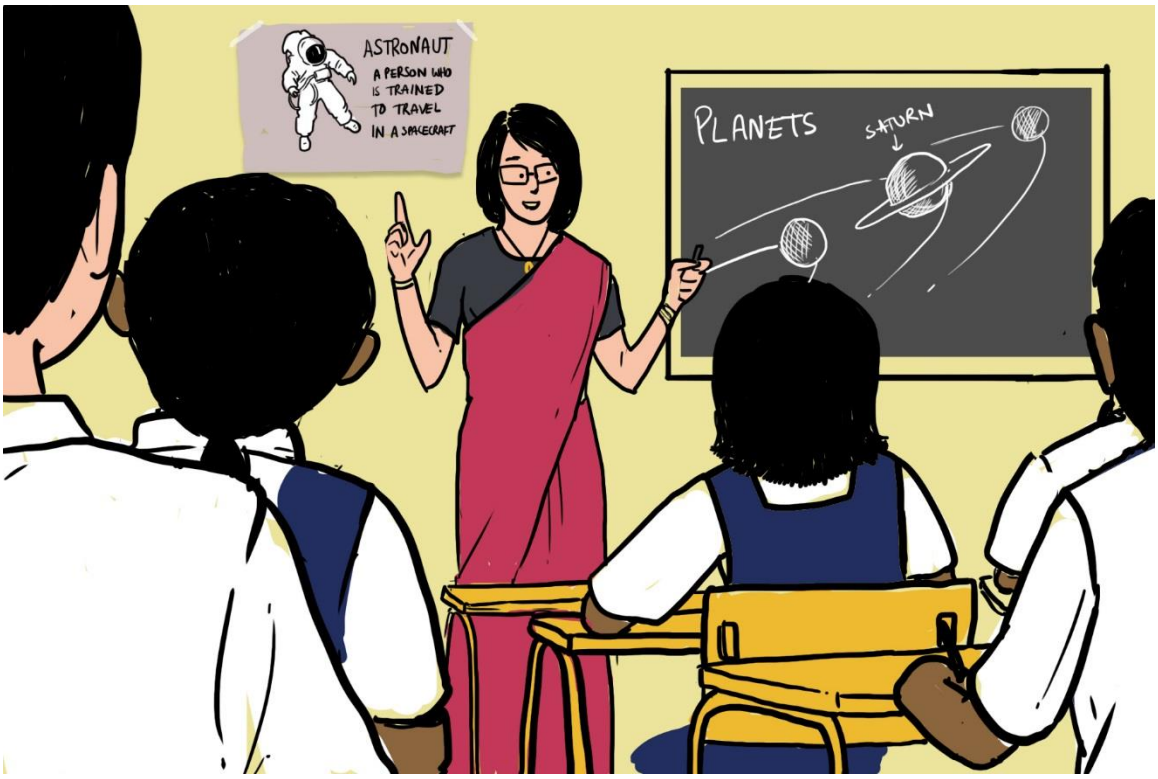
Teaching Astronomy

~ Sujata C



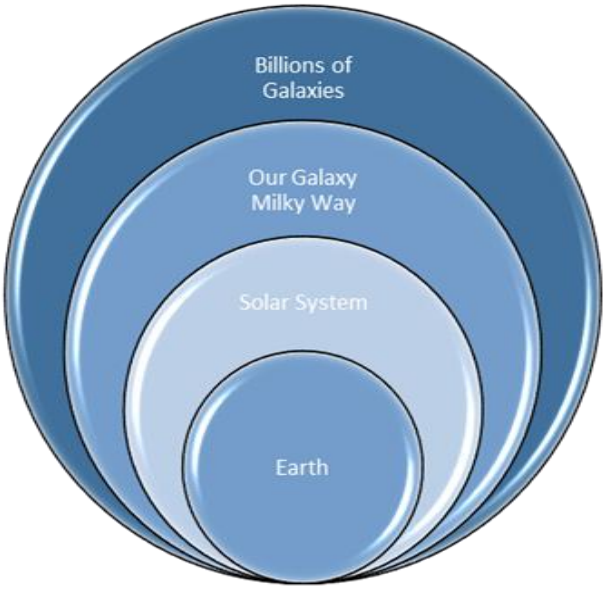
Starry nights are magical and fire our imagination. It is hard to find a person who does not get amazed by the dreamlike ambience that the night sky offers. The branch of science where we study about stars, planets, satellites, space, universe, etc., is termed as *astronomy*. It is a fascinating subject to study, but by no means an easy one to teach in school, due to its vastness and multidisciplinary nature. It makes us realise how small and insignificant we are in this enormous universe. There are at least seven to eight subjects that are closely related to astronomy.

If the teaching of astronomy remains limited to classroom lectures, students may find the concepts difficult to understand. To make it easier, it is best to supplement theoretical lectures with practical stargazing. All one needs is a dark night with a clear sky to get introduced to the stars, planets and constellations. If taught with precision at school level, it can make a lasting impact on a student's mind and pave the way for a lifelong passion or even a meaningful career in the subject.

The sun is the star closest to us. The Hubble telescope reveals that there may be more than 100 billion galaxies in the universe each with a star of its own. Astronomers have so far identified 88 constellations in the Milky Way. *Saptarshi*, *Orion the Hunter*, *Cygnus*, etc., are a few of the more popular ones. Most of us have played the game of connecting dots as children. Similarly, to identify constellations in the sky, one requires to join the stars that form a shape together. There are different cultural contexts behind the naming of the constellations. *Ursa Major* (also known as the *Great Bear*) has got its name for its similarity with a female bear. *Saptarshi*,

formed by a part of *Ursa Major*, has got its name from the seven Hindu sages, (Bhrigu, Atri, Angirasa, Vasishta, Pulastya, Pulalaha and Kratu).

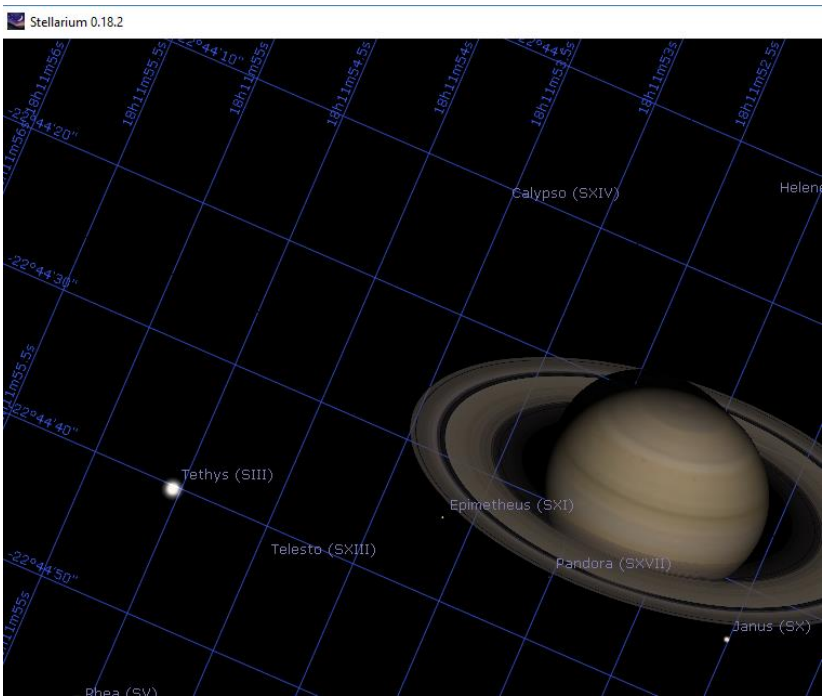
How big is the universe?



The human population on Earth is 7.7 billion but we cannot help wondering whether there is life in some other galaxy of the universe. None can deny the high probability of the existence of extra-terrestrials. It is only now that astronomers are starting to discover exoplanets beyond our solar system. NASA has sent a probe to the sun, and the Curiosity Rover[1] is discovering the secrets of Mars. There are identified land surfaces on Earth which are protected as International Dark Sky Reserve areas. They could be public or private land possessing an extraordinary quality of night-time environment suited for stargazing.

[1] https://www.express.co.uk/news/weird/1098677/alien-discovery-news-nasa-life-on-mars-object-aliens-space

Stellarium is an open source free planetarium software through which one can see the sky just as they would with a telescope.



Saturn and its rings as seen in Stellarium

Astronomy in ancient history

In ancient cultures like that of Babylon, India, Australia, Greece, etc., stargazing was regarded as a scholarly pastime. In Australia, the aboriginals were the first stargazers and astronomers. Many western star names are of Arabic origin. This is because Islamic, Egyptian and Greek astronomy merged at some point and morphed into Western astronomy. Egyptians associate constellations with gods in the sky. For them the Orion is identified with Osiris, one of the most important gods of ancient Egypt, considered as the Egyptian Lord of the Underworld, and Judge of the Dead.

Indian astronomy is as old as the Vedas. In fact it is considered a subsidiary science of the Vedas. Ancient Indian scholars studied astronomy as a science of light *jyotisa* and a science of stars *nakshtra vidya*. They wrote about the cyclical movements of the sun and moon and also put forward astronomical theories called *Vedanga Jyotisha*.

The study of astronomy gave birth to almanacs[2], calendars, clocks, seasons and different cultures. Almost every civilization has their own ways of interpreting the movements and behaviour of the sun, moons and planets.

The earliest star map, a carving of the constellation Orion is over 32,000 years old, and was discovered in 1979 in Germany. It is a tiny slice of a mammoth tusk that contains a carving of a human-like figure with arms and legs outstretched in the same pose as the stars of Orion.

The oldest accurately dated star chart appeared in ancient Egyptian astronomy in 1534 BCE. These ancient maps are proof of human curiosity about the sky and celestial bodies. However, most of them used to believe the theories written in the religious scriptures. The accepted notion in the Middle Age was that the sun rotates around the Earth. Scientists whose theories were against the religious beliefs would get prosecuted, or even burned to death. Much later, during the Age of Renaissance, scientific thought came into prominence through the hands of modern age scientists like Nicholaus Copernicus, Giordano Bruno, Galileo Galilei, Kepler, Descartes, Ptolemy, etc.

But in ancient India the science of astronomy was well advanced and the idea that the Earth is round was already established. Here astronomy was called *Khagolshastra*. In Sanskrit, *kha* means sky and *gol* means round. Khagol was the famous astronomical observatory at Nalanda, where Aryabhatta (470-550 CE) studied. This period coincides with the Bronze Age. The reason for the development of astronomy was the need to have accurate calendars, a better understanding of climate and rainfall patterns for timely sowing and choice of crops, fix the dates of seasons and festivals, navigation, calculation of time and casting of horoscopes for use in astrology. Knowledge of astronomy, particularly knowledge of the tides and the stars, was of great importance in trade because the information was necessary for crossing oceans and deserts during night time. Varahmihira was another important astronomer, mathematician and astrologer. He and his predecessors made the fundamental observations that the Earth was a sphere, and the moon and planets are lustrous not because of their own light but due to reflected sunlight.

[2] Almanac: An annual calendar containing important dates and statistical information such as astronomical data and tide tables.

Aryabhatta later explained that the Earth being round, rotates on its own axis and disproved the idea that the planet is immovable. He explained that the appearance of the sun moving from east to west is false by giving examples. One such instance was when a person travels in a boat, the trees on the shore appear to move in the opposite direction. He also gave a scientific explanation for solar and lunar eclipses. Aryabhatta's work *Aryabhattiyam* has large sections on astronomy.

Modern astronomy: Astronomers of today study computer generated data, radio waves and images obtained from remotely placed telescopes on the ground or in space. We have all seen some of the most dramatic and awe-inspiring images of the universe. These are captured by high-end telescopes in observatories that are constantly surveying the skies. Edwin Hubble, Carl Sagan and Stephen Hawking are the respectable names of the 20th century astronomy. The field of study has evolved so much that it is now sub-divided into fields like:

radio telecope

- **Stellar astronomy:** Study of supernovas, nebulae, black holes, white dwarfs and so on
- **Planetary astronomy:** Study of the life growth and death of planets, a cross-discipline field including aspects of astronomy, atmospheric science, geology, space physics, biology and chemistry
- **Solar astronomy:** Study of the sun
- **Galactic astronomy:** Study of the galaxies and stars to see at what stage of life they are in and how they will progress in future
- **Cosmology:** Study of the birth of the universe during the Big Bang and its evolution
- **Astrometry:** Branch of astronomy that measures the sizes of celestial objects, planets, etc. and makes the predictions about meteor showers, eclipses and other planetary movements

Light pollution is the bane of all sky gazers. For most urban dwellers, the stars have all but disappeared from the night sky. The sky glow from artificial lighting especially in the cities is so high that it hampers star watching. There are light pollution maps to show where the sky is dark and where it is light so that one can find ideal places for stargazing.

Astronomy and the arts: Inspiring as it is, the subject of astronomy has been explored by artists too. The ideas of Kepler, Galileo and Einstein have inspired many famous operas. Film-makers have exploited the subject with great results as aliens and life on other planets continue to sway the Hollywood imagination. Poets too are not far behind in the use of astronomy as a muse. Robert Frost was an amateur astronomer. Shakespeare was deeply influenced by astronomy while writing plays like ***Hamlet***, ***Julius Caesar***, ***King Lear***, ***Romeo and Juliet***, etc., as reflected in the following lines:

"Men at some time are masters of their fate,

The fault, dear Brutus lies not in the stars,

But in ourselves that we are underlings."

Julius Caesar, Act 1, Scene 2

Biographies of well-known astronomers form the core of literature related to astronomy. In India, it is a common practice to decorate the doorstep with star shaped *rangolis* as it is considered auspicious.

making of rangoli

Do stars have a life lesson to teach us? Stars teach us to be ever hopeful. Our feet should be on the ground but our eyes must be on the stars to negotiate the ups and downs of life. The universe is a vast and wonderful place, and while studying astronomy, we must keep in mind the broader aspects of the subject and take a cue from the words of astrophysicist Stephen Hawking: *To confine our attention to terrestrial matters would be to limit the human spirit*.

Sujata C is a writer and editor with more than thirty years of experience. She writes on children, environment, society as well as technology. She has also been a copywriter with an advertising agency for almost fifteen years.

Lesson Plan: Teaching Astronomy

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Astronomy is a very event-oriented subject and that is why its lesson plan should include experiencing eclipses, meteor showers, satellites, comets, constellations, solstices, equinoxes, full moons, blue moons, blood moons and new moons. There are many activities that students can engage in depending on their age and interest levels. Teachers can ask them to do the following:

1. Make a mobile Solar System.

2. Visit a planetarium.

M. P. Birla Planetarium in Kolkata

3. Decorate a ceiling in their home with luminous star stickers. This could be done to match a real time image.

4. Find the Indian equivalent names of Western constellations.

5. Make a telescope from an old binocular.

6. Join an astronomy club and get exposure to skygazing activities.

7. Study about the Jantar Mantars in India, and prepare a PPT about their history and uses.

8. Make a sundial from materials available at home. Take help from the following link: http://www.jantarmantar.org/learn/projects/paperModels/index.html

9. Identify all the major astronomical monuments in the world and prepare a report on any one of them.

10. Read stories from different countries about the origin of the universe and different celestial bodies. In Indian mythology, one will find stories about the formation of Saptarshi Mandal, Dhruva Tara, etc., while in Greek myths, they will find tales about constellations like the Orion, Cygnus, etc.

11. Read the poems of Robert Frost. Study about the lives and works of Varahmihir, Arybhatta, Bhaskara, Galileo, Johannes Kepler and Copernicus.

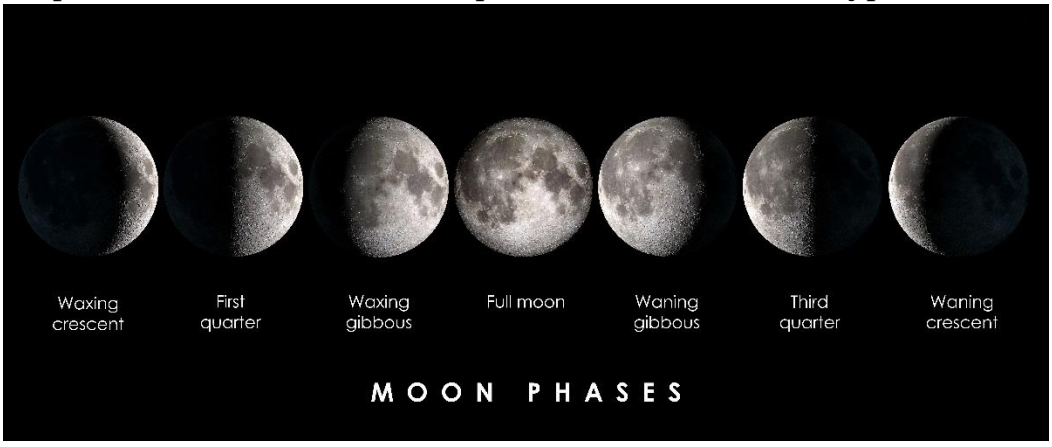
12. Research the topic of light pollution and find out its impact.

13. Watch movies like *Apollo 13*, *ET*, *Star Wars*, *Star Trek*, *Alien*, *Guardians of the Galaxy*, *Avengers: Infinity Wars*, *Avatar*, and TV series, *Wonders of the Universe* by BBC.

14. Write a poem/essay on the beauty of the night sky and its shining stars.

15. Prepare a report on ISRO's missions to the moon, *Chandrayan-1* and *Chandrayan-2*.

16. Prepare a chart on the different phases of the moon and types of full moon.



17. Gather information about astrophotography as a hobby and write an essay on it.

18. Find out locations of International Dark Sky Reserves in the world.

Teachers themselves can conduct the following activities in the classroom:

1. Organize a quiz on stars, constellations and astronomical terms and their meanings.

2. Download any one of the following apps in a smart device and demonstrate how students can identify stars and constellations through it.

    - Star Walk 2
    - SkyView
    - StarChart
    - Star Rover
    - SkyWiki
    - Starlight
    - StarTracker
    - SkEye

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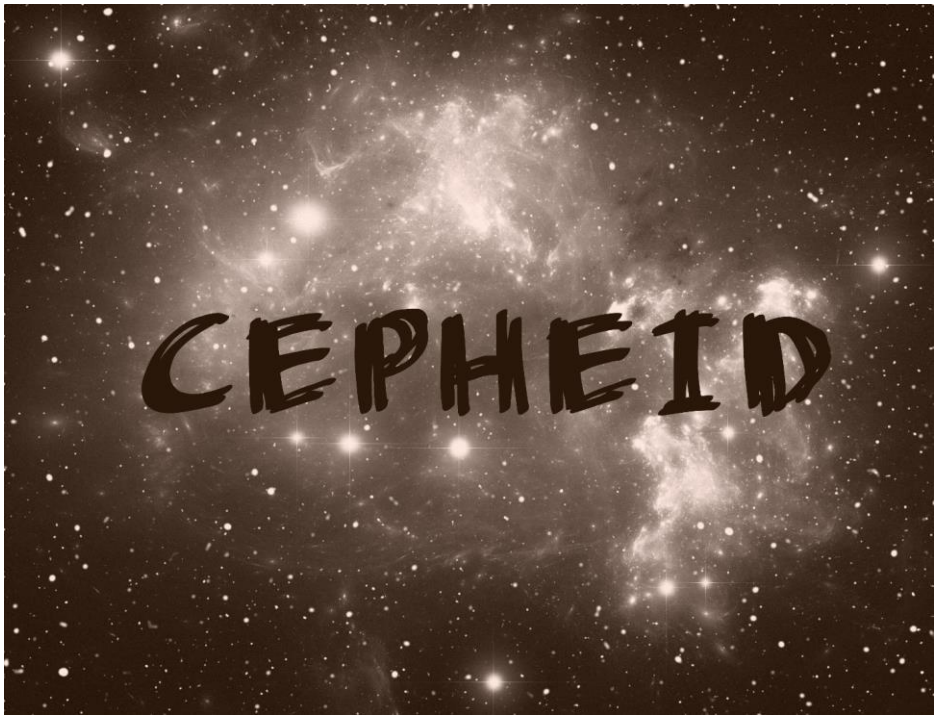
Cepheid (noun)



Pronunciation: /ˈsiːfɪɪd,ˈsɛːfɪɪd/

Meaning: a variable star having a regular cycle of brightness with a frequency related to its luminosity, so allowing estimation of its distance from the earth

Origin: The word got originated in the early 20th century, from the name of the variable star *Delta Cephei*, which typifies this class of stars. These stars are also called *cepheid variable*.

Word section: The first known usage of the word in the meaning defined above dates back to 1903. These stars are members of the constellation, *Cepheus*, located

near the north celestial pole. In history, Cepheus was a king of Ethiopia, the husband of Cassiopeia.

Usage:

1. *Several hundred cepheid variables are known in our Galaxy.*
   (https://en.oxforddictionaries.com/definition/cepheid)

2. In 1924 Hubble discovered a number of Cepheid variables in the great Andromeda nebula. To determine the absolute magnitude…of every Cepheid variable in the heavens.
   (*Stars & Atoms* by A. S. Eddington, 1927)

3. Recent research includes monitoring cepheid variable stars and follow-up observation of gamma-ray bursts.
   (https://eng.ichacha.net/zaoju/cepheid%20variable.html)

4. It has been found that the longer the period of a Cepheid, the greater its real luminosity. If one knows how bright a star really is and how bright it appears, one can at once deduce its distance. Cepheids therefore act as standard candles among the stars.
   (*Yearbook Astrology 1965*)

Contents sources majorly from Oxford Advanced Learner's Dictionary.