

Teaching Activity: The Unique Carbon Atom

Introduction: Carbon is the only chemical element that has a major field of chemistry devoted to the study of its compounds. The field is called *organic chemistry*. Most organic compounds come from living things, or things that were once living. Perhaps the most remarkable thing about organic compounds is that there are so many of them. More than 95% of the millions of known chemical compounds are carbon compounds.

Carbon is important partly because life chemistry is all carbon chemistry, and partly because those same properties that make them so suitable for life, also make it suitable for many industrial processes. Carbon atoms are unique because they can bond together to form very long, durable chains that can have branches or rings of various sizes and often contain thousands of carbon atoms. Silicon and a few other elements can form similar chains; but they are generally shorter, and much less durable. Carbon atoms also bond strongly to other elements, such as hydrogen, oxygen, and nitrogen, and can be arranged in many different ways.

Silicon (Si) has many of the same characteristics as carbon and is located directly below carbon on the Periodic Table. Although the chemistry of modern Earth-based life is based on carbon chemistry, this may not be true all over the universe, and it may not always have been true on Earth. Some scientists believe that the original life form on this planet was based on self-copying organic crystals known as *silicates*. If this is true, organic, self-copying crystals, and eventually DNA, must later have taken over their role. In addition, when studying the similarities and differences of carbon and silicon compounds, scientists have seen a close association between organic chemical processes and silicon-based clay surfaces. This has led to a boost for the theory that clay replicators merged with organic molecules and used them for their own purposes.

In addition to the millions of carbon compounds that are already known, there are new ones being discovered every day. Carbon can form an almost infinite number of molecules of various shapes, sizes and compositions. We use carbon compounds every day without even realizing it because they are silently carrying out important chemical reactions within our bodies; many are so vital that we literally could not live without them.

Important Terms: Carbon, silicon, Periodic Table of the Elements, physical /chemical properties, Carbon- and Silicon based life forms, chemical composition;

Objective:

- To discuss and compare the physical and chemical properties of carbon and silicon;
- To identify as many sources of carbon and silicon as possible;
- To view a videotape about carbon vs. silicon-based life forms;
- To analyze the possibility/probability of silicon based life on other planets;
- To "design" a habitat/ planet for a life form based on silicon;

Procedure:

1. Show some carbon and silicon based materials to the group.
 - Label each one with its common name as well as the chemical composition or formula.
2. Discuss the position of carbon and silicon on the Periodic Table .
 - Identify specific characteristic of each element.
 - Discuss the cycles of these two elements in the Earth system.
3. After the students have some basic information on C and Si, pass out the **Voorhan Information Sheet**.
 - Give students a brief overview of the Voorhan civilization.
 - Instruct student to create an illustration of what they think the Voorhan looked like as well as characteristics of their planet.
4. Show the **Star Trek** episode, "The Devil in the Dark".
 - After viewing the videotape, students should be able to answer the questions in the **Analysis and Comprehension** section.
5. Divide students into small groups.
 - Give instructions for "designing" a habitat or planet for the Horta based on the information they have on Si - based life as well as any information the got from the video.
 - They should include the information requested in the **Alien Information Sheet** and any other information they feel is important or interesting.
 - The design process should include discussion, written information, drawings and /or three-dimensional models.

*****NOTE:** Distribute the sheet entitled "Carbon - Silicon Data Sheet" to aid in designing the planet if you feel students need it.

VOORHAN INFORMATION SHEET

Voorhan (VOR' -Han) (VH)

PHYSICAL DESCRIPTION: The Voorhan are a violent race based on a silicon biology rather than the more normal carbon scheme. The typical Voorhan individual resembles a large rock-like centipede. Individual Voorhani average approximately 5 meters in length and 2 meters in height (with all legs touching ground). Average weight is about 2 metric tons (2000 Kg). The body is divided into 11 distinct segments, each of which is supported by 2 massive 3 jointed legs. The outer surface of the head, legs and each segment is a hard silicon material which appears similar to rock or fused glass. This carapace is secreted by the body and individuals must molt every 6 months until adulthood to allow for body growth. Once adulthood is reached, individuals only replace the carapace once every 2 years. Each of the three forward pairs of legs are equipped with a complex 3 clawed "hand" which can be used for manipulation. The Voorhan can raise itself upward to bring these into use. In the upright position the average Voorhan stands 4 meters tall. The head is triangular in shape and attached to the first body segment by a universal joint. This gives the Voorhan the ability to swivel its head in any direction, even completely backward. Facial features are composed of 5 forward looking eyes, 3 nasal grooves, and hard silicon mouth parts which are adaptable to chewing just about anything. Vision is somewhat limited, but hearing is very acute. The external ear structure is a set of 8 silicon plates, 4 on each side of the head. These plates can be closed to give the Voorhan complete hearing protection or opened for maximum reception. Internal organs consist of a 3 chambered heart in each segment (11 hearts in all) as well as gill/lungs in each segment as well. The breathing apparatus opens to the exterior through small vents in the individual's underside. The digestive/excretory system is very well developed and complex. The Voorhani can eat just about anything: animal, vegetable and mineral. The chew rocks for nourishment in order to grow their silicon-based carapace and body parts. The species has two sexes: male and female. Eggs are deposited by the female, but are carried glued to the underside of the male until they reach maturity. The average egg is about 25 cm in diameter and hatches after a period of seven months. The Voorhan are primarily a subterranean species and spend their lives tunneling, farming and hunting in widespread tunnel complexes. Voorhani make natural miners. Since mining is the primary method for increasing their living space, every Voorhan is a miner at least once in his life. Males compete for females on the basis of how much subterranean territory they personally hold.

VOORHAN INFORMATION SHEET

HISTORY: The Voorhan rose from savagery over a long period of almost constant warfare over territorial rights. Clans, factions and nations predominated their home world for thousands of years before the Xor finally rose to power and subjugated all Voorhani into a "world government". By that time, several areas of the home world's crust were uninhabitable due to nuclear war. Once world government was achieved, space exploration quickly followed and the Voorhan built an orbital platform. They had soon explored their home system and worked out the basics for their own "jump drive". Upon contact with other interstellar societies, however, the Voorhan were quickly overwhelmed. Bribed, coerced, and attacked, their government quickly broke into factions and widespread warfare on their home planet resumed. Universal armageddon soon followed and the Voorhan homeworld is now believed to be completely uninhabited.

SOCIETY: The Voorhan who still survive in Dark Well Space are concentrated at a few settlement sites owned by various allegiances and are employed as miners. They rarely mix with other species, since they have the unfriendly habit of eating them.

CARBON - SILICON DATA SHEET

	CARBON	SILICON
ATOMIC NO.	6	14
ATOMIC SYMBOL	C	Si
ATOMIC MASS	12.011	28.086
FORMS	Graphite, diamond, buckminsterfullerene	Sand, quartz, granite, asbestos, clay, mica.etc.
SOURCES	Sun, stars, comets, atmospheres of most planets;	Sun, meteorites, natural glass;
LOCATION in EARTH SYSTEM	CO ₂ in atmosphere Carbonates in rocks; Coal, oil, natural gas deposits;	25.7% in crustal rocks
MELTING/ BOILING POINT	3823.2 / K	1683 /3553 K
COLOR	Black	Gray-black
GROUP ON PERIODIC TABLE	Nonmetal	Nonmetal
USES	Fuels, lubricants;	Computer chips, lubricants, pottery, glass, enamals;
UNIQUE PROPERTIES	Basis of life; Long, stable compounds;	Important to plant/animal cell walls;
REACTIVITY	High	Relatively unreactive;

Student Activity Sheet #1

ANALYSIS AND COMPREHENSION

1. List the factors common to both carbon and silicon-based life forms.

2. Is the Horta a sentient or non-sentient life form? Explain. _____

3. What are the major differences between the C and Si -based life forms? _____

4. Compare and contrast how the C and Si cycles might maintain life. _____

5. How does the physical appearance of the planet depend on the cycle that supports it?

6. Feedback loops control the levels of various factors within a cycle.

a. What are some feedback loops in the carbon cycle? _____

b. Would there be similar feedback loops in a planet that has Si-based life? Explain.

Student Activity Sheet #1

ANALYSIS AND COMPREHENSION

7. Using what you now know about the chemical properties of C and Si, why is the idea of silicon-based life a possibility? _____

8. How do the Horta and the Voorhani compare as Si-based life forms. _____

SILICON-LIFE FORM INFORMATION SHEET

The following topics **MUST** be included in you project on the silicon-based life form. Any other information may be included at your disgression.

- * **ENERGY**- From where? How is it used?
- * **SENTIENT-NON-SENTIENT LIFE FORM**- Does or doesn't the life form have the power of feeling or perception? Explain.
- * **LITHOSPHERE** -What is the form and composition of the planet's lithosphere?
- * **ATMOSPHERE** -What is the form and composition of the planet's atmosphere?
- * **HYDROSPHERE**-The planet does not have to have water present; it can be another substance in liquid form. If it is not water, what is the liquid,how does the liquid or water react with other parts of the planet?
- * **OTHER ORGANISMS** - What other life forms might inhabit this planet? What do they look like? How do they interact with other organisms? Are they silicon or carbon-based?