29 March 2007

By: Lucian Dorneanu, Science Editor

Silicon life might look like animated crystals, as in this drawing from Dickinson and Schaller

Silicon-based Life?

To be, or not to be...

All known life on Earth is built upon carbon and carbon-based compounds. Yet the possibility has been discussed that life elsewhere in the Universe may have a different chemical foundation, based on the element silicon.These alternative life-forms have been the subject of many sci-fi productions, from Star-Trek and X-files to the more low-budget, kitchen-style special effects movies and TV seriesSilicon is the has the symbol Si and atomic number 14. A tetravalent metalloid, silicon is less reactive than its chemical analog carbon. As the seventh or eighth most common element in the universe by mass, silicon occasionally occurs as the pure free element in nature, but is more widely distributed in dusts, planetoids and planets as various forms of silicon dioxide or silicate. On Earth, silicon is the second most abundant element (after oxygen) in the crust, making up 25.7% of the crust by mass.In 1891, the German astrophysicist Julius Scheiner became perhaps the first person to speculate on the suitability of silicon as a basis for life, based on the heat stability of silicon compounds, that might allow life to exist at very high temperatures.On Earth, carbon is the most important component in all known biological molecules from sugar to DNA and is unique in that its bonding versatility allows it take on many forms: long side chains that make up fatty acids and cell membranes, ring structures that compose hormones and sugars, and even simple gaseous molecules like methane (CH4) or carbon dioxide (CO2). Can silicon compete?Although there are no known forms of life that rely entirely on silicon-based chemistry, there are some that rely on silicon minerals for specific functions. Some bacteria and other forms of life, such as the protozoa radiolaria and diatom algae, have silicon dioxide skeletons, and the sea urchin has spines made of silicon dioxide. These forms of silicon dioxide are known as biogenic silica.The main problem for silicon-based life is that unlike carbon, silicon does not have the tendency to form double and triple bonds.Its powerful affinity for oxygen is another problem. When carbon is oxidized during the respiratory process of a terrestrial organism, it becomes carbon dioxide gas, waste material easy to remove from the organism, while the oxidation of silicon yields a solid because, immediately upon formation, silicon dioxide organizes itself into a lattice in which each silicon atom is surrounded by four of oxygen, the disposal of which poses a major respiratory challenge.Silicon also has the formidable disadvantage of being less abundant in the universe, and furthermore, wherever astronomers have looked, in meteorites, in comets, in the atmospheres of the giant planets, in the interstellar space and in the outer layers of cool stars, they have only found molecules of oxidized silicon, and no substances such as silanes or silicones which might be the precursors of a silicon biochemistry.Another chemical property unique to carbon chemistry that silicon lacks is chirality, or "handedness." All organic carbon molecules may be found naturally in left or right-handed conformations. However, life as we know it utilizes only the right-hand form of sugars, integral components in DNA structure, and the left-hand form of amino acids, the building blocks of proteins. Very few silicon compounds have handedness at all.So, silicon seems to be an unlikely participant in the biological reactions of life, although it could have certainly lent a helping hand to the origin of life.Well, even though scientists rule out the possibility of silicon-based life, the sci-fi producers are still left with that of artificial life or intelligence with a significant silicon content. Does it sound already familiar?