**Carl Sagan Life on Venus**

There is water vapor, there is carbon dioxide, there is sunlight, and very likely there are small quantities of minerals stirred up from the surface. These are all the prerequisites necessary for photoautotrophs in the clouds. In addition the conditions are approximately S.T.P. The only serious problem that immediately comes to mind is the possibility that downdrafts will carry our hypothetical organisms down to the hot, deeper atmosphere and fry them faster than they reproduce. To circumvent 126 CARL SAGAN this difficulty, and to show that organisms might exist in the Venus clouds based purely on terrestrial biochemical principles, Harold Morowitz and I (1967) devised a hypothetical Venus organism in the form of an isopycnic balloon, which filled itself with photosynthetic hydrogen and maintained a constant pressure level to avoid downdrafts. We calculated that, if the organism had a wall thickness comparable to the unit membrane thickness of terrestrial organisms, its minimum diameter would be a few centimeters. This heuristic argument had at least one salutary consequence: The Saturday Evening Post ran a cartoon showing a ping pong player (dressed in Florida sports shirt and Bermuda shorts) about to serve, and interrupted by the cry from his ping pong ball, "Stop! I am a friendly visitor from another planet! "

**The Hunt for Alien Life (peter Linde) ch. “what do the aliens look like?”**

* + **Carbon and water.**The reason is that carbon is a basic element that has an especially good ability to connect to other atoms, and to itself. We also noted that water was unusually suitable as a solvent, which facilitates the transport of many important building blocks inside a cell.
  + **Silicon and SiliconDioxide**It has been suggested that silicon-based molecule chains would survive much better in a sulphuric environment than in a water environment. If, like us, silicon-based life used oxygen for breathing, you would expect the exhalation product to contain silicon dioxide instead of carbon dioxide. However, the problem with that is the fact that silicon dioxide in principle is the same as sand, i.e. a solid substance. In an environment with sufficiently high temperatures silicon dioxide is, however, liquid.
  + **Temp and Pressure and alternative liquids** There are also conceivable alternatives to water as a solvent. We note that is not only the temperature but also the pressure which determines when a substance can exist in liquid form. As is well known, water boils at a temperature of 100 °C, but this is valid only at normal atmospheric pressure. At a one hundredth of the atmosphere pressure, water boils at 7 °C and at a pressure one hundred times higher it will not boil until a temperature of 311 °C. We have already noted that temperatures and pressures strongly vary across the solar system. Thus, water may be liquid under rather extreme conditions, but so can other liquids. As an example, ammonia can be a liquid at low temperatures and in a rather large temperature range. The same goes for methane and ethane, which are gases at Earth conditions but liquids on Saturn’s moon Titan. If a biosphere could work with such a substance as a solvent you may, due to the low temperature, expect to find the metabolism in a hypothetical life form to be very slow.

**Facts that can support the kid’s book’s illustrations**

* + - **Primarily alien eyes, nose, navigation but can be used for cloudy environments, luminosity/distance of stars.**Certain basic characteristics for a creature, intelligent or not, are reasonably obvious, and originate from clear-cut survival factors. Our star, the Sun, radiates over a wide spectrum of wavelengths, but mostly in the yellow part of visible light. This follows fundamental physics describing the relation between temperature and light emission (see Box  [6.2](https://doi-org.ezproxy.cul.columbia.edu/10.1007/978-3-319-24118-0_6#FPar2)). That living organisms develop vision sensors (eyes) adapted for such light (or similar) is natural. Further, at least two eyes are necessary to perceive depth. The brain combines two slightly different images from the eyes to achieve a sense of depth. Admittedly, depth can also be sensed using ultra-sound reflections. To perceive sound is another survival factor. Here, too, at least two auditory organs (ears) are necessary to determine from which direction an enemy is approaching. These organs have a certain advantage by being located as high as possible, and preferably located only a small distance from the analysis and manoeuvering organ (the brain). Similar arguments can be given for other bodily functions and senses. At the same time, it is obvious that these characteristics by no means are unique to humankind. Many highly developed animals have senses clearly superior to those of man’s. Others possess a few that we do not have, for instance sonar that bats and whales use for distance determination and identification of potential prey. Another example is chemical communication via extremely sensitive smelling sensors. Perhaps somewhere beings have developed natural radio communication? That would come quite close to what we call telepathy.
* **Help answer why I’m curious.** 
  + **Thesis: to explore all the possibilities of what like can become by stepping away from the humanoid stereotype. Considering the fact that life on earth evolves from microbes to intelligent life and possibilities of ever seeing it considering the time frames and how long it would take to reach other worlds. How different can life look? What is the simplest and most evolved we can imagine? Just saying, on earth we started with singular celled and we still have squids and humans. Also how environments have sooo much to do with evolution.**Whatever happens with life on other worlds, even if these by chance would have an environment similar to Earth’s, is simply impossible to predict. Not to mention predictions even harder in the very different environments that are clearly indicated among the exoplanets and their satellites. Yet, on the other hand, they may not be entirely unlike ourselves. In Fig. [13.3](https://link-springer-com.ezproxy.cul.columbia.edu/chapter/10.1007/978-3-319-24118-0_13#Fig3) we see beings that may have developed along similar lines as mankind. The overall requirements for mobility, senses to perceive the surrounding reality, capabilities to manipulate tools and so on, are all reasonable and probable, but give ample room for speculation. What would a civilisation on a water world look like? Probably somewhat similar to our fish, but would it be possible to have an industry, even to use fire? On the other hand, the water environment may provide advantages, such as an increased buoyancy, to transport heavy structures. What would beings look like on a super-Earth, with much higher gravity than on Earth? But it is said that reality sometimes surpasses fiction. Perhaps we are speculating along completely erroneous lines?
* **Astrobiology and evolutionary approach (kolb) “extraterrestrial Life: what are we looking for?”**
  + **Intro statement**Life and its environment cannot be separated. is fact is clearly shown by the three terrestrial planets, Earth, Venus, and Mars, in our solar system… ese drastic and diverse environmental changes aected the habitability of Venus, Earth, and Mars in markedly dierent ways.(kolb 400)
  + Venus pg 402
    - Today, Venus has a thick carbon dioxide–nitrogen atmosphere with little water, and the planet has no water in any form on the surface.
    - Today, Venus has a thick carbon dioxide–nitrogen atmosphere with little water, and the planet has no water in any form on the surface.
    - One surprising recent result was the detection of an ozone layer at an altitude of about 100  km (Montmessin et  al., 2011), hundreds of times less dense than on Earth, but possibly indicating that some of the same key chemical reactions occurring in Earth’s stratosphere may also operate on Venus. e most earthlike conditions that can be found today on Venus are in the lower cloud layer of the atmosphere.
    - Due to the thickness and superrotation of the Venusian atmosphere, particles of micrometer dimensions have much longer residence times than in Earth’s atmosphere, on the order of months compared to days (Schulze-Makuch et al., 2004). If microbial life on Venus ever gained a foothold, either by independent origin or by panspermia from Earth, thermoacidophiles could have evolved as the surface waters turned warmer and more acidic and then retreated to the large liquid droplets of the lower cloud layer, where they might still oat as microbial extremophiles 402 ◾ Astrobiology today (Schulze-Makuch and Irwin, 2008), provided that the changes occurred slowly enough for microbial life to adapt to an airborne state. I
  + **Life on mars: cold and dry now but maybe once wet (402-403)**
  + Mars is thought to have become a very cold desert about 3.7–3.8 Ga ago, a er the endogenic activity steadily decreased, the magnetosphere collapsed, and the atmosphere and hydrosphere were mostly lost to space (Fairén et al., 2010). Also, around that time, whatever plate tectonic activity had been occurring probably ceased (Fairén and Dohm, 2004). However, the long-persistent hyperarid state was punctuated by short-duration episodes (~104–105 years) of considerably wetter conditions (Baker et al., 2005; Fairén, 2010). ese episodes appear to have been induced by magmatic-driven activity at arsis and Elysium (Fairén et al., 2003) triggering cataclysmic outbursts of huge oods that carved the Martian outow channels and led to temporary water bodies ranging from lakes to oceans (Baker et al., 1991; Fairén et al., 2003; Fairén, 2010). Further, cycles of exaggerated tilting of the Martian axis (Jakosky et al., 1995) resulted in the redeposition of water–ice accumulations from the pole to the equator and vice versa (Levrard et al., 2004). Major impacts on the surface of Mars, like those that formed the Hellas, Argyre, and Isidis basins, surely melted frozen reservoirs and released subterranean water on a global scale. ese periods must have been accompanied by a thicker atmosphere, leading to a transiently warmer planet with conditions more likely to be habitable. e scenario that thus emerges for Mars is that of a planet that has been cold and dry for most of its history, with the possible exception of the rst few hundred million years. During these earlier times, Mars was already cold, albeit warmer than today, and certainly wet (Fairén, 2010; Figure 18.2). e overall trajectory toward a colder and drier planet, however, has been punctuated by (1) sporadic global ooding triggered by episodic volcanisms and asteroid/cometary bombardment (Segura et al., 2002; Toon et al., 2010) and (2) localized ow from snowmelt or groundwater eruptions (Mangold et al., 2004). Many surface features on Mars are consistent with this picture, both for catastrophic ooding (Toon et  al., 2010) and local sapping or seepage of groundwater (Grant, 2000).
  + Given that life on Earth originated at least 3.5 billion years ago (Schidlowski, 1988; Mojzsis et al., 1996), and that Earth and Mars shared similar environmental conditions early in their histories, it seems reasonable to speculate that life on Mars originated during its earlier warmer and wetter Noachian Eon. If so, as the planetary conditions became drier and colder (Fairén, 2010), the biosphere would have had to adapt accordingly and retreat to the subsurface, where locally habitable conditions would have still prevailed (Figure 18.3). Microorganisms may have retreated to the deep subsurface, beneath the ice sheets and permafrost, pursuing a psychrophilic lifestyle and scavenging organic nutrients still accessible there. Or, microbes, and possibly larger commensal or independent organisms feeding on them (Irwin and Schulze-Makuch, 2011), may have retreated to remaining favorable niches on or near the surface, such as hydrothermally active areas (Schulze-Makuch et al., 2007) and caves (Léveillé and Datta, 2010).
  + **All of page 404-----what life can look like on mars**
  + **All of page 406 titan**
    - Nitrogen atmosphere
    - **Liquid methane**
    - Large cells slow metabolism
    - e biochemistry of an organism in a hydrophobic solvent would be quite dierent though. For example, the miniaturization of cellular life in water on Earth may be a misleading model for life in a nonaqueous environment (Schulze-Makuch and Irwin, 2008). In an extremely cold, hydrophobic (but liquid) environment, surface/volume ratio considerations may be less constraining than at higher temperatures in polar solvents, because of the lower viscosity of the solvent and the slower diusion rates permitted by the greatly reduced rate of metabolism. us, life on Titan could involve huge (by Earth standards) and very slowly metabolizing cells (Schulze-Makuch and Irwin, 2008).
  + **Pg 407,** **why liquids are important (maybe for explanations on a webpage)**
    - The presence of liquis is favorable for living processes because macromolecules and nutrients can be concentrated within a bounded internal environment without immobilizing interaction constituents (Schulze-Makuch and Irwin, 2008). e need for liquids is usually taken as a requirement for an aqueous medium, though this is not necessarily the case. Liquids in the atmosphere, on the surface, or beneath the surface are a function of chemistry, pressure, and temperature and can exist on very cold planetary bodies, such as the methane/ethane mixture of Saturn’s moon Titan and other subsurface liquids seen to erupt periodically on worlds like Saturn’s moon, Enceladus, and Neptune’s moon, Triton

NASA Europa

* 1. If Europa does have a salty ocean, chemical reactions between the water and the rocks on the ocean floor could create hydrogen-rich materials. And if there are areas where the ocean interacts with hot rock, then, like hydrothermal vents in Earth's oceans, that water could be pouring out chemical nutrients to power life. In short, Europa may have a variety of processes that work together to make the chemical energy available for powering life processes of simple organisms like bacteria.
* 1. The chemical elements for life might be found within Europa's icy shell, as well as its ocean. Tidal heating could be powering a system that cycles water and nutrients between the moon's rocky interior, ice shell and ocean, creating a watery environment rich with chemistry conducive to life.
* 2. *Galileo* observations of neighbouring Callisto and Ganymede indicate abundant quantities of **organic compounds** containing oxygen, carbon, sulphur, hydrogen and nitrogen. If similar abundances are found on Europa (which is likely), and if Europa does indeed possess a liquid ocean (which is likely), then the prospects are **good** for life to exist **today** on this icy moon. This life might be found around **geothermal vents** on the ocean floor, much like the extremophiles which live on **black smokers** in Earth's oceans (see [Lecture 6](http://www.astro.wisc.edu/~townsend/static.php?ref=diploma-6)).
* 2. Interestingly, some scientists have claimed that **evidence for life** on Europa already exists. The reason why cracks in its surface ice are visible, is that they are somewhat **darker** than the surrounding ice, and reddish-brown in colour. Infra-red spectra taken by *Galileo* have been used to investigate the reasons for this different colouration. The general consensus is that it arises from **salt minerals** contained within the ice, but attempts to find the precise composition of these minerals have proven difficult.

NASA Titan

* **Cold temps**
* **seas of liquid hydrocarbon in warmer spots**
  + prob **ethane** surrounding continents of rock and water ice
* The methane in Titan's atmosphere is continually being destroyed by incoming sunlight, leading to the formation of **more-complicated molecules**, of the sort which were found in Earth's early history. **Atmospheric lighting** may also play a part in this process, reminiscent of the **Miller-Urey experiment** (see [link:diploma-4|Lecture 4]). Although the temperatures on Titan are very low, it is widely accepted that **complex organic chemistry** occurs on this moon.
* The present-day prospects for life on Titan are **poor**, due to the low temperatures. Nevertheless, Titan is very interesting from a biological standpoint, since its atmosphere and surface are expected to be rich in the **prebiotic compounds** which eventually produced life on Earth.
* Although Titan is almost certainly lifeless today, there is a chance that life may develop there in the **distant future**. When the Sun exhausts its supply of hydrogen fuel in its core, it will swell up into a **red giant**, and its luminosity may increase greatly. With the greater amounts of radiation reaching Titan, temperatures may rise high enough for the ice to **melt**, producing **liquid water** on the moon's surface. Since the necessary **chemical building blocks** would be in abundance, it is possible that life would then develop. However, one problem with this scenario is that, if temperatures were high enough on Titan for water to remain liquid, the **low surface gravity** of the moon would mean that the water would **evaporate** and escape into space.

METHANE

Space.com and titan

* On Titan, where the temperature is just 94 degrees above absolute zero (minus 290 degrees Fahrenheit; 179 degrees Celsius) water is as solid as rock and liquid methane runs through the river valleys and into the high-latitude polar lakes. Instead of a water cycle, Titan has a methane cycle, and a [complex molecular soup](https://www.space.com/10488-life-ingredients-form-titan-surface.html) formed from reactions in the upper atmosphere between ultraviolet radiation from the sun and methane.
* **Methan could create a whole new habitable zone!!! Great for red dwarf stars**
* **How life forms can on titan can consume blank and exhale methane.** McKay already has a few suggestions and, tantalizingly, there may even be supporting evidence from Titan. In 2005, he published a paper with Heather Smith of the International Space University in Strasbourg, building on work by Steven Benner of the University of Florida, describing how [methane-based lifeforms on Titan](https://www.space.com/8188-alien-life-titan-stink.html) (‘methanogens’) could consume hydrogen, acetylene and ethane, and exhale methane instead of carbon dioxide. If such a lifeform existed, it could reveal itself through a depletion of hydrogen, acetylene and ethane at the surface.
* **Life would be slow and sluggish**
* RED DWARFS
* **HOT METHANE PLANETS NEED HIGH PRESSURE** "You would have to invoke a lot of pressure to keep methane liquid at warmer temperatures," Kaltenegger said. "And if you think about it, water and carbon are extremely abundant. So if you make the planet warmer, you are much more likely to get carbon dioxide than methane, and methane would go out of its liquid phase so you wouldn’t have the triple point [where for a given temperature and pressure a material can exist as a liquid, solid or gas] like the triple point of water on Earth."

Journal of Cosmology **Rampelotto 2010**

* **Water is a NO No bc oxygen is highly reactive**Silanes burn spontaneously when in contact with oxygen to form silicate and molecular hydrogen. Hence, a biochemistry based on such compounds requires an ambient free of oxygen. The affinity of silicon to oxygen is so strong that whether silicon is placed in water, it will form a silica shell, stripping the oxygen from the water (LeGrand 1998). Thus, water is not a compatible solvent for silicon compounds. Methane, ethane or any compounds that contain methyl groups are more compatible solvents for a silicon-based system.
* **Ideals and silicon works best with methan and silicon best in cold places** These studies altogether suggest that whether silicon-based life exist, it may be restricted to an environment with minor amounts of oxygen, scarcity of water, a compatible solvent such as methane and low temperatures (at least below 0°C). Titan provides the best target in our solar system for investigating this possibility. It meets all the described criteria (Fulchignoni et al 2005; Naganuma and Sekine 2010). Although has been considered that the abundance of carbon compounds on Titan may compete with silicon as the building block of life, silicon may have advantage in such extreme cold environment due to its higher reactivity.
* Ammonia based life, sulfur based life