Kepler 90

The true garden of the Hesperides

An Imaginary Exoplanet Report

Created by
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Kepler 90i, the true garden of Hesperides

On December 14 2017, NASA and Google announced the discovery of an exoplanet (a planet that revolves around a star other than the sun) in the Kepler-90 system. The newfound planet is named Kepler90i and is the eighth planet found in the system. This fact makes this discovery unique since the planetary system has an equal number of observed planets to the Solar System.

In 2009, NASA's Kepler spacecraft was observing stars on its photometer, the instrument it uses to detect transit events, in which a planet crosses in front of and dims its host star for a brief and roughly regular period of time. In its last test, Kepler observed 50000 stars in the Kepler Input Catalog, including Kepler-90; the preliminary light curves were sent to the Kepler science team for analysis. Discovery of the exoplanet was aided by a newly utilized computer tool, deep learning, a class of machine learning algorithms implemented by Google.

Kepler-90 is a G-type main sequence star located about two thousand five hundred light-years from Earth in the constellation of Draco. The name of the constellation is derived by the dragon Ladon, the dragon who guarded the golden apples of the Hesperides.

In Greek mythology, the Hesperides are the nymphs of evening and golden light of sunset, who were the "Daughters of the Evening" or "Nymphs of the West". They tend a blissful garden in a far western corner of the world, located near the Atlas mountains in North Africa at the edge of the encircling Oceanus, the world-ocean.

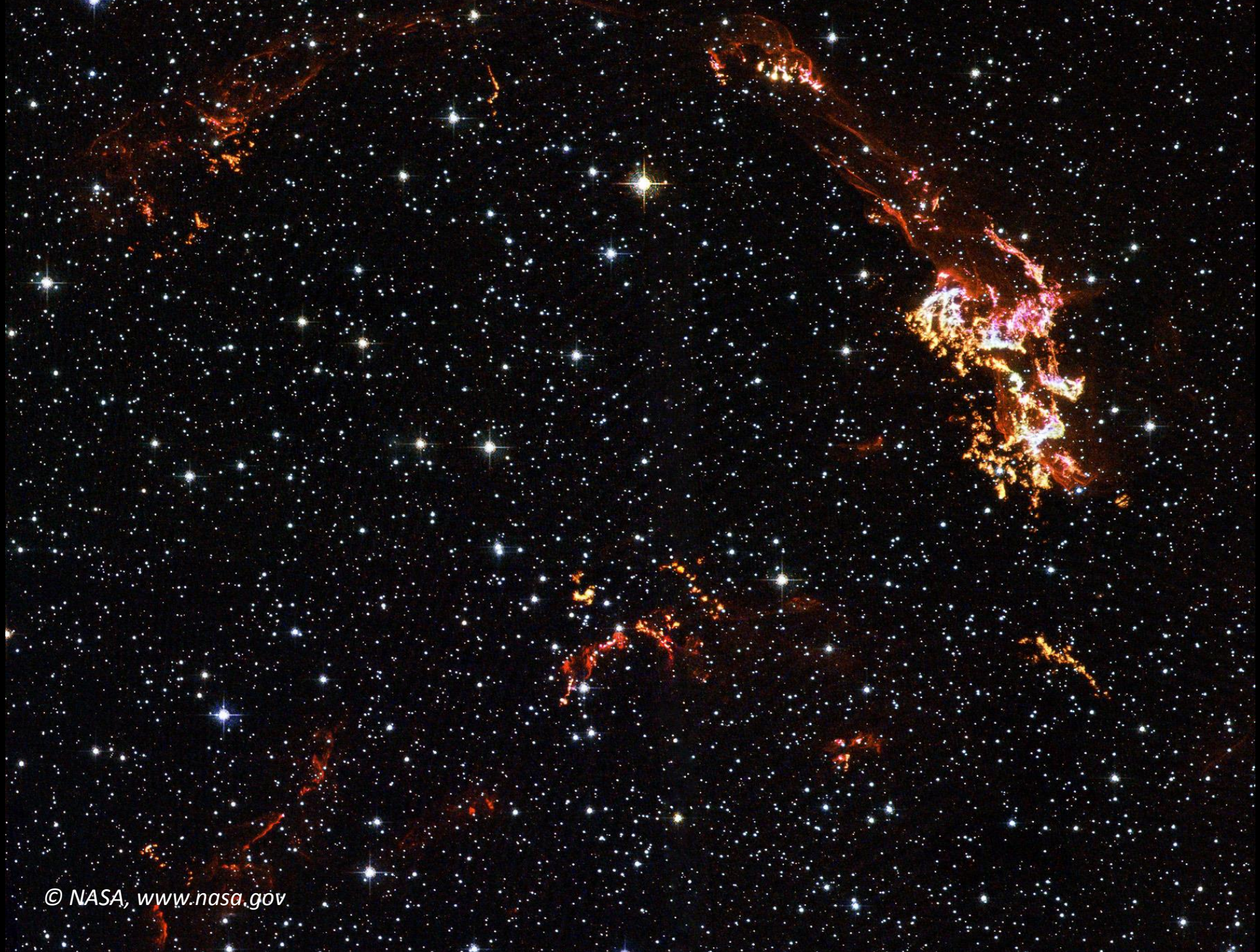
This project is actually an imaginary exoplanetary discovery report based on scientific facts and pseudo-scientific evidences, revealing the nature of the exoplanet Kepler 90i, the true garden of Hesperides.

Sarantis Raftopoulos
March 2018

Kepler 90

The true garden of the Hesperides

The Discovery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“Artificial Intelligence, NASA data used to discover eighth planet circling distant star.”

Our solar system now is tied for most number of planets around a single star, with the recent discovery of an eighth planet circling Kepler-90, a Sun-like star 2,545 light-years from Earth. The planet was discovered in data from NASA’s Kepler Space Telescope.

The newly-discovered Kepler-90i was found using machine learning from Google. Machine learning is an approach to artificial intelligence in which computers “learn.” In this case, computers learned to identify planets by finding in Kepler data instances where the telescope recorded signals from planets beyond our solar system, known as exoplanets. “Just as we expected, there are exciting discoveries lurking in our archived Kepler data, waiting for the right tool or technology to unearth them,” said Paul Hertz, director of NASA’s Astrophysics Division in Washington. The discovery came about after researchers Christopher Shallue and Andrew Vanderburg trained a computer to learn how to identify exoplanets in the light readings recorded by Kepler – the minuscule change in brightness captured when a planet passed in front of, or transited, a star.

Inspired by the way neurons connect in the human brain, this artificial “neural network” sifted through Kepler data and found weak transit signals from a previously-missed eighth planet orbiting Kepler-90, in the constellation Draco. While machine learning has previously been used in searches of the Kepler database, this research demonstrates that neural networks are a promising tool in finding some of the weakest signals of distant worlds. Other planetary systems probably hold more promise for life than Kepler-90. About 30 percent larger than Earth, Kepler-90i is so close to its star that its average surface temperature is believed to exceed 800 degrees Fahrenheit, on par with Mercury. Its outermost planet, Kepler-90h, orbits at a similar distance to its star as Earth does to the Sun.

Excerpt from NASA Press Release, 14 Dec 2017, https://www.nasa.gov/kepler

Technicians working inside the Astrotech Space Operations facility near NASA's Kennedy Space Center look over the Kepler spacecraft. Image Credit: NASA/Tim Jacobs

NASA's Kepler spacecraft in a clean room at Ball Aerospace & Technologies Corp. Image credit: NASA/JPL-Caltech/Ball

Kepler Spacecraft

Kepler is a space observatory launched by NASA to discover Earth-size planets orbiting other stars. Named after astronomer Johannes Kepler, the spacecraft was launched on March 7, 2009, into an Earth-trailing heliocentric orbit.

Designed to survey a portion of our region of the Milky Way to discover Earth-size exoplanets in or near habitable zones and estimate how many of the billions of stars in the Milky Way have such planets, Kepler's sole scientific instrument is a photometer that continually monitors the brightness of over 145,000 main sequence stars in a fixed field of view. These data are transmitted to Earth, then analyzed to detect periodic dimming caused by exoplanets that cross in front of their host star.

Kepler 90, Planetary System Description

Kepler-90 is notable for similarity of the configuration of its planetary system to that of the Solar System, in which rocky planets are nearer the star and gas giants farther away. The six inner planets are either super-Earths or mini-Neptunes due to their size. Two of the outer planets are gas giants. The penultimate known planet orbits its host star at about the same distance as Earth from the Sun. The outermost planet has yet to be fully researched Kepler-90 was used to test the "validation by multiplicity" confirmation method for Kepler planets. Six inner planets met all the requirements for confirmation. The penultimate planet showed transit-timing variations, indicating that it is a real planet as w[e9l]l. The Kepler-90 system is the only eight-planet candidate system from Kepler, and the second to be discovered after the Solar System. It was also the only seven-planet candidate system from Kepler before the eighth was discovered in 2017, and one of two total seven planet systems, along with TRAPPIST-1. Additionally, the inner six planets range in size from that of Earth to smaller than Neptune, and the outer two planets are the size of gas giants. All of the eight known planet candidates orbit within 1 AU from Kepler-90.

Prior to Kepler observation, Kepler-90 had the 2MASS catalogue number 2MASS J18574403+4918185. It has the designation of KIC 11442793 in the Kepler Input Catalog, and given the Kepler object of interest number of KOI-351 when it was found to have a transiting planet candidate. The name Kepler-90 derives directly from the fact that the star is the catalogued 90th star discovered by Kepler to have confirmed planets. The designation b, c, d, e, f, g, h, and i derives from the order of discovery. The designation of b is given to the first planet orbiting a given star, followed by the other lowercase letters of the alphabet. In the case of Kepler-90, there are eight planets discovered, so designations up to i are used.

Kepler-90 is a G-type star that is approximately 120% the mass and radius of the Sun. It has a surface temperature of 6080 K, and an estimated age of around 2 billion years. In comparison, the Sun is about 4.6 billion years old and has a surface temperature of 5778 The star's apparent magnitude, or how bright it appears from Earth's perspective, is 14. Therefore, it is too dim to be seen with the naked eye.

Kepler 90, Planetary System Description

Kepler 90 Planets

Companion (in order from star)	**Mass**	**Semimajor axis** (AU)	**Orbital period** (days)	**Eccentricity**	**Inclination**	**Radius**
b	—	0.074 ± 0.016	7.008.151	—	89.4°	1.31 R⊕
c	—	0.089 ± 0.012	8.719.375	—	89.68°	1.18 R⊕
i	—	0.1234	1.444.912	—	89.2°	1.32 R⊕
d	—	0.32 ± 0.05	5.973.667	—	89.71°	2.88 R⊕.
e	—	0.42 ± 0.06	9.193.913	—	89.79°	2.67 R⊕
f	—	0.48 ± 0.09	1.249.144	0.01	89.77°	2.89 R⊕
g	<0.8 MJ	0.71 ± 0.08	21.060.697	—	89.8°	8.13 R⊕
h	<1.2 MJ	1.01 ± 0.11	33.160.059	—	89.6°	11.32 R⊕

Kepler-90's eight known planets all have periods that are close to being in integer ratio relationships with other planets' periods; that is, they are close to being in orbital resonance. The period ratios b:c, c:i and i:d are close to 4:5, 3:5 and 1:4, respectively (4:4.977, 3:4.97 and 1:4.13) and d, e, f, g and h are close to a 2:3:4:7:11 period ratio (2:3.078:4.182:7.051:11.102; also 7:11.021). f, g and h are also close to a 3:5:8 period ratio (3:5.058:7.964). Relevant to systems like this and that of Kepler-36, calculations suggest that the presence of an outer gas giant planet facilitates the formation of closely packed resonances among inner sup Earths.

Source: https://en.wikipedia.org/wiki/Kepler-90

Kepler 90, Planetary System Description

Kepler 90 System details

Observation data

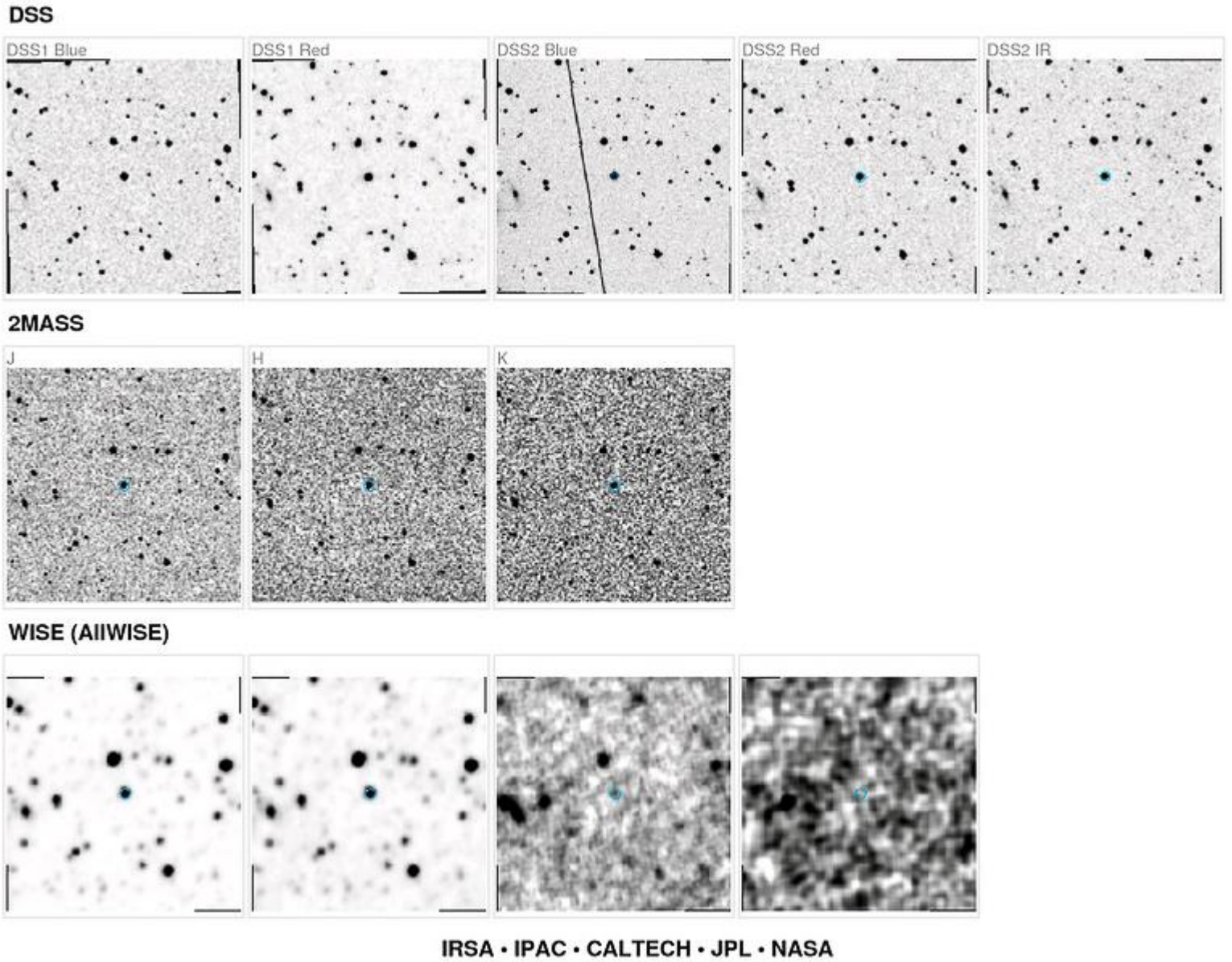
Epoch 2000	Equinox 2000
Constellation	Draco
Right ascension	18h 57m 44.038s
Declination	+49° 18′ 18.58″
Apparent mag(V)	14

Characteristics / Astrometry

Spectral type	G0V
Distance	2545 ly (780 pc)
Absolute mag(MV)	ca 4.3

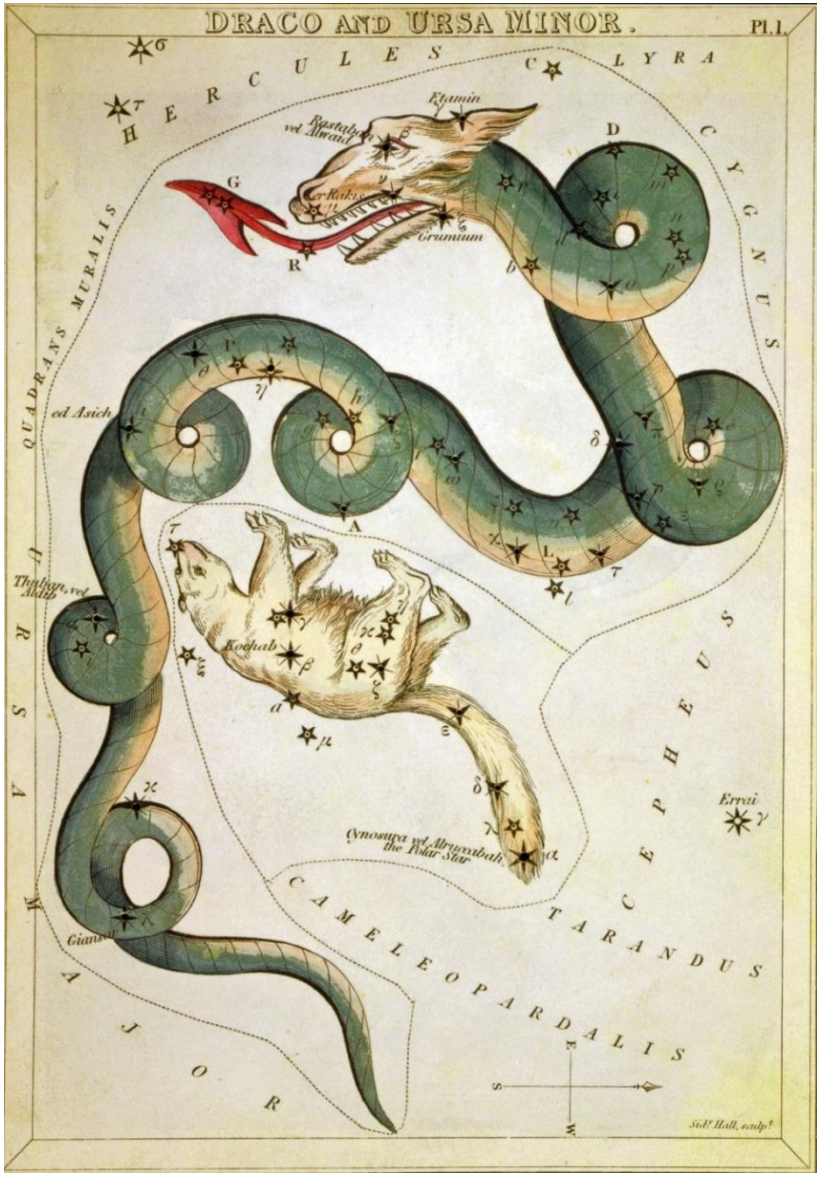
Details

Mass	1.2 ± 0.1 $M_\odot$
Radius	1.2 ± 0.1 $R_\odot$
Surface gravity	4.4 cgs
Temperature	6080+260 −170 K
Metallicity [Fe/H]	−0.12 ± 0.18 dex
Rotational velocity	4.6 ± 2.1 km/s
Age	~2 Gyr
Other designations	KIC 11442793, KOI-351



Confirmed Exoplanet Database , FinderC hart KOI-351; 284..4335022 +49.3051605 EQ J2000; 300x300arcsec (Wed Dec 17 18:28:07 PST 2014)

Source: NASA Exoplanet Archive, https://exoplanetarchive.ipac.caltech.edu



"Draco and Ursa Minor", plate 1 in Urania's Mirror, a set of celestial cards accompanied by A familiar treatise on astronomy by Jehoshaphat Aspin. London c.1825

Draco constellation in mythology

Kepler 90 system is located within the boundaries of Draco constellation, named after the Dragon Ladon, who according to ancient Greek mythology guarded the golden apples of the Hesperides. Heracles killed Ladon during his 12 labors; he was tasked with stealing the golden apples.

In Greco- Roman legend, Draco was a dragon killed by the goddess Minerva and tossed into the sky upon his defeat. The dragon was one of the Gigantes, who battled the Olympic gods for ten years. As Minerva threw the dragon, it became twisted on itself and froze at the cold North Celestial Pole before it could right itself.

The Garden of the Hesperides is Hera's orchard in the west in the region of mount Atlas in north Africa, where either a single apple tree or a grove grows, producing golden apples that grant immortality when eaten. The trees were planted from the fruited branches that Gaia gave to Hera as a wedding gift when Hera accepted Zeus. The Hesperides were given the task of tending to the grove, but occasionally picked apples from it themselves. Modern accounts of the myth indicate that the golden apples were actually oranges.

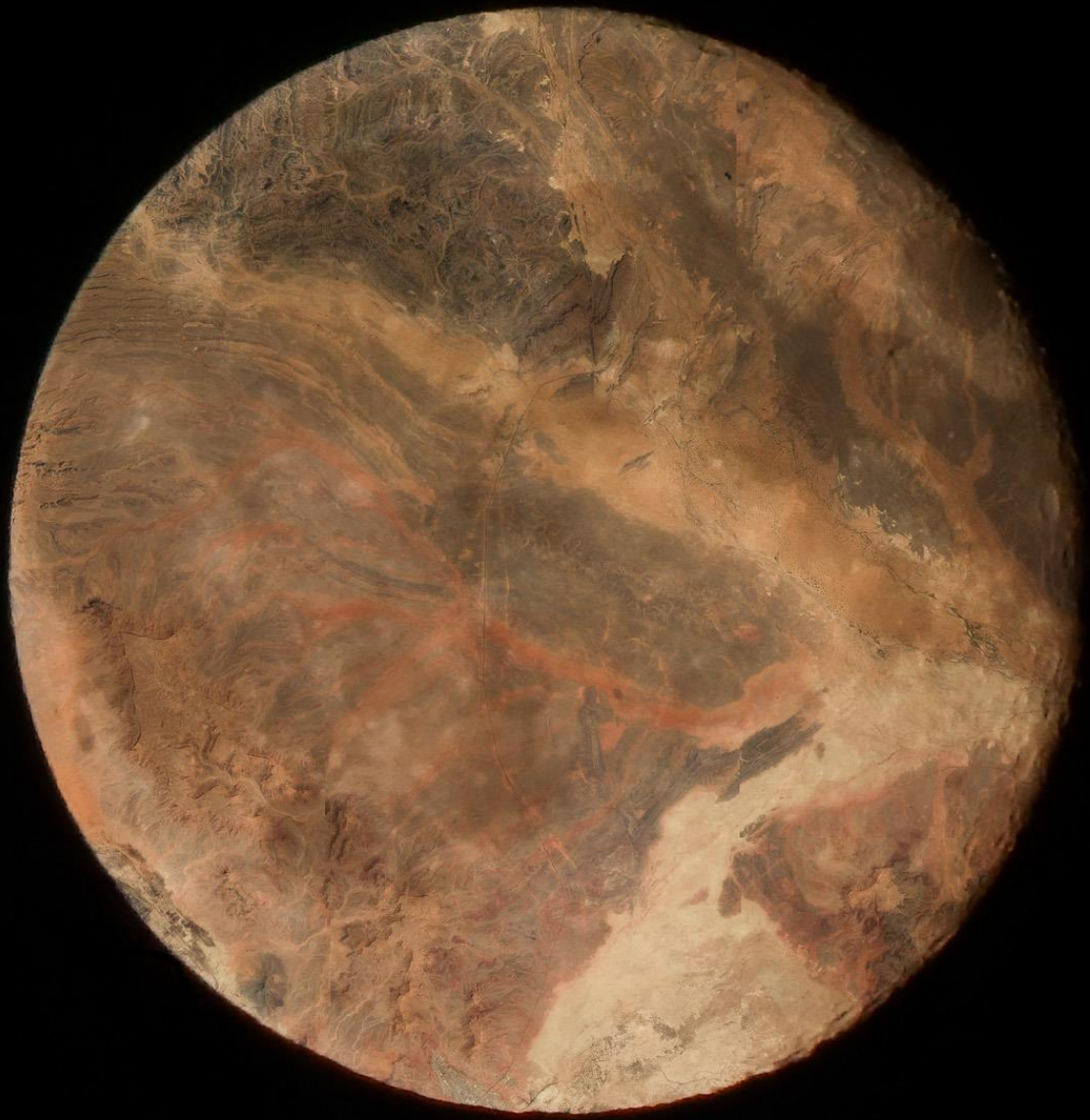
Image: Location of KOI 351 in the sky (red mark).

Source: SIMBAD Astronomical Database - CDS (Strasbourg) http://simbad.u-strasbg.fr/simbad/

Kepler 90

The true garden of the Hesperides

The Planet



Kepler-90i

Kepler-90i (also known by its Kepler Object of Interest designation KOI-351i) is a super-Earth exoplanet with a radius 1.32 that of Earth, orbiting the early G-type main sequence star Kepler-90 every 14.45 days. It is located about 780 parsecs from Earth. The exoplanet is the eighth in the star's multiplanetary system. Kepler-90i was found with the transit method, in which the dimming effect that a planet causes as it crosses in front of its star is measured.

Physical characteristics
Radius (r) 1.32±0.21 R⊕
Temperature (T) 709 K

Orbital elements
Semi-major axis (a) null; 0.1234 AU
Eccentricity (e) null
Orbital period (P) 14.44912±0.00020d
Inclination (i) 89.20 (+0.59° −1.30°)
Number of Moons: TBD
Distance from Earth: 780 parsecs

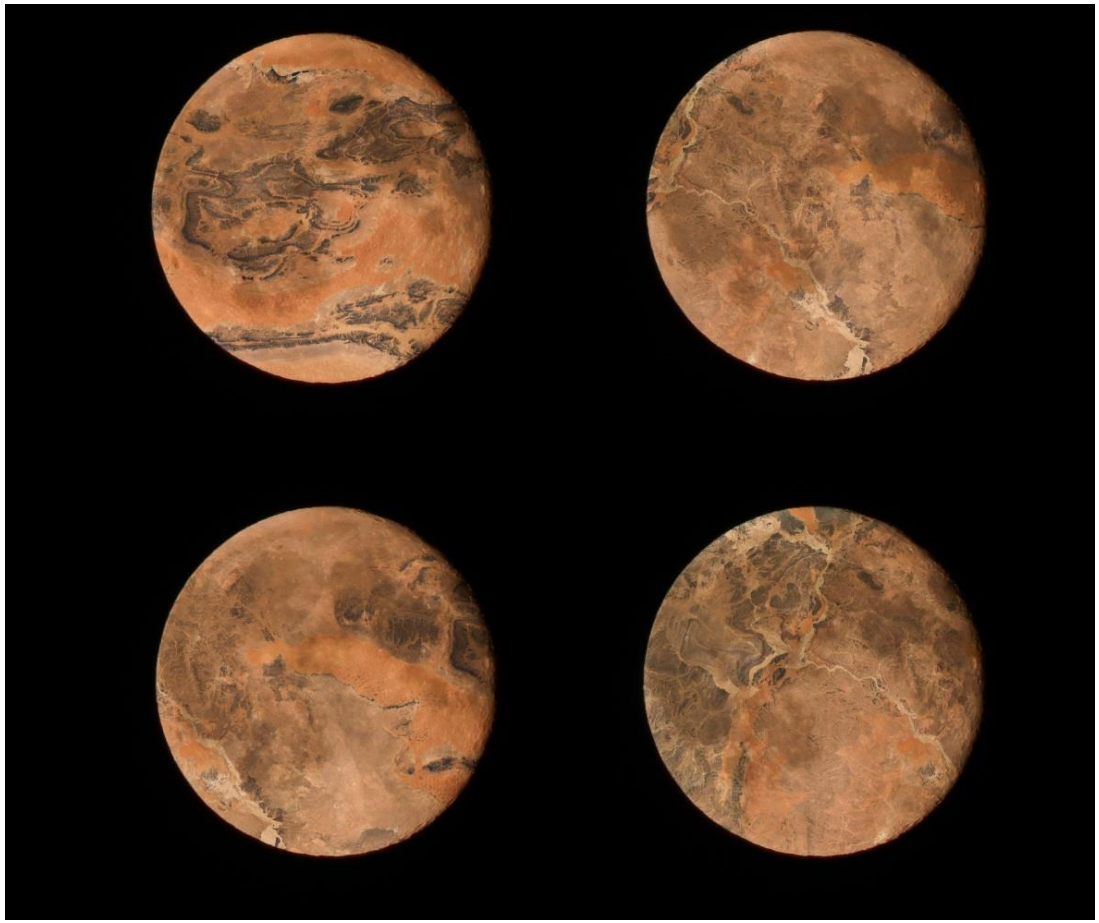


Image: Phases of the planet, during one complete revolution.

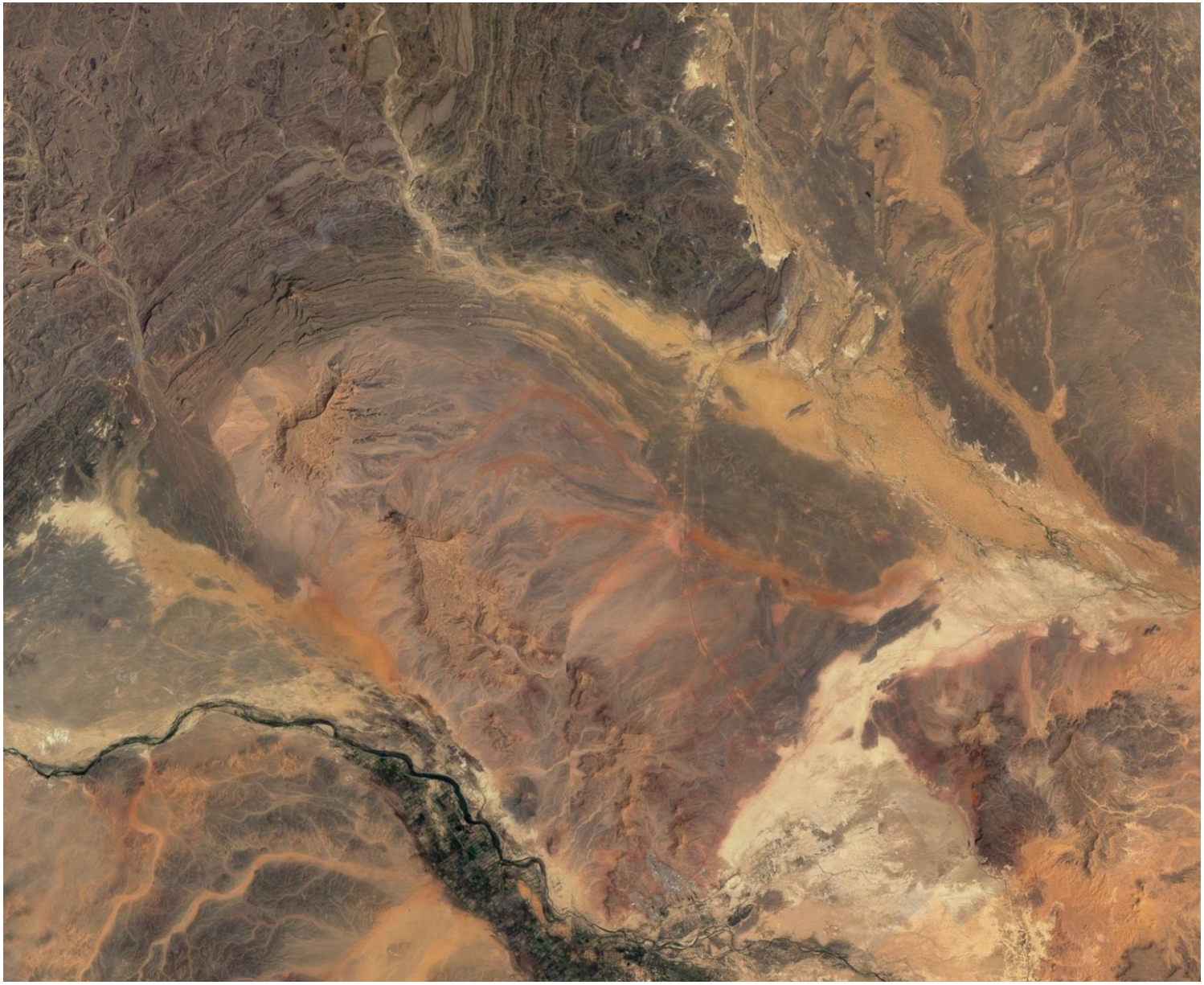


Image: Aerial photo of exo-planet surface (Oceanus Draconis region)

Image: Parnassos, the largest of the two exo-moons of Kepler 90i's. Shown in a full moon.

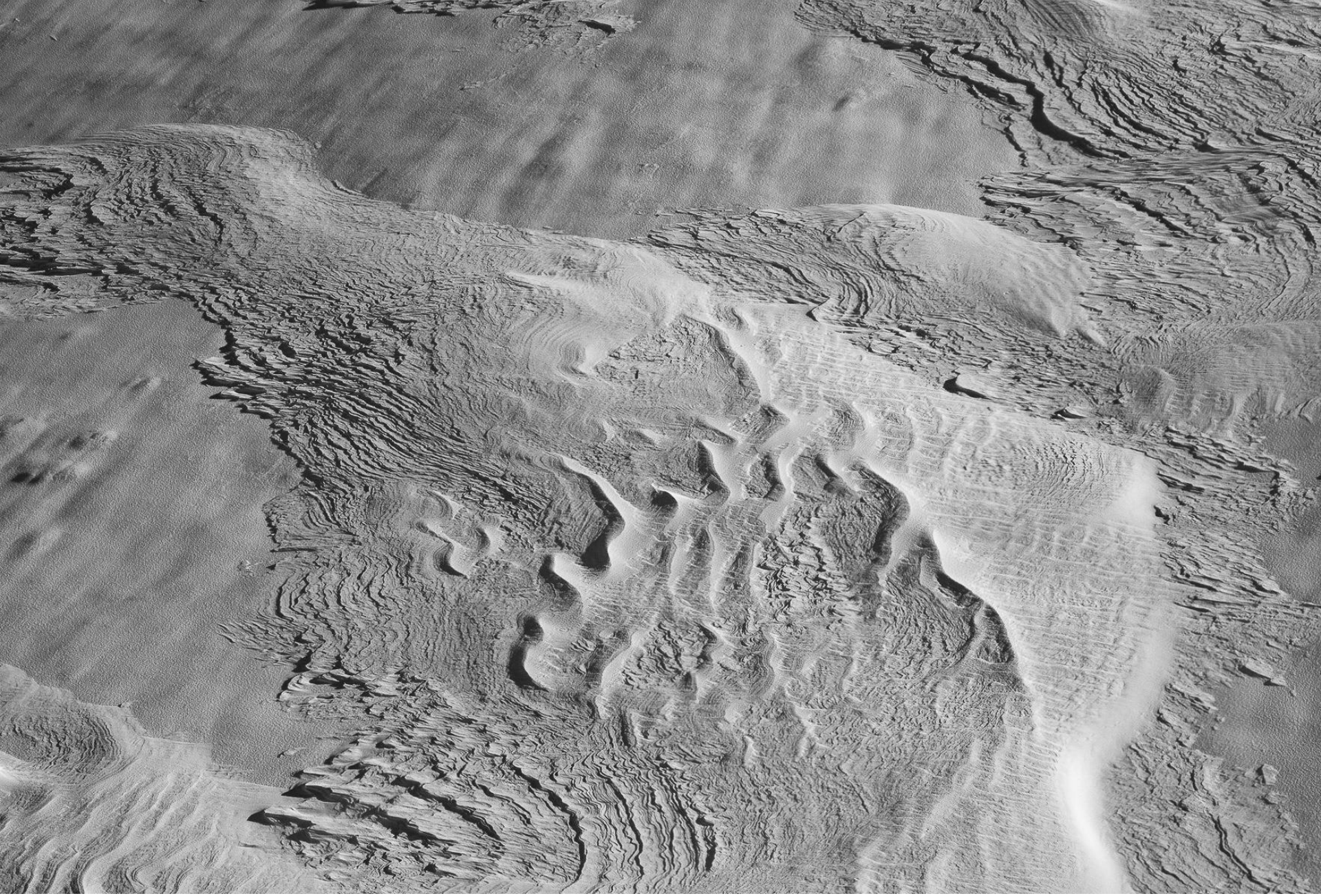
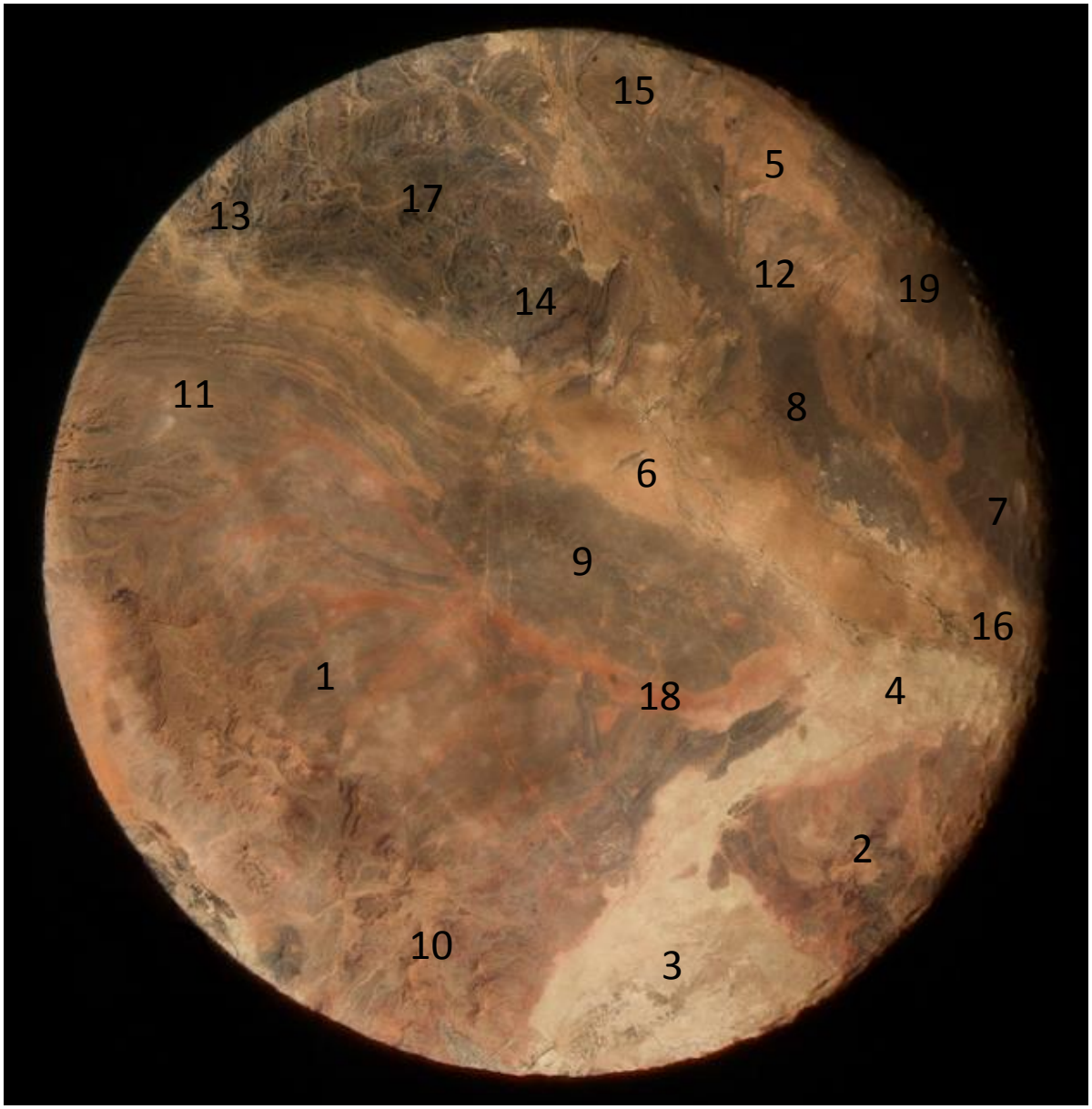


Image: Surface photo of Parnassos, one of the two Kepler 90i's exo-moons. Western Vidit mountain complex , possibly an active volcanic region.

Kepler 90i – Geographic Regions (Eastern Hemisphere)



Oceanus Draconis	1
Oceanus Vesperum	2
Vallis Fulva	3
Vallis Mala	4
Vallis Vaporum	5
Vallis Insomniae	6
Mare Nubium	7
Mare Electrogenense	8
Mare Quadraginta	9
Mare Keplerense	10
Mare Lapidis	11
Mons Noctis	12
Mons Horti	13
Mons Rammos	14
Montes lucustarum	15
Montes Mendacium	16
Montes Atlantis	17
Promontorium Caliginis	18
Lacus Resonantiae	19

Kepler 90

The true garden of the Hesperides

Atmosphere and Terra

Atmosphere and Lithosphere

Kepler 90i Atmosphere

The atmosphere of Kepler 90i is composed of the gases such as: Oxygen (O_2), Hydrogen (H_2), Nitrogen (N_2), fluorine (F_2), Chlorine (Cl_2) , Chlorine dioxide (ClO_2), Dichlorine monoxide (Cl_2O), Alkanes (C_nH_{2n+2}). The exact composition of the atmospheric gases is yet unknown, however, the yellow/orange color observed indicates a strong presence of Nitrogen, Fluorine and Chlorine vapor compounds that attenuate of the blue light due the mechanisms of absorption of specific wavelengths.

Kepler 90i Lithosphere

Lithosphere of Kepler 90i presents resemblances with Earth's lithosphere. Its lithosphere includes the crust and the uppermost mantle, which constitute the hard and rigid outer layer of the exoplanet. The lithosphere is subdivided into tectonic plates. The uppermost part of the lithosphere that chemically reacts to the atmosphere, hydrosphere and biosphere through the "soil" forming process is the planet's pedosphere and it is the foundation of terrestrial life. Kepler 90i's pedosphere is extended few kilometers above the mantle. There is an abundance of chemical elements and minerals on the planet including silica (SiO_2), Cobalt(III) ammine complexes $Co(NH_3)^{3+}_6$, Lead(II) iodide (PbI_2), numerous other Carbon (C), Silicon (Si), Selenium (Se) and Tellurium (Te) compounds.

Image: Aerial photo of exo-planet surface, in the west of Montes Atlantis*. In the top center of the image, a formation of Cumulonimbus incus cloud with a velum edge can be observed. The solid vapor mass indicate presence of aerial life forms.*

Image: photo of exo-planet surface, hills on Pyrra island located in northern Mare Lapidis region . On the right slope of the hill, an unidentified superficial structure (or formation) can be observed.

Image: photo of the exo-planet surface, Rammos hills in the area of Mandacium Mountains, possibly an active volcanic region.

Abiogenesis

The earliest life on the Kepler-90i is expected to be existed more than 2.5 billion years ago. A biogenic graphite in 2.7 billion-year-old metasedimentary rocks from southwestern Locustarum mountains and microbial mat fossils found in 2.48 billion-year-old sandstone from Rammos mountains are within the first abiogenetic findings. Evidence of early life in rocks from Pyrra Island, near the Isua supracrustal belt in southwestern Keplerense sea, dating to 2.7 billion years ago have shown biogenic carbon isotopes. In other parts of the Isua supracrustal belt, graphite inclusions trapped within garnet crystals are connected to the other elements of life: oxygen, nitrogen, silicon, cobalt, carbon and possibly phosphorus in the form of phosphate, providing further evidence for life 2.7 billion years ago.

At Strelley Pool, in the Pilbara region of Western Vesperum ocean, compelling evidence of early life was found in pyrite-bearing sandstone in a fossilized beach, that showed rounded tubular cells that oxidized sulfur by photosynthesis in the absence of oxygen. Further research on zircons from Western Atlas suggested that life likely existed on the exo-planet at least 3.1 billion years ago. This finding suggested that there was almost instant development of life after oceans were formed. The structure of the microbes was noted to be similar to bacteria found near hydrothermal vents and provided support for the hypothesis that abiogenesis began near these vents.

These evidences puts the origin of life on exoplanet Kepler-90i chronologically around 1 billion years after the first evidences of life found on planet Earth.

Image: Abiogenetic environment on sulphidic hydrothermal vents *on Kepler 90i.*

Image: Abiogenetic Formations (Stromatolite fossil).

Image: Echo lake (Lacus Resonantiae), ambiogenetic formations in salt waters

Kepler 90

The true garden of the Hesperides

Fauna - Flora - Mineralia

Exo-Biochemistry

Life forms live in every part of the planet biosphere, including soil, clouds, minerals hot springs, inside rocks at least 19 km deep underground, the deepest parts of the ocean, and at least 64 km high in the atmosphere. Under certain test conditions, life forms have been observed to thrive in the near-weightlessness of space and to survive in the vacuum of outer space Life forms appear to thrive in the Gloriana Trench, the deepest spot in the Kepler 90i's Draconis ocean.

About 49 chemical elements play an active positive role in living organisms on the planet. More than 90% of living matter is built upon only 8 elements: carbon, hydrogen, nitrogen, oxygen, silicon, sulfur, fluorine and chlorine . These eight elements form the basic building blocks of virtually all life on Kepler 90i.

Biodiversity is key characteristic on the planet, where carbon and non-carbon biochemistries are not only co-exist, but also interact. The majority of the life forms are based on carbon biochemistry and share the same basic structural and metabolic functions as the life forms on Earth. However the presence of two other families of lifeforms belonging two distinct taxonomy domains, based on silicon and mineral biochemistries respectively, make this eco-system unique.

Mineral Based Life

Various metals, together with oxygen, can form very complex and thermally stable structures rivaling those of organic compounds; the heteropoly acids are one such family. Some metal oxides are also similar to carbon in their ability to form both nanotube structures and diamond-like crystals (such as cubic zirconia). Titanium, aluminum, magnesium, and iron are all more abundant in the Kepler 90i's crust than carbon.

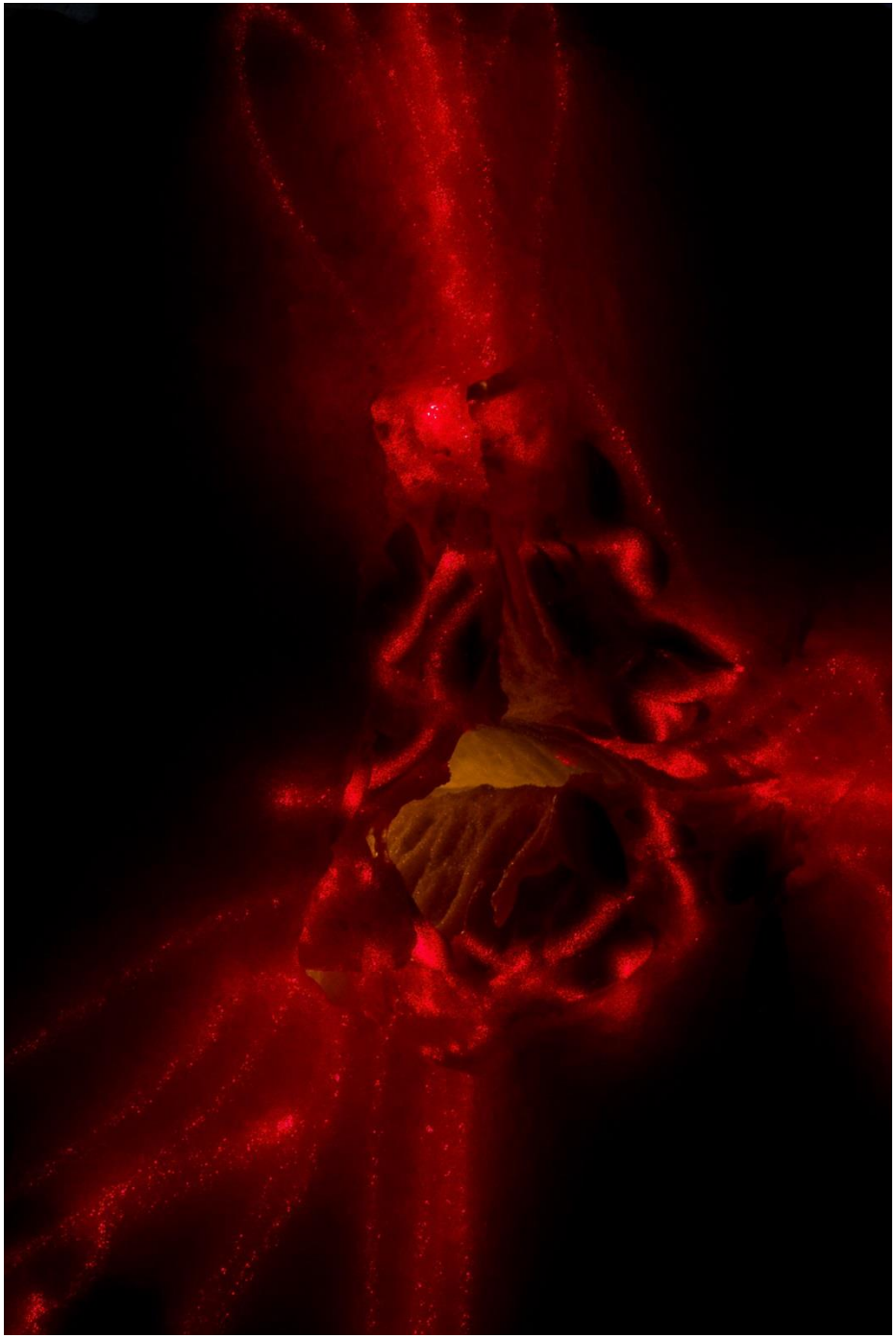
In its simplest form, tungsten polyoxometalates are self assembled into cell-like spheres (inorganic-chemical-cells or iCHELLs). By modifying their metal oxide content, the spheres can acquire holes that act as porous membrane, selectively allowing chemicals in and out of the sphere according to size playing the role of mineral life building blocks. The major characteristics of mineral based life are the allotropy, polymorphism and metamorphism.

Silicon Based life

Silicon-based life can exist on a very hot planet with a hydrogen-rich and oxygen-poor atmosphere like Kepler 90i, allowing complex silane chemistry with reversible silicon bonds with selenium or tellurium.

The element of Silicon which presents very similar chemical properties to carbon, it can form four bonds and it can be found in abundance in the surface of Kepler 90i. According to the Clay hypothesis, silicate minerals in water are playing a crucial role in abiogenesis: they replicate their crystal structures, interacted with carbon compounds.

Biogenic silica is used by some indigenous life forms, such as the silicate skeletal structure of diatoms. Carbon–silicon bonds have been added to biochemistry processes by using directed evolution (artificial selection). A major characteristic of silicon based life is Bio-luminance.



Metamorphic Process

Metamorphic mineral life forms arise from the transformation of existing rock types, in an self-intentional process called metamorphism. The original rock (protolith) is generating extensive heat and inner pressure, causing profound physical and chemical change. The protolith may be a sedimentary, igneous, or existing metamorphic rock.

The metamorphic mineral is usually take the form of other silicon or carbon based life forms by the process of mimetic metamorphosis for the purposes of physical camouflage, interspecies communication, interspecies competition, or even recreational activities.

The term metamorphism must not be confused with Metasomatism which is the unintentional chemical alteration of a rock by hydrothermal and other fluids. It is the replacement of one rock by another of different mineralogical and chemical composition. The minerals which compose the rocks are dissolved and new mineral formations are deposited in their place. Dissolution and deposition occur simultaneously and the rock remains solid.

The behavior of metamorphosis is mainly a characteristic of the mineral lifeforms, yet it is observed also in the silicon and in the carbon life forms. The exact reasons for this widespread habit needs to be examined, however it is speculated that originate from the symbiotic yet antagonistic eco-system of the planet.

Image: Mineral forest in the region of Noctis mountain. The microclimate of the area provides excellent conditions for the growth of Pyromorphites, Mimetites and Nesosilicates species.

Image: Exo-Biolumiescent Corundum, a crystalline form of aluminium oxide (Al2O3) containing traces of iron, titanium and chromium.

Exo-Bioluminescence

Bioluminescence occurs widely among the indigenous species. With the strict definition of term (“the production and emission of light by a living organism"), and since the species taxonomy differs from that of the planet earth, we should widen the perimeter and to include also species not having carbon based chemistries. Consequently, species emitting light due to other light emitting mechanisms such as Crystallo-luminescence, Photoluminescence and Thermo-luminescence need also to be included in the category of Bioluminescent species. The term Exo-Bioluminescence is proposed to cover the aforementioned case.

Exo-Bioluminescence has several functions in different taxa such as counter illumination camouflage, mate attraction, lure attraction, defense against predators, warning (aposematism), communication (quorum sensing) and Mimicry.

Image: Silicon Monopod

Image: Silicon Polypod

Image: Silicon Polypod in metamorphic stasis

Image: Exo-Biolumiescent phosphophyllite (Serpent's Egg), a rare mineral life form composed of hydrated zinc phosphate. Zn2Fe(PO4)2•4H2O

Image: Photophore Megastoma in quorum sensing state.

Image: In progress metamorphosis of Quarzite (SiO_2 -Fe_2O_3 *) into Photophore Megastoma.*

Exo-Medusae

Exo-Medusae(Aerial Jellies) are alien forms that inhabit the lower atmospheric layers of the Kepler 90i. They do not present any particular intelligence except that of mating etiquette.

Exo-Medusae are softbodied, free-waving aerial animals with a gelatinous umbrella-shaped bell and trailing tentacles. The bell can pulsate to acquire propulsion and locomotion. These animals vary from bell-shaped to the shape of a thin disk, scarcely convex above and only slightly concave below. The upper or aboral surface is called the exumbrella and the lower surface is called the subumbrella; the mouth is located on the lower surface, which may be partially closed by a membrane extending inward from the margin (called the velum). The digestive cavity consists of the gastrovascular cavity and radiating canals which extend toward the margin; these canals may be simple or branching, and vary in number from few to many. The margin of the disk bears sensory organs and tentacles.

Exo-Medusae. Reproduction

Exo-Medusae reproduce both sexually and asexually. Upon reaching adult size, Exo-Medusae spawn daily given enough food. In most species, spawning is controlled by light, so the entire population spawns at about the same time of day, often at either dusk or dawn. Exo-Medusae are usually either male or female (with occasional hermaphrodites). In most cases, adults release sperm and eggs into the surrounding water, where the (unprotected) eggs are fertilized and mature into new organisms.

After a growth interval, the polyp begins reproducing asexually by budding and, in the Scyphozoa, is called a segmenting polyp, or a scyphistoma. Budding produces more scyphistomae and also ephyrae. Budding sites vary by species; from the tentacle bulbs, the manubrium (above the mouth), or the gonads of hydromedusae. Polyps asexually produce free-swimming ephyra, which then become a medusa. New specimens float away from the polyp and then grow. Some polyps can asexually produce a creeping frustule larval form, which then develops into another polyp.

In a few species, the sperm swim into the female's mouth, fertilizing the eggs within her body, where they remain during early development stages. In moon jellies, the eggs lodge in pits on the oral arms, which form a temporary brood chamber for the developing planula larvae.

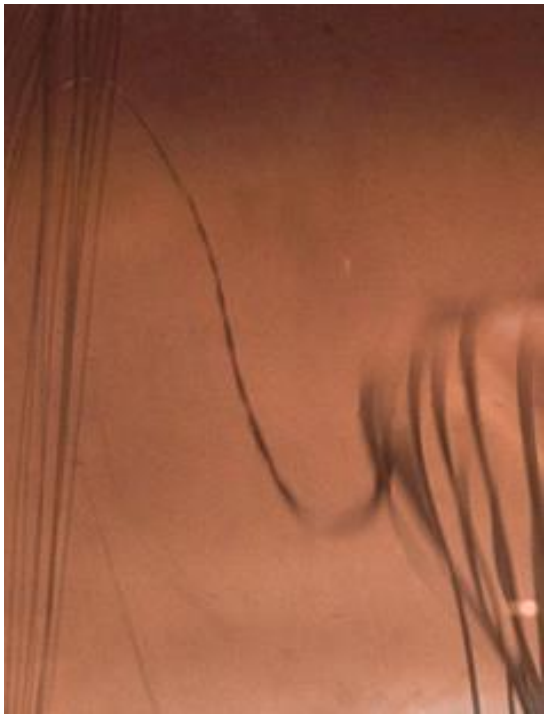


Image: details on Exo-Medusae reproductive organs

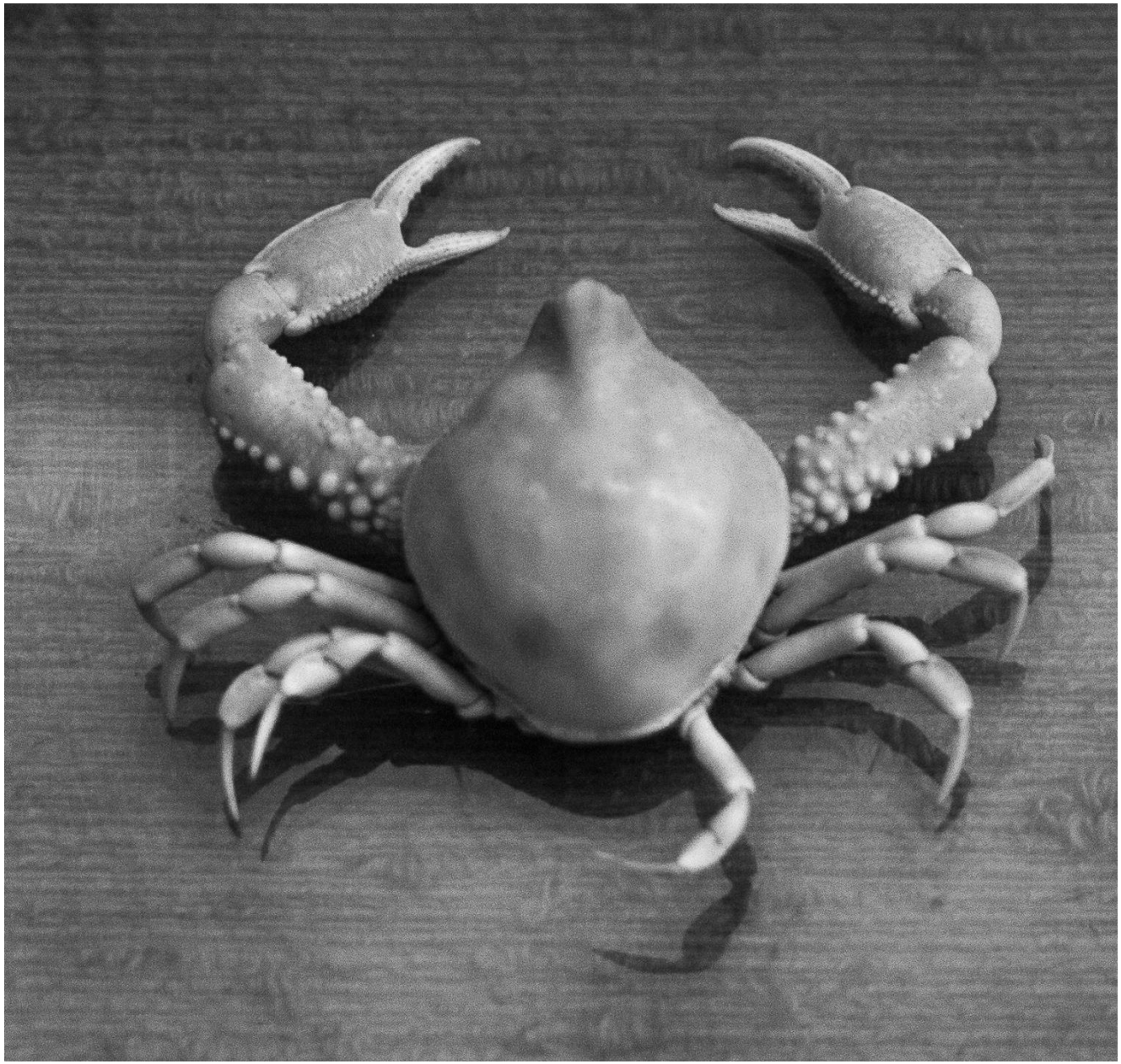


Image: Mineral symbiotic decapod crustaceans (nano-species)

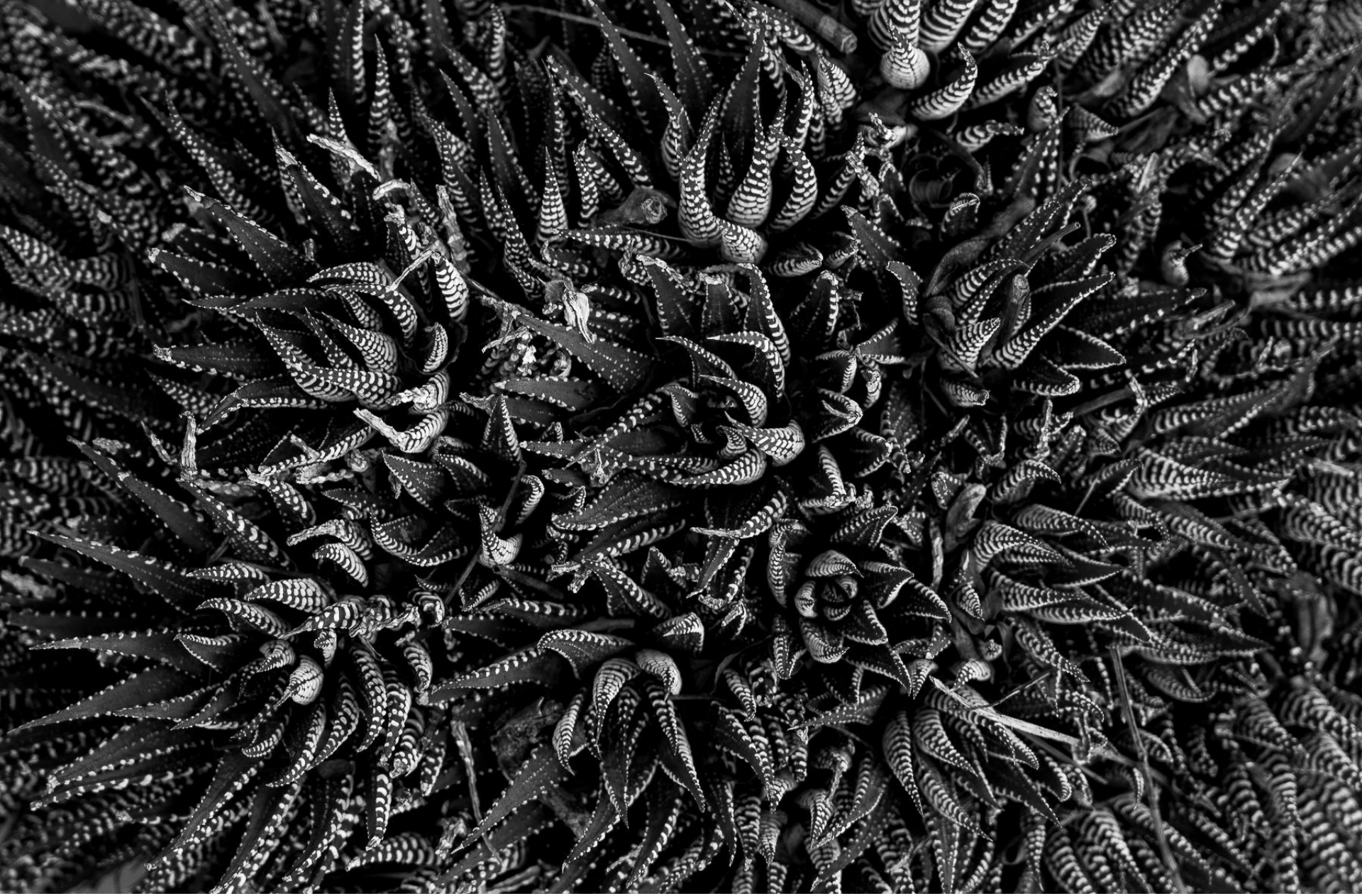


Image: Mineral symbiotic miliapod crustaceans (nano-species)

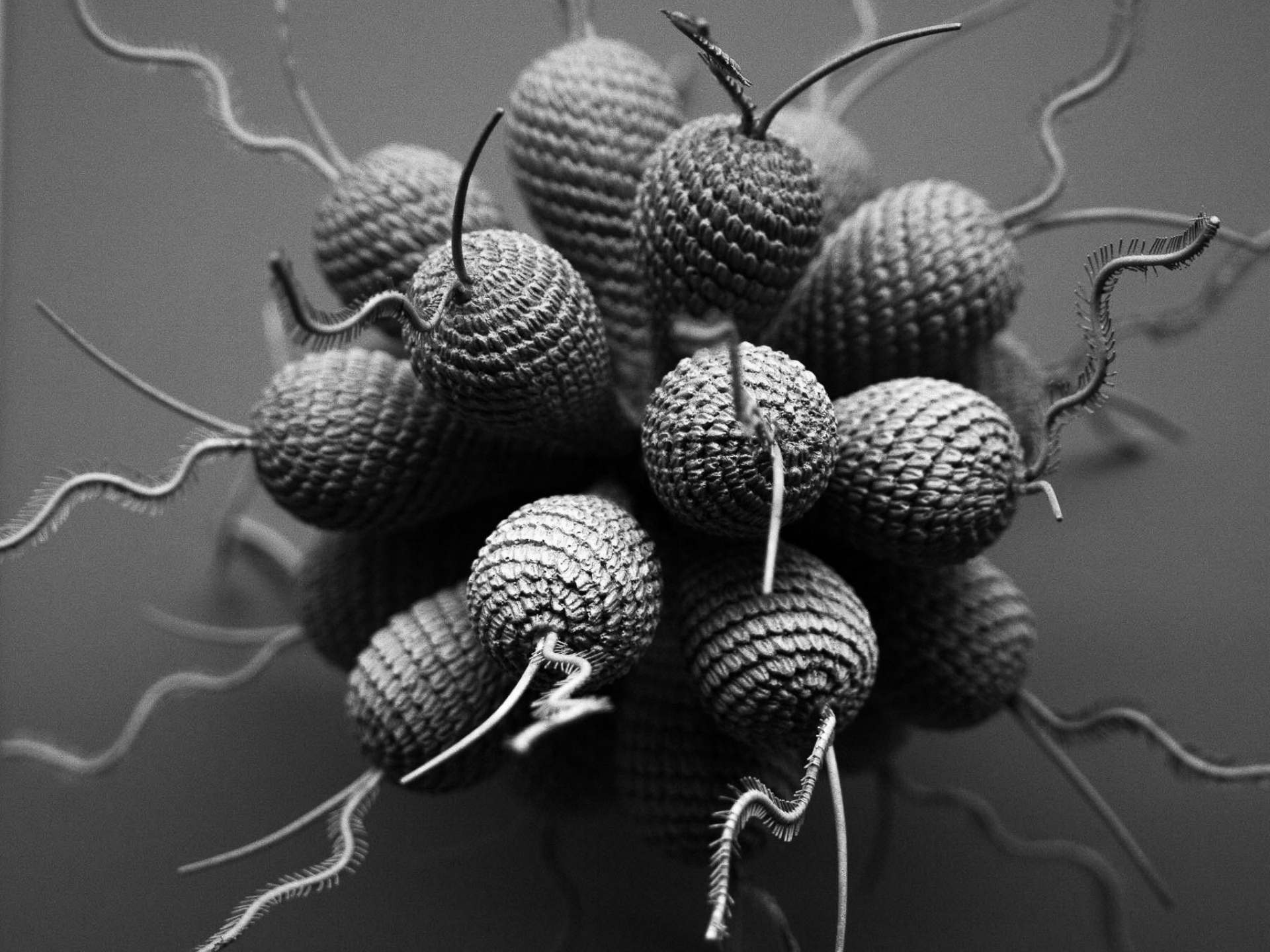


Image: Carbon Based plants (Embryophyta)

Image: Carbon Based exoskeleton plants (Embryophyta Armis)

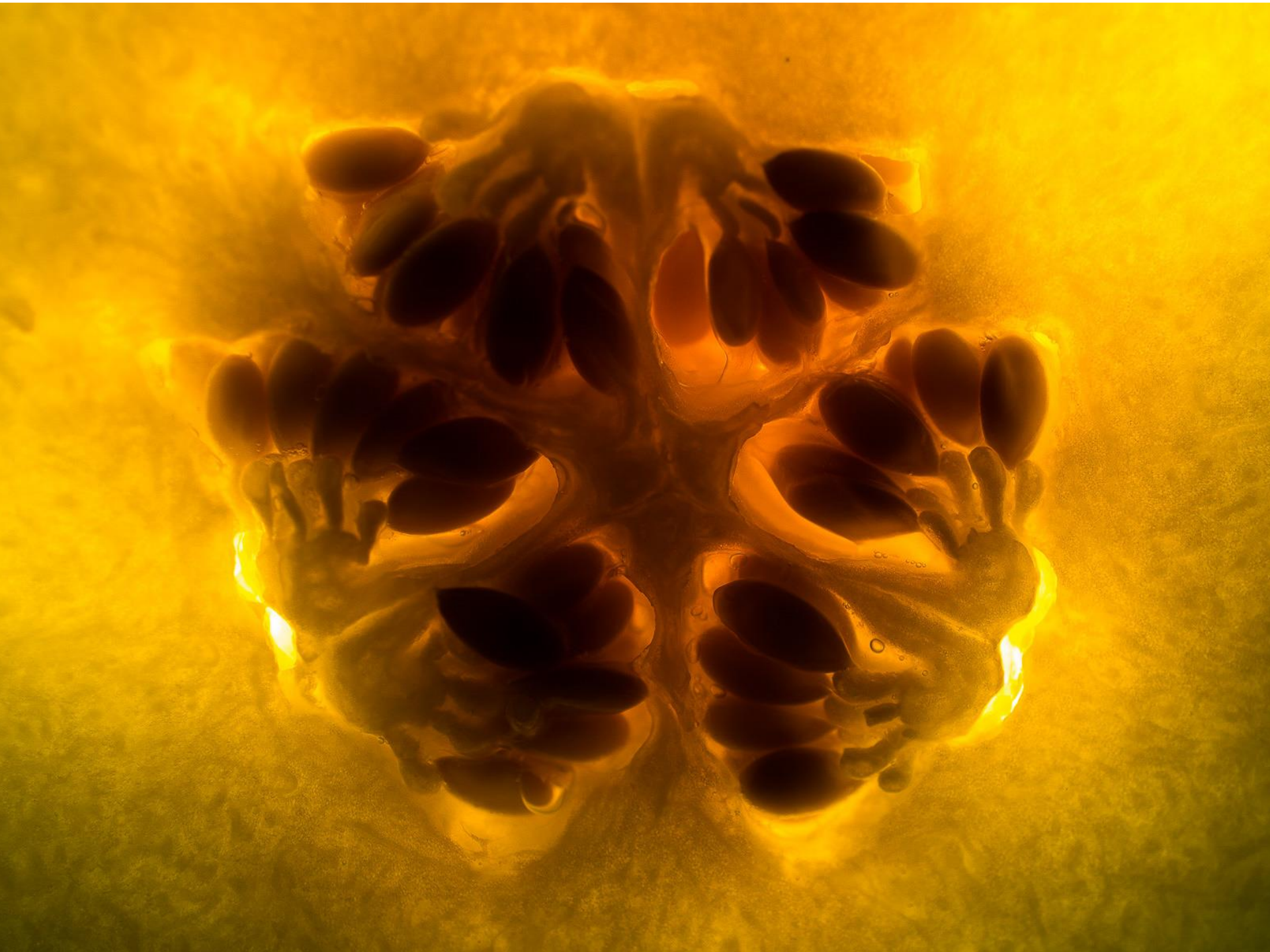


Image: Helium bird

“One is startled towards fantastic imaginings by such a suggestion: visions of silicon-aluminium organisms—why not silicon-aluminium men at once?—wandering through an atmosphere of gaseous sulphur, let us say, by the shores of a sea of liquid iron some thousand degrees or so above the temperature of a blast furnace.”

H.G. Wells, 1894:

Kepler 90

The true garden of the Hesperides

An Imaginary Exoplanet Report

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