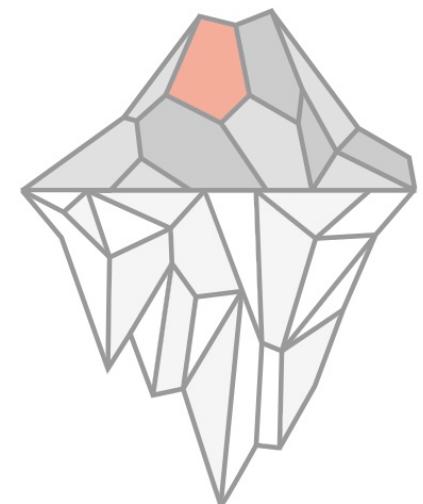


MICROBIAL METABOLISM AND PLANETARY HABITABILITY



INTRODUCTION – HABITABILITY AND GEOENGINEERING

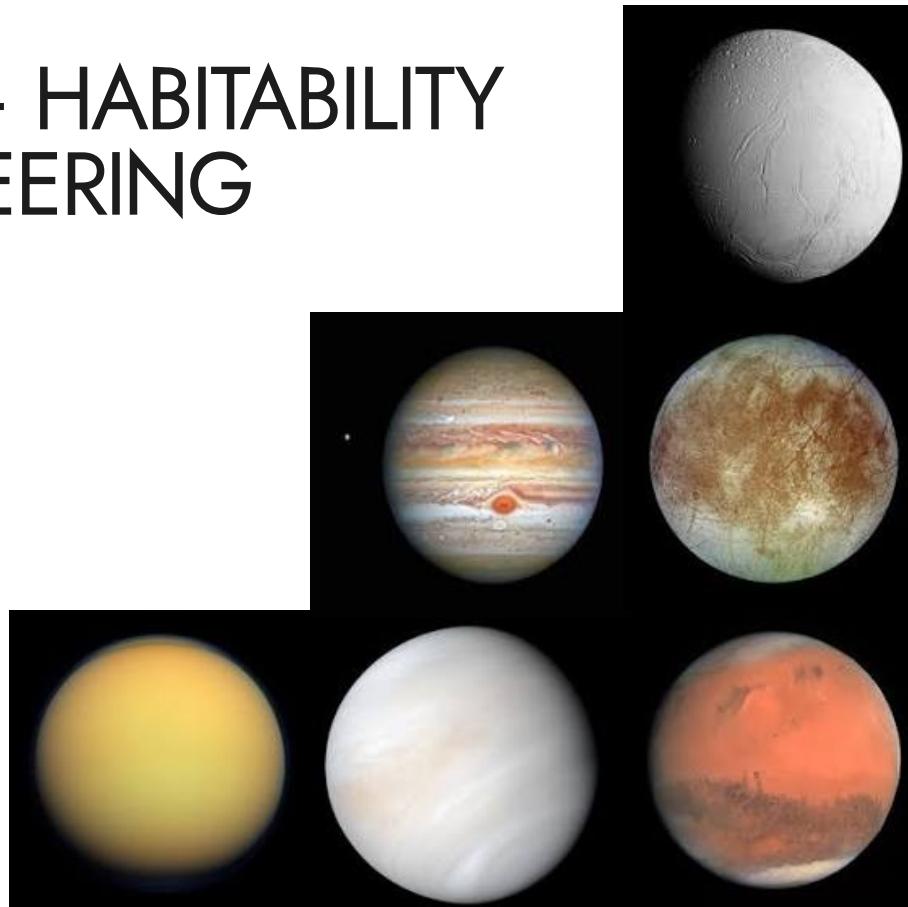
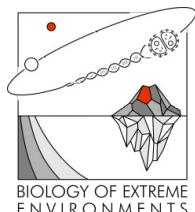
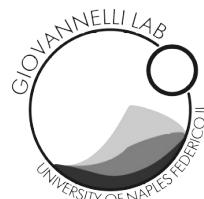
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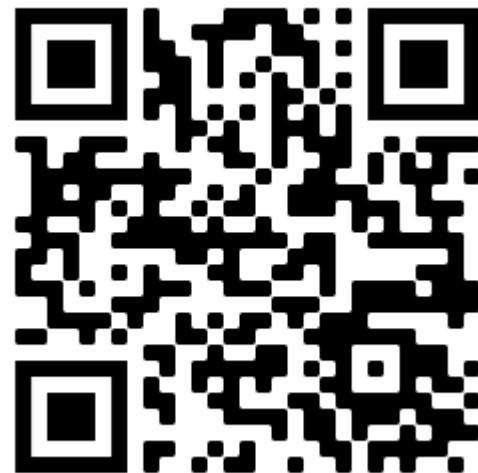
 [@d_giovannelli](https://twitter.com/d_giovannelli)

 [@donatogiovannelli](https://www.instagram.com/donatogiovannelli)



INTRO POLL

<https://forms.gle/hRZvqswAjnnFKbu56>



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This will be a *highly interactive* course. This will be a course designed with a learn-by-doing approach

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Bring your laptop/tablet/cell phone



EXPECTATIONS

I expect active participation in the class activities

I expect full collaboration and an inclusive attitude

Groups for in class activities will be constantly changed

As part of this class I will also introduce a number of general and soft-skill lectures regarding the approach to science and research



MAIN COURSE PROJECT

- Form groups of 2-3 students (*international!*)



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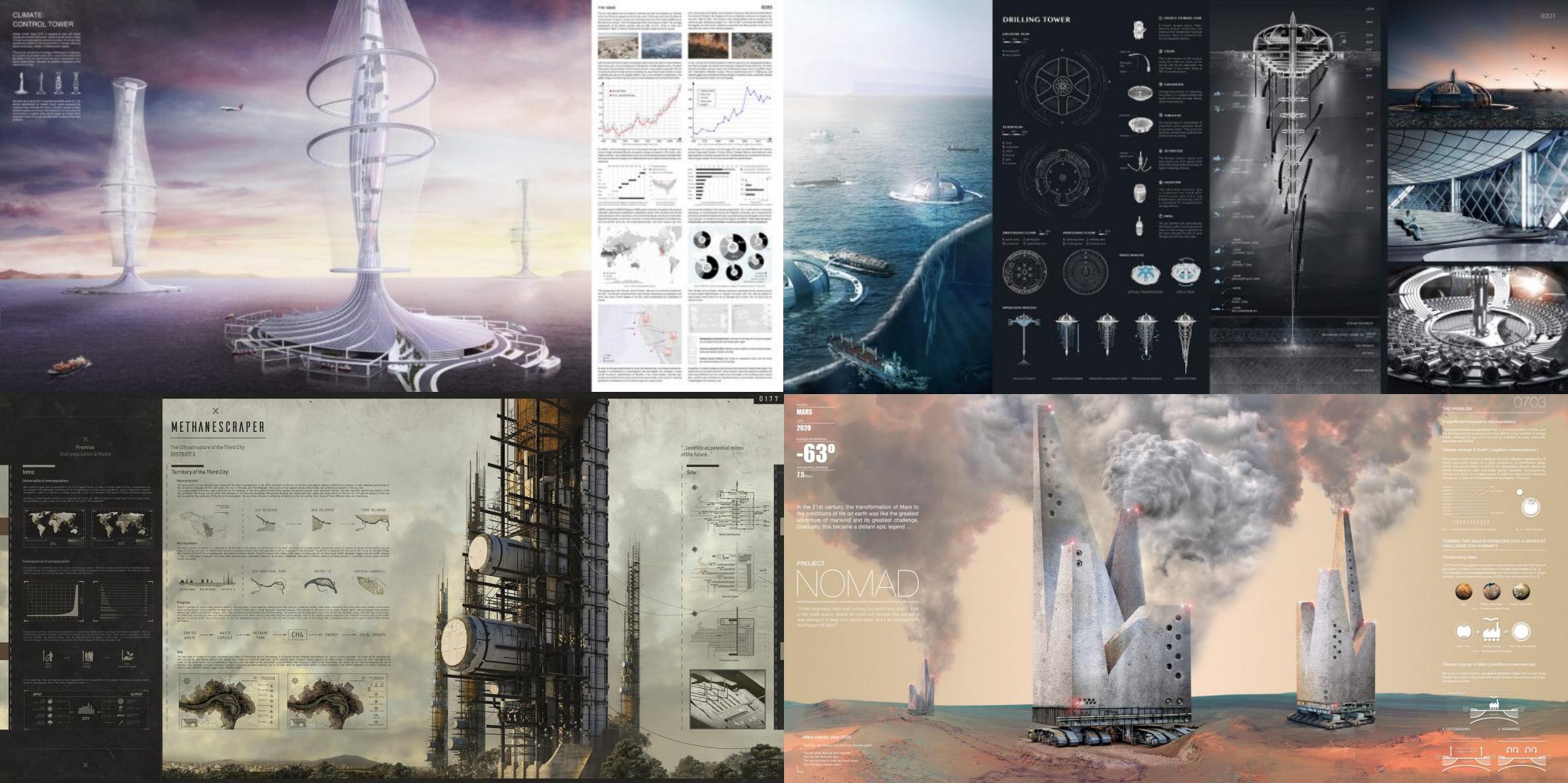
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- Present it as a visual poster the terraforming plan



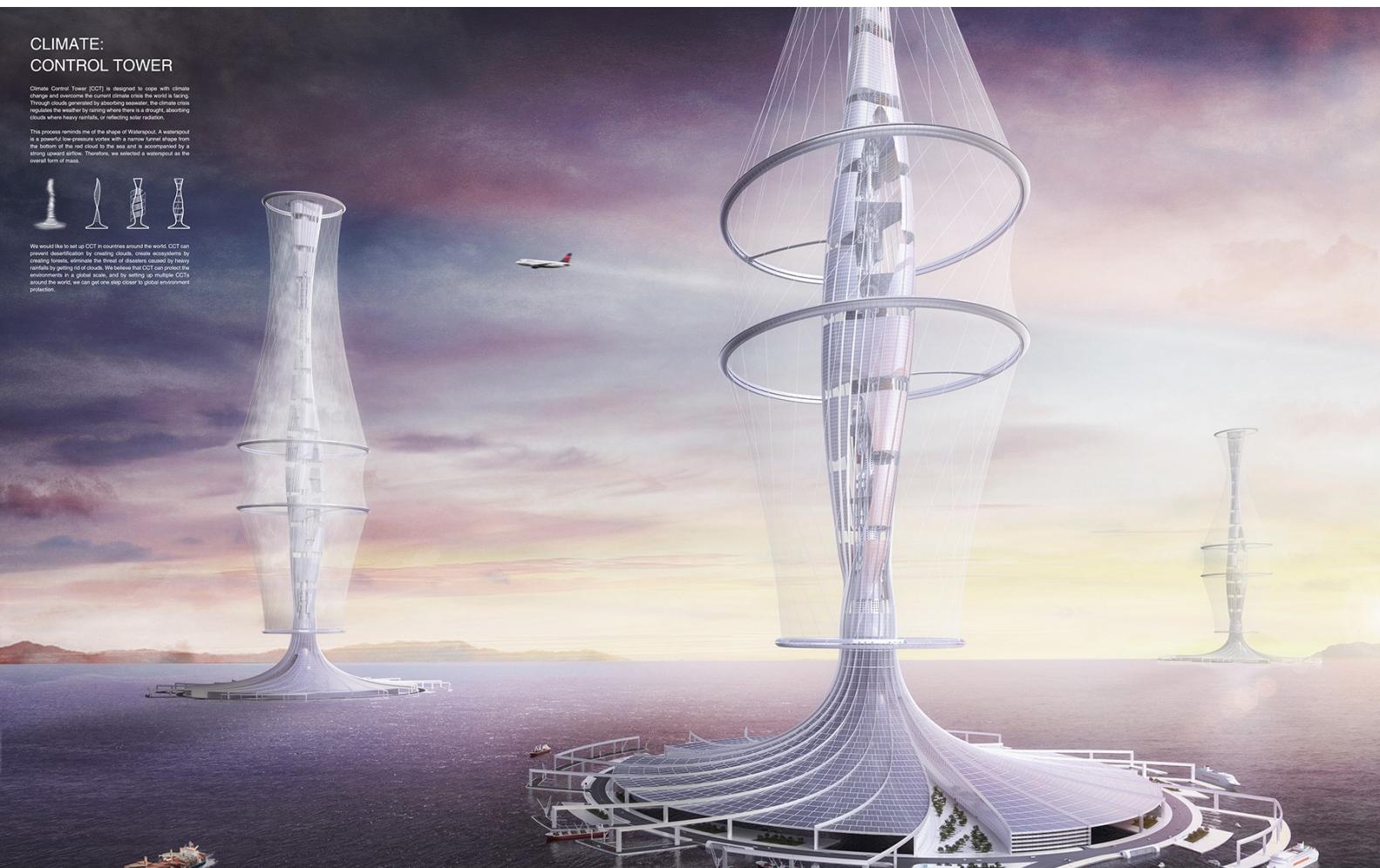
**CLIMATE:
CONTROL TOWER**

Climate Control Tower (CCT) is designed to cope with climate change and overcome the current climate crisis the world is facing. Through clouds generated by absorbing seawater, the climate crisis regulates the weather by raining where there is a drought, absorbing clouds where heavy rainfalls, or reflecting solar radiation.

This process reminds me of the shape of Waterspout. A waterspout is a powerful low-pressure vortex with a narrow funnel shape from the bottom of the red cloud to the sea and is accompanied by a strong upward airflow. Therefore, we selected a waterspout as the overall form of mass.



We would like to set up CCT in countries around the world. CCT can prevent desertification by creating clouds, create ecosystems by creating forests, eliminate the threat of disasters caused by heavy rainfalls by getting rid of clouds. We believe that CCT can protect the environments in a global scale, and by setting up multiple CCTs around the world, we can get one step closer to global environment protection.



THE ISS

The two risk factors that will come into play over the next decade are “Climate change” and “failure to respond to the climate crisis”. 2019 was confirmed the “Second warmest year in history”. Experts are referring to the end of the Earth as 2050 due to the abnormal climate. From the beginning of the 21st century to 2021, the average temperature of Earth’s surface rose by 0.93 °C, which is more than two-thirds of 1980. (A level of temperature increase varies around the world).

Items. According to the global natural disaster frequency table by the United Nations Environment Program, the frequency of natural disasters continues to increase rapidly from 1960 to 2021. This shows a very similar pattern with an increase in the world average temperature graph from 1951 to 2021 announced by NASA. One of the biggest and most known disasters is sea-level rise. Many people are aware that sea-level rise is due to the melting of glaciers.

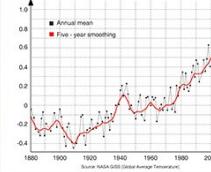


Land temperature has been increasing at about twice the rate of ocean temperatures every year since 1970, up to 0.25 degrees Celsius per decade.

There are many factors influencing climate change. Some people speculate that the increase of carbon dioxide density caused by the use of fossil fuels and the increase in greenhouse gas are the biggest factors. Due to the increase in temperature, the global village is currently facing various natural disasters and environmental problems.

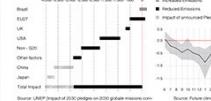
In fact, not only the melting of glaciers near the sea-level, but rising global temperatures have also caused many changes in the sea-level.

For example, heavy rains in July 2021 resulted in 160 deaths in Western Europe. This is a record high rainfall in 1,000 years, and experts judge it as a prelude to climate change. In addition, China and India suffered a lot of damage from heavy rain and flooding.



In addition, various damage, but the most serious damage of climate change to extreme drought and desertification caused by drying up long-term. If only, reclamation of forest, man-made factors such as environmental pollution and deforestation have happened to happen, but desertification due to global climate change is accelerating.

According to the 'countries with the largest IFL loss' by World Resources Institute, several large-scale forests in Russia, Brazil, Canada, Bolivia, and Venezuela were destroyed due to natural causes like fire. A dramatically dry environment due to climate change caused the fire and accelerated the desertification.



UNEP's [Impact of 2000 Pledges on 2020 global missions compared with previous nationally determined contribution submissions] shows that countries around the world are aware of the importance of environmental issues and move to solve them. Despite these global movements, however, environmental disasters and desertification around the world are still rising exponentially, and some experts say that environmental problems have already progressed a lot. In other words, awareness and policy on environmental issues are important naturally, but a movement to solve environmental problems through a groundbreaking technological and architectural approach is needed and should be applied worldwide. Then, how can we architecturally prevent desertification as well as persistent natural disasters?



The answer lies in the "Climate: Control Tower". We want to control the climate with the CCT. The climate consists of three major factors: temperature, precipitation, and wind, and most of them appear in the sky, which emphasizes the importance of clouds.

The "Climate: Control Tower" absorbs seawater to generate clouds, sending clouds to areas where desertification or drought continues. CCT can also be placed on cloud routes where there is a lot of damage due to snow, rain, or heavy rain to absorb clouds.





DRILLING TOWER

LOCATION PLAN
0 50m 100m
A. energy port
B. ferry station

FLOOR PLAN
0 50m 100m
A. hotel
B. restaurant
C. office
D. library
E. gym
F. museum

SIGHTSEEING FLOOR 0 50m
A. guest room
B. restaurant
C. dining bar
D. sightseeing trails

PROCESSING FLOOR 0 50m
A. collecting area
B. crushing area
C. melting area
D. drawing area

SPACE ANALYSIS
VERTICAL TRANSPORTATION CIRCLE SPACE

OPERATION PROCESS

- COLLECT PLASTIC
- 3D PRINTING RUNNING
- PRINTING UNDERSEA FLOOR
- PRINTING BIOSENSOR
- COMPLETE FORM

① ENERGY STORAGE TANK
A closed, opaque space. High-density plastic materials can withstand low pressure and high pressure, which is convenient for storing liquefied methane.

② CRANE
The crane moves on the surface to collect plastic waste around the energy tank by the telescopic rod and claws. It can rotate freely at 360° in a fixed position.

③ CONVERTER
Through the process of collecting, the plastic is crushed,melted and converted into high-density 3D printing material.

④ THRUSTER
The energy tower is composed by 12 propellers, which generate thrust to move the tower, pushing the building forward and stabilize the position during mining.

⑤ 3D PRINTER
The flexible tubular robotic arm and nozzle can print spiral coral structures and other objects according to digital modeling software.

⑥ LIQUEFIER
The absorbed methane gas is collected and sent after purification and ultra-low temperature processing, which is convenient for transportation, storage and use.

⑦ DRILL
The gas hydrate will automatically decompose when the temperature rises, so heat energy is injected into the layer through the drill to send the gas out from the solid state.

DEEP OCEAN LAYER
+125.00
+96.00
+65.00
+25.00
+0.00
-150M CONTINENTAL SHELF
-200M EPICHLAGIC ZONE
-250M NAVY SUBMARINE
-320M SCUBA DIVER
-400M
-460M HARD SUIT DIVER
-500M
-610M ELEPHANT SEALS
-650M MIDNIGHT ZONE
-700M ABYSSOPELAGIC ZONE
-800M
-900M HADAL ZONE
-1000M MIR SUBMERSIBLES

DEEP OCEAN FLOOR
OCEANIC SEDIMENTS
IMPERMEABLE ROCK FORMATION
GAS HYDRATE
OILFIELD
GROUNDWATER

DEEP OCEAN TOWER
+125.00
+96.00
+65.00
+25.00
+0.00
-150M
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Premise:
Overpopulation & Waste

Intro:

Universality of overpopulation

Very soon all regions of the planet will be the largest "towns" of today. In a large number of cities, overpopulation can be observed. This is due to the fact that the strength of existing social infrastructures causes a reduction in economic development, resulting in a reduction in available resources, as well as an increase in the amount of waste and harmful substances.

According to United Nations statistics, it is predicted that by the year 2050 the planet will inhabit over 9 billion people, where the percentage of urban society will exceed 70% of the world's total population.

Consequences of overpopulation

Overpopulation can potentially have very serious consequences, some of which are already reflected in the indisputable problem of global warming, the disappearance of certain natural habitats and pollution of the natural environment. The reduction of limited natural resources, such as drinking water, fertile land and fossil fuels.

Program

District 3 contains six waste towers (vertical) containing seven temporary concrete pools that serve as a temporary landfill, each having an industrial area, toxic waste area, multiple control rooms and a sustainable energy system. They are made of steel, concrete, glass and plastic, being recycled and reused. The towers are built by hand, using traditional methods. The workers are the Roma people. The work they do does not differ much from the job that most Roma already know how to do. Roma collectors have been doing the job for decades. Part of the company could be employed in the transport of waste, part of the landfill and sorting facility. Since Roma are one of the most marginalized groups in the city with very bad income status, part of the energy that is produced could be used to power some of their informal settlements.

SITE:

...landfills as potential mines of the future...

Territory of the Third City:

Macrocontext

The macro-context of the analyzed region represents the place of juxtaposition of the three "situations" of the city, its presence and complete absence, manifested in relations of built-inhabited coastal areas of the old and new Belgrade and the "void" across the river - "Old, New, and Third Belgrade". The results of the research include defined urban and architectural elements of the new city. Two main research questions are the analysis of the macro-structure of the city and the analysis of the micro-structure of the city. The macro-structure of the city is the analysis of the relations of the new settlement with formed entities within the confluence of the Sava into the Danube and Novi Beograd with Zemun and urban, spatial and visual identity of the new city. Through the analysis of the form and re-examining the significance of the city in its development, the new urban structure is acting like an addition to the two existing cities. Areas of three different cities are shown below.

Microcontext

The initial structure of District 3 is connected to the left bank of the Danube, on land east of the Great War Island. Six strategic points, such as the centers of genesis of typical vertical facilities, are the pillars of the new city core. An infrastructure network is developed around them, which generates a further urban plan of the settlement. The district is connected with the rest of the city by the Pančevo Bridge. Main function of District 3 is a recycling plant and system of vertical landfills. They are located in the middle of the island, in a free zone not far from Vraca landfill, Belgrade's biggest and only landfill, because of its proximity to the river to transport waste when necessary and a wastewater connection can easily established. Since most of Vraca's waste is not recycled, it is possible to move around waste for further processing.

Vertical Landfills

Site Structure

Production Zones

location:

MARS

year:

2020

average temperature:

-63°

atmospheric pressure:

7.5 Mbar

In the 21st century, the transformation of Mars to the conditions of life on earth was like the greatest adventure of mankind and its greatest challenge. Gradually, this became a distant epic legend ...

PROJECT

NOMAD

@VoloMagazine #OverPopulation #GlobalWarming #Mars #ProjectNomad #Factories #Terraforming

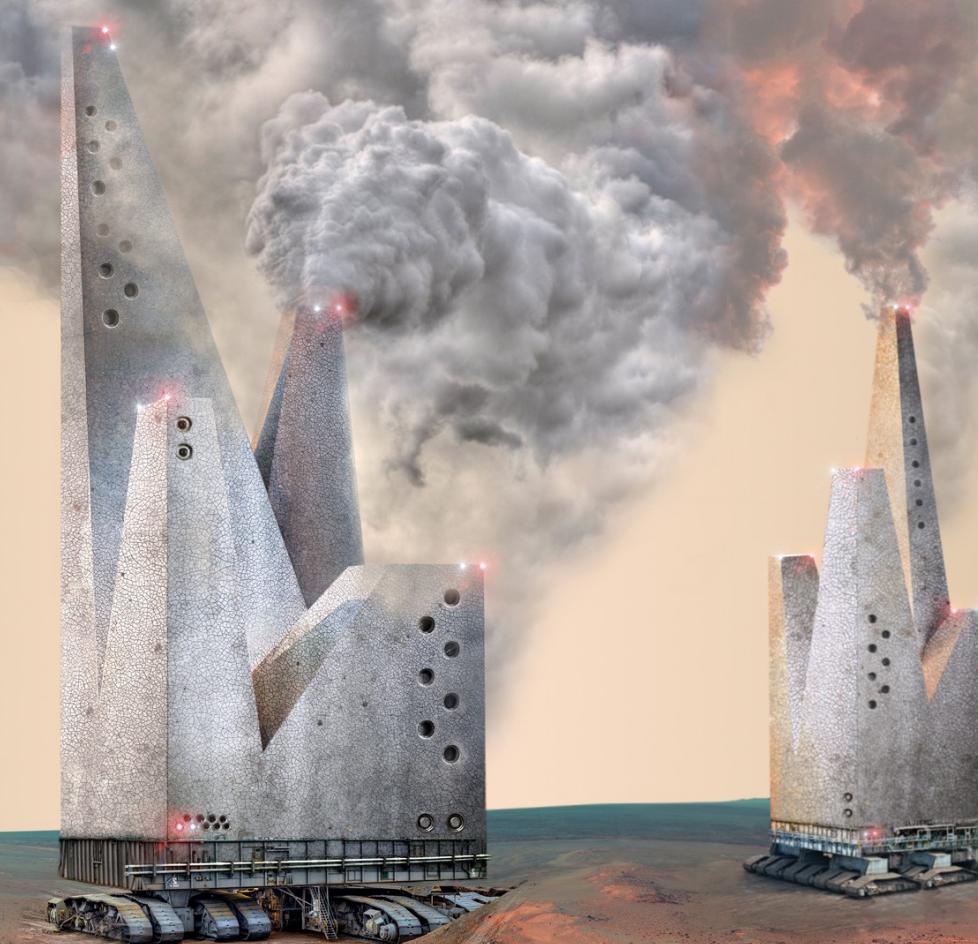
"In the beginning there was nothing but rocks and dust ... Lost in the great space, where life could not venture, the red world was resting in a deep and glacial sleep. But it all changed with the Project NOMAD"

...

Mars planet, year 2020

One day, the nomad factories tore the sky apart.

The air grew warmer and warmer.
The clouds filled the sky.
The ground shook over and over again.
Then the blue waters came.



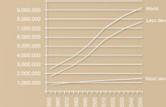
THE PROBLEM

A significant increase in the population

The global increase in population (Fig. 1), its concentration in cities, and the development of emerging countries lead to a big increase in energy needs. Although oil, gas and coal will be available for many years still, resources are limited.

Climate change in Earth [negative consequences]

The planet is known to have undergone dramatic climatic changes (Fig. 2) which have been linked, by a large consensus, to greenhouse gases (GHG). The concentration of GHG in the atmosphere directly affects the global temperature, with potentially global, dramatic consequences. Without any doubt, it is indispensable to define an objective of maximum emissions, in order to limit problems in the future in the earth.



TURNING TWO MAJOR PROBLEMS INTO A GREATEST CHALLENGE FOR HUMANITY

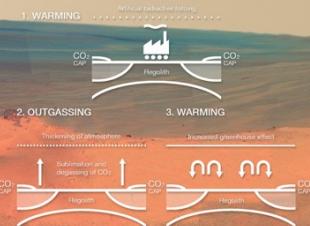
Terraforming Mars

The Project Nomad goal is to change the atmospheric and soil chemistry of the planet to make it more hospitable for human colonization (Fig. 3). The concept is to build nomad factories that use martian minerals to create complex carbon greenhouse gases (CH₄) in the atmosphere (Fig. 4).



Climate change in Mars [positive consequences]

We know to warm planets, our goal is to terraform Mars from a cold, dead planet into a warm, vital planet with green forests, blue oceans and a sustainable ecosystem.



EXAM AND FINAL PRIZE

The final exam will consist of the discussion and defense of your terraforming project

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Poster will contribute to 70% of final grade, presentation 30%

EXAM AND FINAL PRIZE

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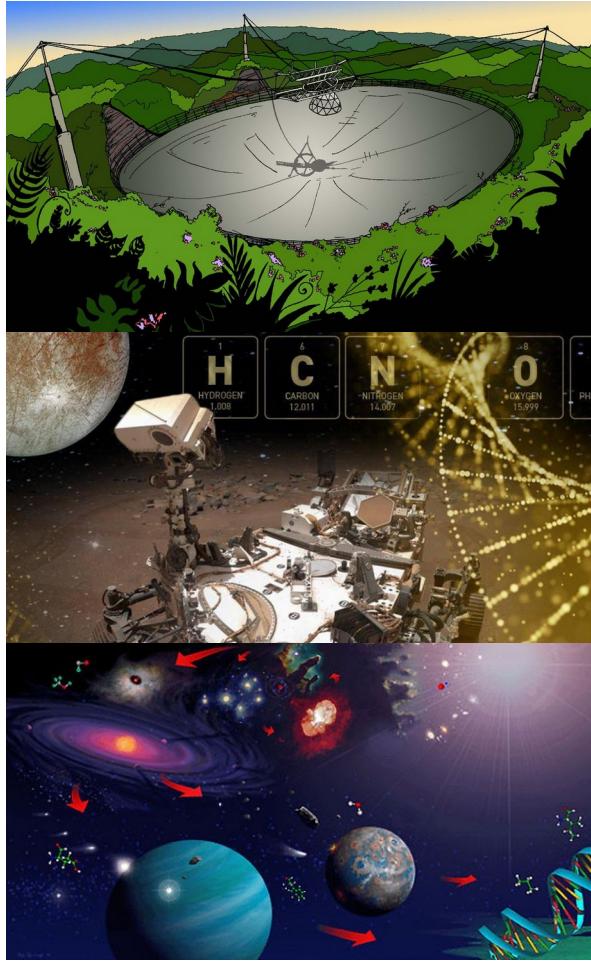
The winning poster will be presented at an international conference



International Geochemical Society
Goldschmidt 2023 - Lyons



GOLDSCHMIDT[®]
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9-14 JULY

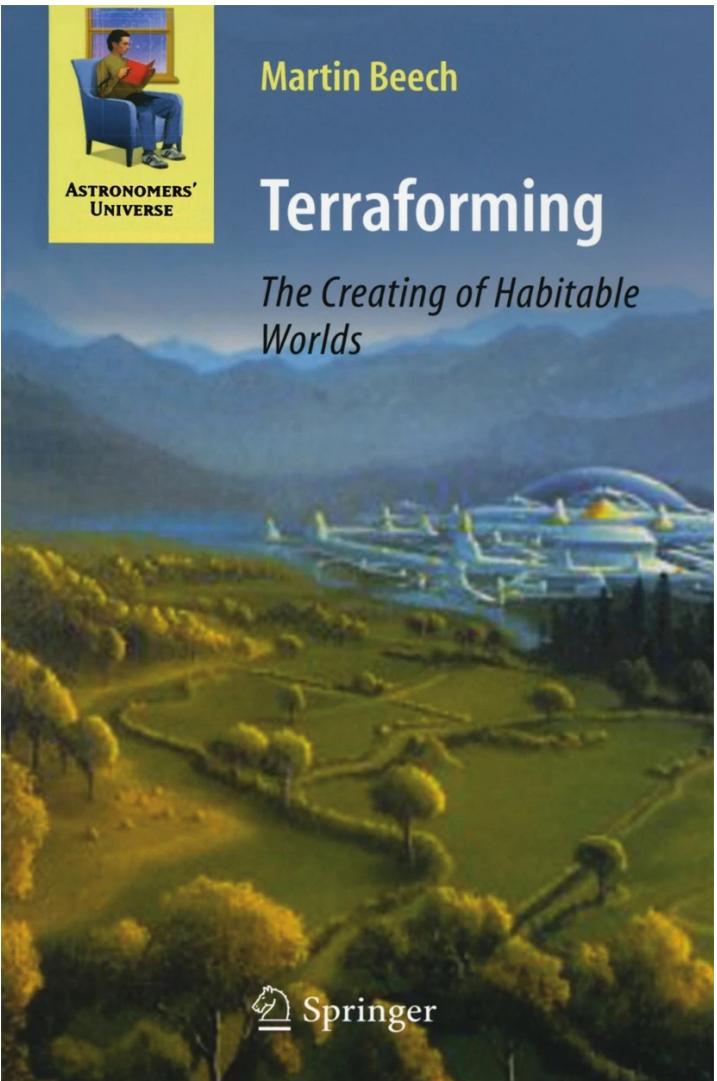


Astrobiology Science Conference
AbSciCon 2024





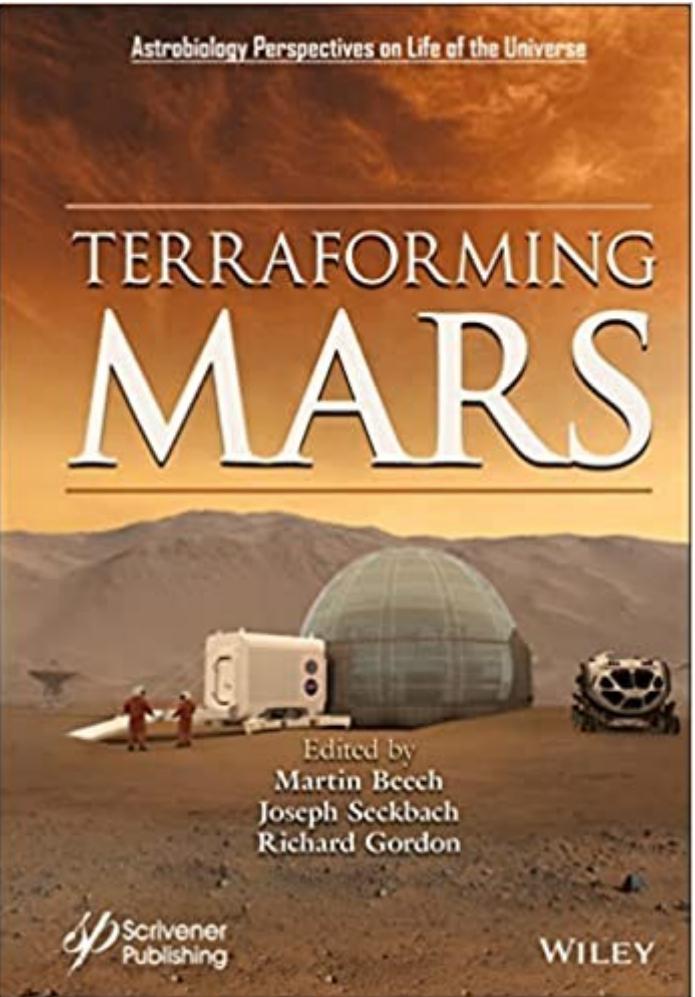
COURSE MATERIAL AND IN-DEPTH READINGS



Terraforming
*The Creating of Habitable
Worlds*

Beech

2009 Springer



Terraforming Mars

Beech, Seckbach, Gordon

2022 Wiley Edition



MICROBIAL METABOLISM AND PLANETARY HABITABILITY



Life or life

Write a definition of Life



Life or life

“It is commonly said,” the scientists Frances Westall and André Brack wrote in 2018, *“that there are as many definitions of life as there are people trying to define it.”*

- *Empirical definitions of Life*
- *Physical definitions of Life*
- *Life as Information*
- *Darwinian definition fo Life*
- *Life as a Process*

The Definition of Life: A Brief History of an Elusive Scientific Endeavor

Stephane Tirard, Michel Morange, and Antonio Lazcano 

Published Online: 16 Dec 2010 | <https://doi.org/10.1089/ast.2010.0535>



Published: 29 January 2011

Why I stopped worrying about the definition of life... and why you should as well

Edouard Machery 

Synthese 185, 145–164 (2012) | [Cite this article](#)



Mol Biol Rep. 2021; 48(8): 6223–6230.

Published online 2021 Jul 27. doi: [10.1007/s11033-021-06594-5](https://doi.org/10.1007/s11033-021-06594-5)

What is life?

Jaime Gómez-Márquez 

Published: June 2004

A Universal Definition of Life: Autonomy and Open-Ended Evolution

Kepa Ruiz-Mirazo, Juli Peretó & Alvaro Moreno 

Origins of life and evolution of the biosphere 34, 323–346 (2004) | [Cite this article](#)

Perspectives in Biology and Medicine

Volume 53, Number 3, Summer 2010

Johns Hopkins University Press

Article

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Additional Information

Towards a Definition of Life

Peter T. Macklem and Andrew Seely

HYPOTHESIS AND THEORY article

Front. Astron. Space Sci., 18

March 2020

Sec. Astrobiology

<https://doi.org/10.3389/fspas.2020.00007>

This article is part of the Research Topic

Presentations at the 4th Workshop of the German Astrobiological Society (DABG) on Astrobiology, 26–27 September 2019, Vienna, Austria

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What is Life?



Guenther Witzany*



Life or life

Instance vs Phenomenon

Life or life

Instance vs Phenomenon

Instance: an example or single occurrence of something

Phenomenon: something that is observed to occur or to exist, often abstracted to its most general form



Life or life

Instance vs Phenomenon

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life: like life on Earth, can be used to refer to a specific instance of the general concept



Life or life

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Instance: an example or single occurrence of something

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life: like life on Earth, can be used to refer to a specific instance of the general concept

Life: is the universal phenomenon



HABITABILITY

Habitable: suitable and fit for a person to live in

Planetary habitability is the measure of a planet's or a natural satellite's potential to develop and maintain environments hospitable to life



HABITABILITY

Habitable: suitable and fit for a person to live in

Planetary habitability is the measure of a planet's or a natural satellite's potential to develop and maintain environments hospitable to life

Habitable vs Inhabited

DIFFERENT HABITABILITIES



Homo sapiens

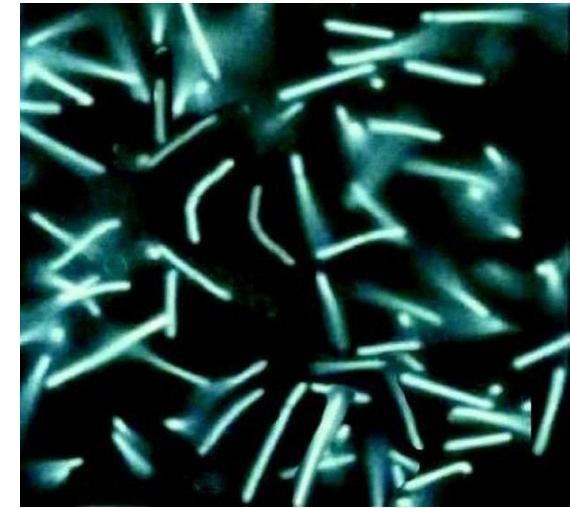
Human habitability (and mammals habitability in general) requires a narrow range of conditions

DIFFERENT HABITABILITIES



Homo sapiens

Human habitability (and mammals habitability in general) requires a narrow range of conditions



Methanopyrus kandleri

Microbial habitability and have a very broad (or narrow) set of conditions under which can thrive

DIFFERENT HABITABILITIES



Natural Habitability

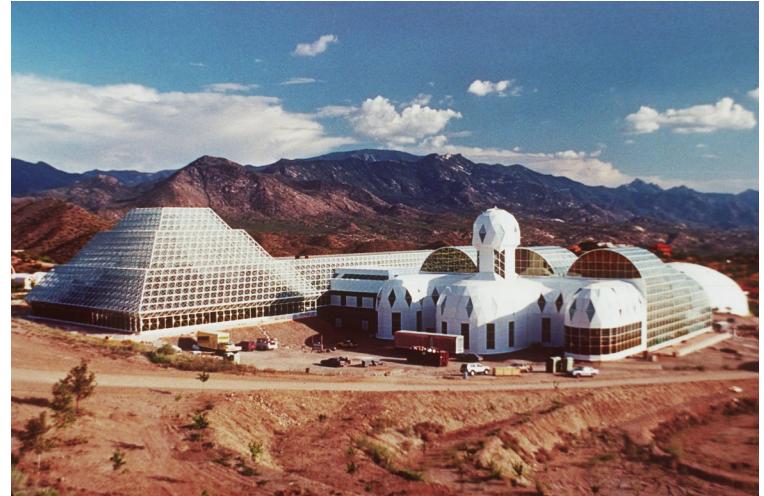
An environment or ecosystem that meets the habitability requirement for a given species/community without the need for technological sustaining

DIFFERENT HABITABILITIES



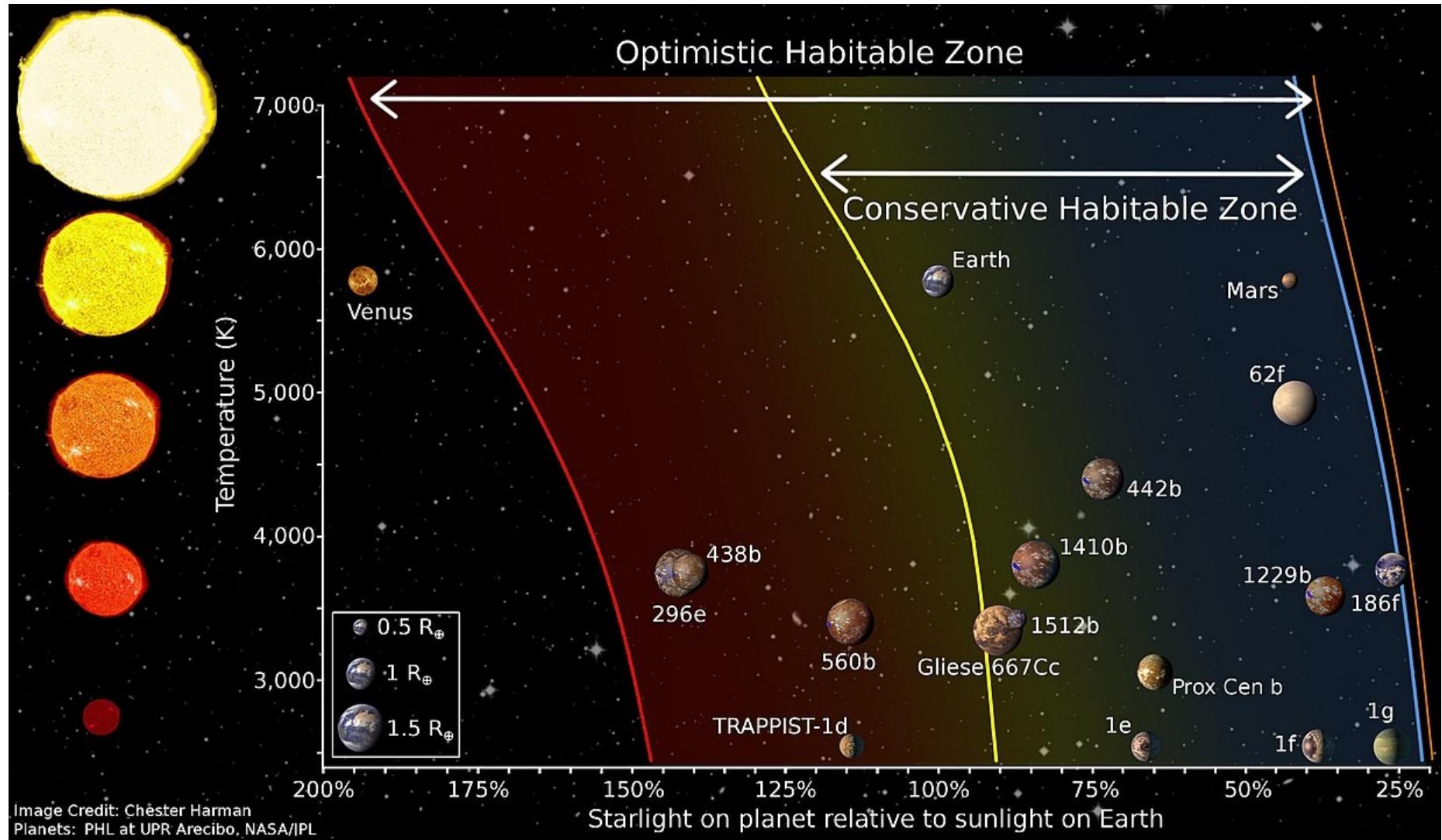
Natural Habitability

An environment or ecosystem that meets the habitability requirement for a given species/community without the need for technological sustaining



Technological Habitability

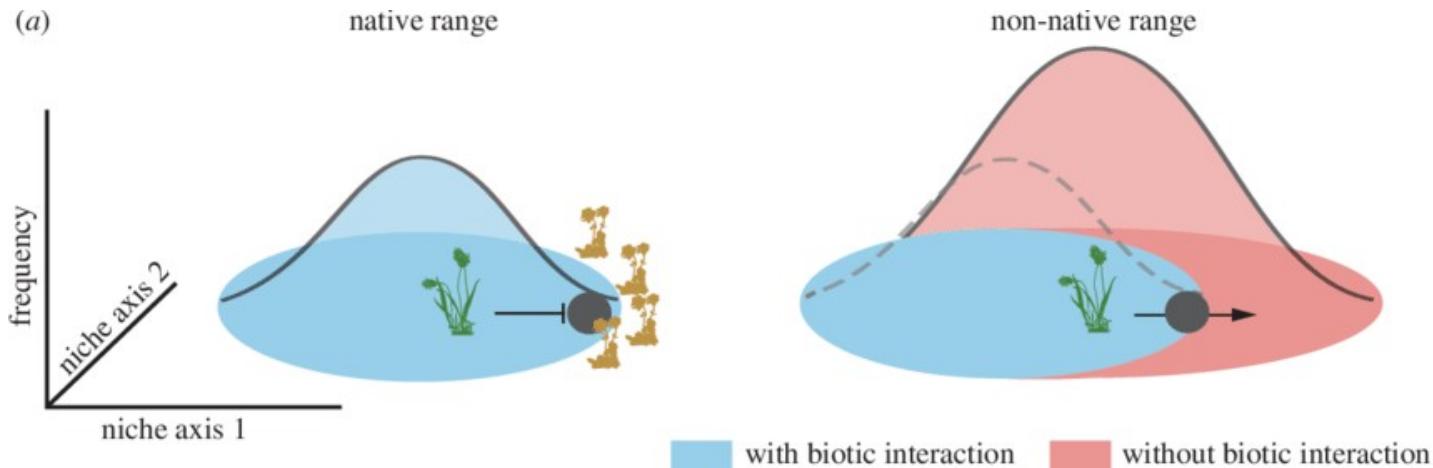
The use of technology (life-support systems) to overcome limitations in the conditions naturally found in an environment/ecosystem



ECOLOGICAL NICHE

In ecology, a *niche* is the match of a species to a specific environmental condition. It describes how an organism or population responds to the distribution of resources and competitors.

The type and number of variables comprising the dimensions of an environmental niche vary from one species to another and the relative importance may vary according to the geographic and biotic contexts.



NICHE CONSTRUCTION

Niche construction is the process by which an organism alters its own (or another species') local environment. Alterations are generally physical change to the environment. Alterations are often beneficial to the constructor, but not always.

For niche construction to affect evolution it must satisfy three criteria:

- 1) The organism must significantly modify environmental conditions
- 2) The modifications must influence one or more selection pressures
- 3) There must be an evolutionary response caused by the environmental modification



EXTENDED PHENOTYPE

The set of environmental modifications produced by organisms related to the extended phenotype concept that may persist for longer than the individual constructors, and may continue to modulate the impact of these effects on subsequent generations of the same or other populations, even driving macroevolution over geological timescales. (1982 Richard Dawkins)





HABITABLE PLANET CLASSIFICATION

Class I planetary bodies with liquid water available at the surface, along with sunlight, so that complex multicellular organisms may originate

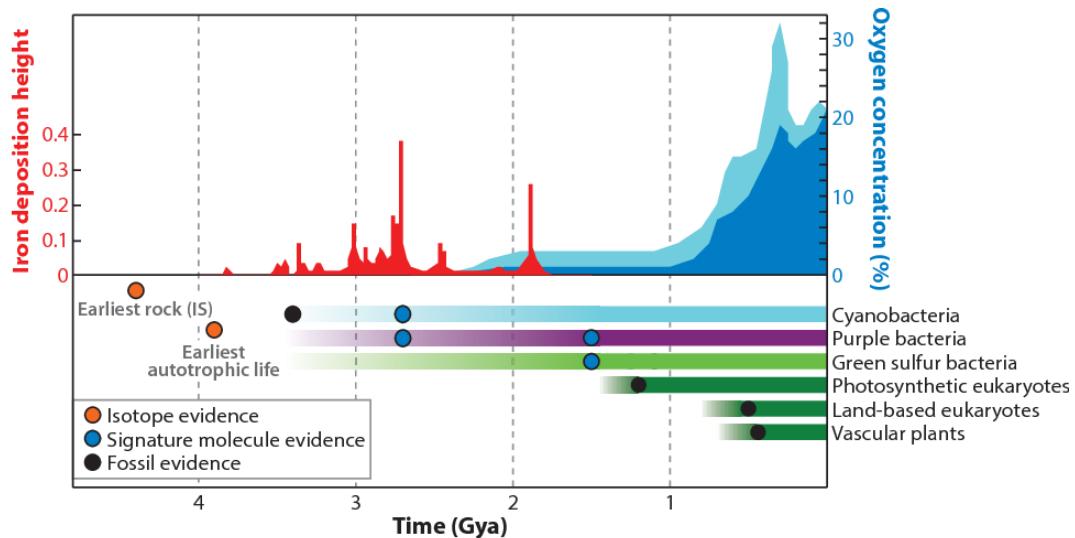
Class II planetary bodies that lost their ability to sustain liquid water on their surface over time and never developed complex life

Class III planetary bodies where liquid water oceans exist below the surface, where they can interact directly with silicate-rich rocks

Class IV planetary bodies where a liquid water layers is between two ice layers, or liquids above ice, so that water cannot interact with silicate-rich rocks

ECOLOGICAL INHERITANCE

Ecological inheritance is the passing on to descendants of inherited resources and conditions, and associated modified selection pressures, through niche construction. Ecological inheritance has significant implications for macroevolution.





Water	Inventory of water in different phases Activity of liquid water Past or future liquid and ice inventories Salinity, pH, and Eh of available water
Chemical Environment	C, H, N, O, P, S and building blocks Essential metals and micronutrients Availability/mineralogy Toxic substances Active recycling of elements and volatiles
Energy for metabolism	Solar energy (surface and near-surface only) Geochemical/Geothermal (near-surface and subsurface) Availability of oxidants and reductants Redox gradients and redox recycling
Physical conditions	Temperature fluctuation (daily, seasons) Low pressures Ultraviolet and cosmic radiation shielding Climate stability (short term and long term) Transport (aeolian, atmosphere, hydrology, erosion rock cycling)