NASA Bio Mimicry Project

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ARTIST CONCEPT OF THE MARS ONE HABITAT ON THE RED PLANET

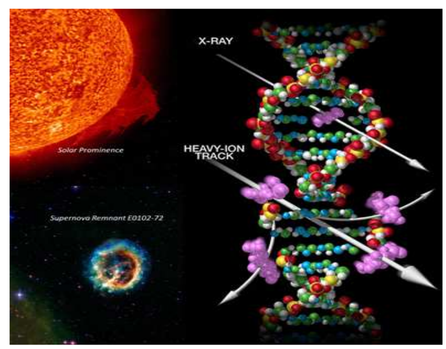
Shelter on Mars

September 29th, 2016

How can humans live on Mars?

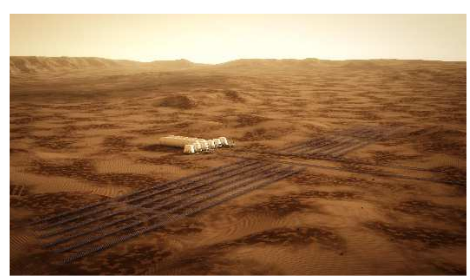
By Robert Dumitru

Humans have always been trying to discover new way to explore extreme environments on earth, whether it be the inside of a volcano or the top of Mount Everest, but the human body can only take so much before it fails. This is why structures and objects are needed in order for humans to be able to explore new extreme environments, the more extreme the environment, the more protection will be needed. The most extreme environment that humans have yet to explore is our neighbor planet Mars. In order to sustain life in general humans need many things. "Space is a dangerous place to send complicated, delicately tuned systems, and "perhaps the most complex system of them all is the human body," said health specialist Saralyn Mark, president of SolaMed Solutions. [1]" In order to survive on mars we need a shelter that can protect the human body from the sun and the atmosphere of Mars. Without the protection of the earth's magnetic field solar radiation would accumulate in the body of the human and that would raise the risk of cancer [2]. Also Mars can get extremely cold, reaching minus 125 degrees Celsius at times, temperatures no human can naturally survive. If a number of humans should live on Mars they can't be expected to wear a space suit the entire time, so they will need a shelter to sleep, eat and live in, that can maintain the living conditions needed. One challenge is building on Mars is



Ensuring crew safety

Outside of the Earth's protective magnetosphere, astronauts are at risk from exposure to radiation from solar particle events and high-energy galactic cosmic rays. Cell and tissue damage caused by exposure to these types of radiation are distinct from that caused by terrestrial radiation sources such as x-rays, and the biological consequences are poorly understood [5].



Life on the Red Planet

A human settlement on Mars through the integration of existing, readily available technologies from the private space industry [6].

That building on Mars is drastically different then building on earth. "Here on Earth we take the materials in cement and mix it with some crushed stone and water and make this thick slurry paste that we call concrete — Then we can use that to make various structures," says Andrews. "The challenge on Mars, in particular, is that while water has been observed there, it's not present everywhere and maybe not present in areas where you would want to put a landing site. So the way of binding the materials couldn't involve a water-based chemistry like what we use here on Earth. [3]" There are plans to address all these problems however. For one water is a good way to stay shielded from the radiation of the sun and from cosmic rays, and once they are on Mars the shelter can have around 2 meters of Martian soil to protect them from the harmful solar particles. Furthermore, there is a plan to send along rovers which will be fed Martian soil which has ice in it. This ice will be evaporated and make oxygen and take nitrogen from the atmosphere of Mars to create an earth like atmosphere [4]. The easiest way to get power on Mars is the sun (like the solar panels used on the Mars rovers). Therefore it is defiantly logical ideas on how to work around the relatively frail human body to live on Mars in a habitat that will provide shelter and earth-like conditions in order to sustain human life.

Plants were grown in a preliminary experiment comparing (left to right) potting soil, regolith simulant with added nutrients, and simulant without nutrients. [7].

[1]A. Mann, "Why We Can't Send Humans to Mars Yet (And How We'll Fix That)", *WIRED*, 2016. [Online]. Available: https://www.wired.com/2013/05/actually-getting-to-mars/. [Accessed: 30- Sep- 2016].

[2]A. Mann, "Why We Can't Send Humans to Mars Yet (And How We'll Fix That)", *WIRED*, 2016. [Online]. Available: https://www.wired.com/2013/05/actually-getting-to-mars/. [Accessed: 30- Sep- 2016].

[3]J. Ronson, "How NASA is using the hive mind to plan a mars colony," in www.inverse.com, 2016. [Online]. Available: https://www.inverse.com/article/13892-nasa-thinks-a-hive-mind-can-solve-mars-colony-problems-before-rocket-scientists. Accessed: Oct. 2, 2016.

[4] Life on Mars: How a One-Way Martian Colony Project Could Work", *Space.com*, 2013. [Online]. Available: http://www.space.com/23838-mars-one-colony-martian-volunteers.html. [Accessed: 30- Sep- 2016].

[5]"Space Radiation Program", *Dsls.usra.edu*, 2016. [Online]. Available: http://www.dsls.usra.edu/science/research/spaceRad/. [Accessed: 30- Sep- 2016].

[6] Life on Mars: How a One-Way Martian Colony Project Could Work", *Space.com*, 2013. [Online]. Available: http://www.space.com/23838-mars-one-colony-martian-volunteers.html. [Accessed: 30- Sep- 2016].

[7]"Farming in 'Martian Gardens'", *NASA*, 2016. [Online]. Available: http://www.nasa.gov/feature/farming-in-martian-gardens. [Accessed: 30- Sep- 2016].

Images

http://www.space.com/23838-mars-one-colony-martian-volunteers.html

http://www.dsls.usra.edu/science/research/spaceRad/

Eating as astronauts.

October 1st, 2016

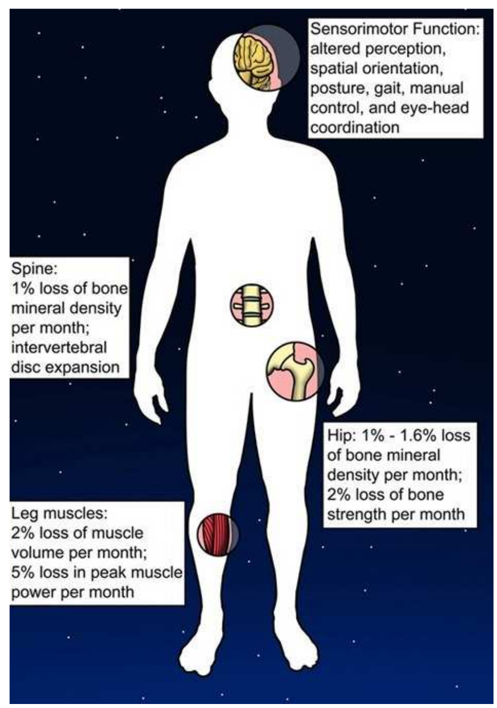
MIZUNA LETTUCE GROWING ABOARD THE INTERNATIONAL SPACE STATION BEFORE BEING HARVESTED AND FROZEN FOR RETURN TO EARTH. IMAGE CREDIT: NASA {6]

IN THIS ISSUE

Feeding the astronauts.

By Robert Dumitru

Humans have sent rovers out to our neighboring planet Mars to test the soil, yet if humans where to grow food there they would have to bring numerous things from earth in order to accomplish this, such as seeds and fertilizer. "There may not be the right amount of nutrients depending on where astronauts land on the Red Planet, so fertilizers may need to be added to the soil" [1]. Yet there is potentially a greater challenge for the astronauts, which is having food for the trip to Mars. A round trip to Mars would take two and a half to three years. That much food for 6 fully grown people could weigh about 12 tons [2]. Just like normal people on earth astronauts need nutrients from their food, and on a long trip to Mars, in an anti-gravity situation where the astronauts bone density in slowly deteriorating, even one nutrient deficiency can easily be deadly. NASA is looking into sending a loaded vessel with food to Mars before the astronauts to make sure there is food there for when they get to Mars, but this of course easier said than done. "Besides creating a perfectly balanced meal plan with a half-decade shelf life, NASA researchers need to account for disappearing nutrients. Some nutrients break down naturally over time. [3]" Vitamin C is notorious for breaking down very easily in foods, and that is arguably



Some of the affects that space can have, mentally and physically.

One of the most important vitamins for the human body. One of the most obvious solutions is growing food on the space ship and on mars, this would solve many of these problems. "Astronauts wouldn't need to lug as much food with them. They'd have fresh produce rich in vitamins. And they could mix up their menus with some of that texture they miss. [4]" There has been lettuce grown in the international space station before and scientist are looking into other types of plants that can be grown in space. "Including dwarf tomatoes and peppers, and even dwarf plums. On Mars, astronauts might grow not just fruits and veggies, but staple crops like wheat. [5]" At the moment transporting and maintaining food for up to five years seems very difficult so the best option right now is investing in learning more about growing food on the space ship and on Mars in order for the astronauts to maintain a nutritious diet. Even if the scienstist find a way to grow sagnificant amounts of food on a space ship or on Mars, that dosen't mean the austronaughts are home free. They still need to worry about the nutrients that are unattainable from plants and the ressources needed to farm on mars. So scientist still need to work on getting the materials to Mars as well as the people.

The first-ever bites of a crop grown in space. It was red romaine lettuce, sprouted from pillows under purplish lights.

[1]G. Jordan, "Can plants grow with mars soil?," in NASA.gov, NASA, 2015. [Online]. Available: http://www.nasa.gov/feature/can-plants-grow-with-mars-soil. Accessed: Oct. 2, 2016.

[2]E. Preston, "How NASA Is Solving the Space Food Problem", Eater, 2015. [Online]. Available: http://www.eater.com/2015/9/17/9338665/space-food-nasa-astronauts-mars. [Accessed: 02- Oct- 2016].

[3]E. Preston, "How NASA Is Solving the Space Food Problem", Eater, 2015. [Online]. Available: http://www.eater.com/2015/9/17/9338665/space-food-nasa-astronauts-mars. [Accessed: 02- Oct- 2016].

[4]E. Preston, "How NASA Is Solving the Space Food Problem", Eater, 2015. [Online]. Available: http://www.eater.com/2015/9/17/9338665/space-food-nasa-astronauts-mars. [Accessed: 02- Oct- 2016].

[5]E. Preston, "How NASA Is Solving the Space Food Problem", Eater, 2015. [Online]. Available: http://www.eater.com/2015/9/17/9338665/space-food-nasa-astronauts-mars. [Accessed: 02- Oct- 2016].

[6]L. Meggs, "Growing plants and vegetables in a space garden," in NASA.gov, Brian Dunbar, 2010. [Online]. Available: http://www.nasa.gov/mission_pages/station/research/10-074.html. Accessed: Oct. 2, 2016.

Images.

https://www.quora.com/What-is-the-longest-time-an-astronaut-can-spend-in-space-before-it-is-too-hard-to-re-acclimatize-to-Earth

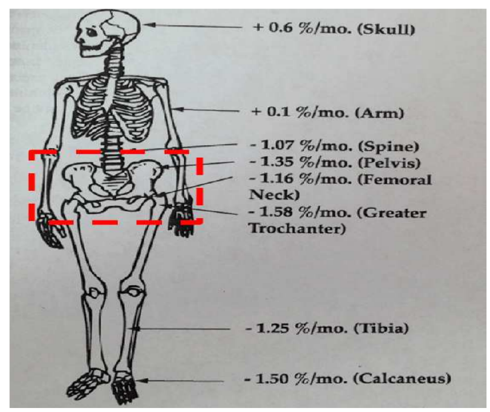
Effects of space on a human

October 2nd 2016

What's harder, living on Mars, or getting there?

by Robert Dumitru

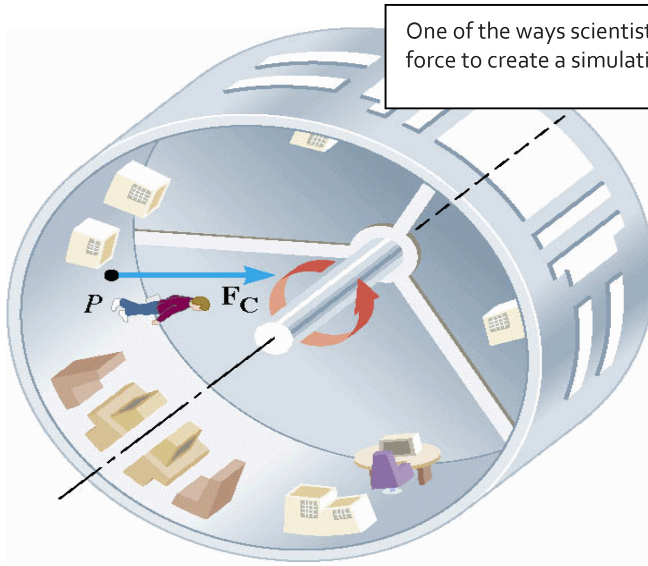
The first astronauts on Mars would have a hard time simply because no one else has ever lived on Mars, but there is a potentially an even greater risk even before the astronauts make it to Mars, and that is getting there. Humans as a species have evolved to live on a planet with gravity, our bones and organs only know how to deal with gravity, not without it. "Since our bones are not experiencing the loads they experience on the ground, they feel no need to maintain themselves. Bone tissue is absorbed and not rebuilt. This absorbed bone can cause kidney stones [1]." Bone deterioration can be very dangerous for a human who has to deal with all the problems that come with space travel, but the problems do not stop there. There are a plethora of problems astronauts face in space such as, thinner bones, eye problems, thinner blood, more blood in the upper body, increased heart rate, issues in liver and kidney function, and increased sweating (which leads to the loss of desperately needed magnesium), these are among the most devastating problems astronauts face [2]. Scientist believes the eye problems arise from the fact that the eyes can't maintain their pressure because the fluids move up towards the skull. The thinner blood is a result of the fact that for a reason still unknown, younger red blood cells tend to die shortly after production when a human is in space. The human body is constantly trying to work as if it was on earth, therefore even in space the body



A graphic that shows the rate of bone loss for various parts of the body in a one month time period [6].

Identical twins: Scott and Mark Kelly, Scott is in space while they research Mark's DNA on earth and compare it to Scott's. [7]

acts as if it were still trying to live on earth, but this not what astronauts want. Scientists and engineers are looking into ways to solve all these problems. The most obvious solution is to try to simulate gravity in space, this way astronauts would be able to maintain their bodies fairly easily. "Scientists have thought about using artificial gravity to relieve such problems, but this could lead to issues with the mission -- such as an accident with the spacecraft. [3]" Yet, even if an effective way to create artificial gravity for a trip to Mars was created there is one other major problem with staying in space for up to three years at a time, which is the radiation on space, which is normally deflected by earth's magnetic fields. Radiation can easily cause cancer for astronauts who are not protected. NASA typically doesn't allow the lifetime cancer risk to be raised by more than three percentage points, but 2.5 years is a long time and could very well pass that point. [4]" There are two main ways NASA is looking into solving the problem of radiation. One of them is sheer volume of material, the sheer volume surrounding a structure would absorb the energetic particles and their associated secondary particle radiation before they could reach the astronauts. This provides the obvious problem that launching the ship would be more expensive and more fuel would be required in order to get the ship the Mars. Alternatively, using some sort of material to block the astronauts from the radiation. "Using materials that shield more efficiently would cut down on weight and cost, but finding the right material takes research and ingenuity. NASA is currently investigating a handful of possibilities that could be used in anything from the spacecraft to the Martian habitat to space suits. [5]" In terms of getting people to Mars with artificial gravity to inhibit the body from deteriorating and shielding these people from radiation, there is still a lot of research to be done, but NASA and other organizations have already built the stepping stones to finding to optimal and most effective way to get people safely to Mars.



One of the ways scientists are already using centripetal force to create a simulation of gravity.

[1]R. Frost, "How long can humans live in space and what is the worst case scenario for someone who lives too long in space?", www.quora.com, 2016. [Online]. Available: https://www.quora.com/How-long-can-humans-live-in-space-and-what-is-the-worst-case-scenario-for-someone-who-lives-too-long-in-space. [Accessed: 02- Oct- 2016].

[2]R. Walker, "How long can humans live in space and what is the worst case scenario for someone who lives too long in space?", www.quora.com, 2016. [Online]. Available: https://www.quora.com/How-long-can-humans-live-in-space-and-what-is-the-worst-case-scenario-for-someone-who-lives-too-long-in-space. [Accessed: 02- Oct- 2016].

[3]T. Kaiser, "DailyTech - NASA Trying to Solve Medical Issues Associated with Long-Term Space Missions", Dailytech.com, 2016. [Online]. Available: http://www.dailytech.com/NASA+Trying+to+Solve+Medical+Issues+Associated+with+LongTerm+Space+Missions/article34228.htm. [Accessed: 02- Oct- 2016].

[4]T. Kaiser, "DailyTech - NASA Trying to Solve Medical Issues Associated with Long-Term Space Missions", Dailytech.com, 2016. [Online]. Available: http://www.dailytech.com/NASA+Trying+to+Solve+Medical+Issues+Associated+with+LongTerm+Space+Missions/article34228.htm. [Accessed: 02- Oct- 2016].

[5]S. Fraiser, "How to Protect Astronauts from Space Radiation on Mars", NASA, 2016. [Online]. Available: http://www.nasa.gov/feature/goddard/real-martians-how-to-protect-astronauts-from-space-radiation-on-mars. [Accessed: 03- Oct- 2016].

[6]R. Frost, "How long can humans live in space and what is the worst case scenario for someone who lives too long in space?", www.quora.com, 2016. [Online]. Available: https://www.quora.com/How-long-can-humans-live-in-space-and-what-is-the-worst-case-scenario-for-someone-who-lives-too-long-in-space. [Accessed: 02- Oct- 2016].

[7]D. Warmflash, "Space twins: Scott Kelly's one-year space mission could yield genetic bounty | Genetic Literacy Project", Genetic Literacy Project, 2015. [Online]. Available: https://www.geneticliteracyproject.org/2015/03/27/space-twins-scott-kellys-one-year-space-mission-could-yield-genetic-bounty/. [Accessed: 03- Oct- 2016].

Images.

http://world-warotter.com/archives/14217

http://pics-about-space.com/artificial-gravity-in-space-stations?p=2#img6843860606649589119

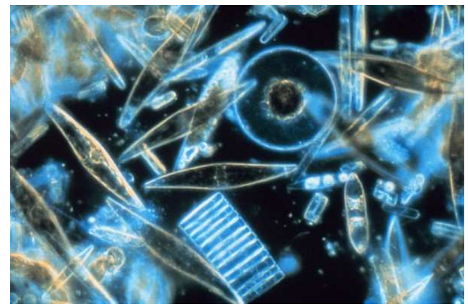
Function

Prohibit water or other liquids from freezing.

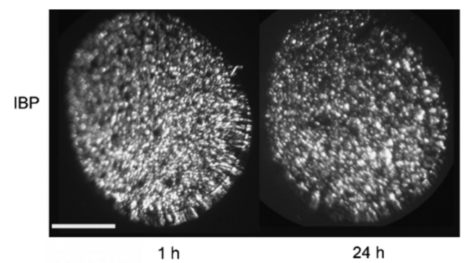
Organism

Sea ice diatoms

Biology strategy



Sea ice diatoms are single-celled algae that live in very cold, aquatic environments, including Arctic and Antarctic sea ice. In these harsh environments, they have developed ways to protect themselves against the extreme temperature. A mechanism used is extracellular ice-binding protein. Extracellular ice-binding proteins, excreted by sea ice diatoms, align themselves with and bind to the small, growing ice crystals that are directly outside of the sea ice diatom's outer layer. Even though the exact binding mechanism is not known for sure, it is believed that the ice-binding proteins act as complementary pieces to ice crystals in a three-dimensional jigsaw puzzle. The ice-binding proteins lock the small ice crystals in place, thereby preventing them from rearranging into a larger ice crystal. This rearrangement of small ice crystals into a larger one is known as ice recrystallization and it occurs naturally and is a normal part of ice crystal growth. Ice recrystallization is one of the primary means of cell death in freezing temperatures. While the small ice crystals can exist at the surface of cells without causing cell death, the large ice crystals cannot. Large ice crystals, formed when the nearby small ice crystals join together and align themselves in the same direction, act as knives to the cells. The large ice crystals are powerful enough to puncture the cell's outer layer. The insides of the cells, when exposed to freezing temperatures, die. The extracellular ice-binding proteins prevent the large ice crystals from forming, and are therefore essential for the growth and survival of sea ice diatoms embedded in ice.



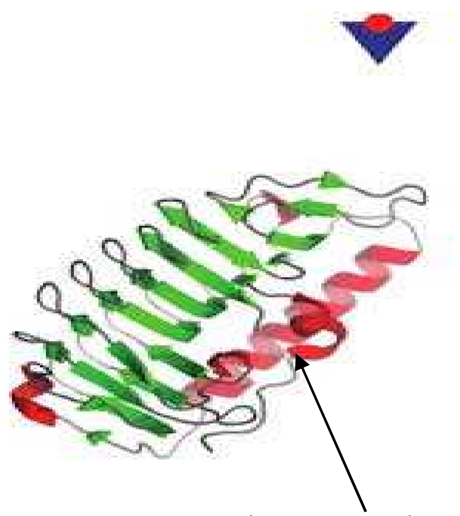
Ice crystals becoming smaller and smaller.

Mechanism

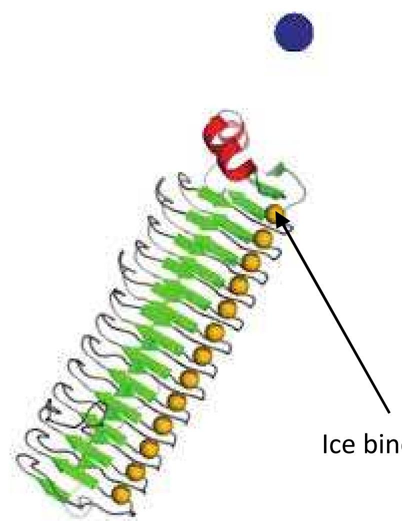
Extracellular ice-binding proteins help water stay as a liquid in extremely cold environments

Design principal.

To inhibit water to become solid ice in extremely cold conditions by using proteins that inhibit large ice crystals from forming.



Another ice crystal



Ice binding proteins

Application idea

- Place these proteins in large storage tanks in very cold climates (like Mars) to stop crystallisation of water

Key life principals

- Things that seem so simple could turn out to be very challenging in hostile environments
- Use chemistry that does not hurt any living thing.

References

Davis, "Ice-Binding Proteins and Their Function - Annual Review of Biochemistry, 85(1):515", Annualreviews.org, 2016. [Online]. Available: http://www.annualreviews.org/doi/abs/10.1146/annurev-biochem-060815-014546?journalCode=biochem. [Accessed: 11- Oct- 2016].

J. Lawrence, "Protein enables growth in freezing temperatures : Diatomaceae - AskNature", AskNature, 2016. [Online]. Available: https://asknature.org/strategy/protein-enables-growth-in-freezing-temperatures/#jp-carousel-8115. [Accessed: 11- Oct- 2016].

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http://www.annualreviews.org/doi/abs/10.1146/annurev-biochem-060815-014546?journalCode=biochem

Function

Provide protection from extremely cold environments as well as strong winds.

Organism

Pygoscelis papua Gentoo penguin

Biology strategy

Earth and its biodiversity creates many different climates, each of which are inhabited, no matter how harsh they may be, by life. To ease the constant struggle against the everlasting forces of nature, life uses concepts such as dynamic insulation in order to be able to spend more of its energy gathering resources. Penguins, or rather their feathers, offer a superb model of this concept; they provide excellent insulation against the harshly weather and they can immediately regain their loft after they've been compressed. This is due to every single feather having a shaft which houses a muscle that the penguin can retract so that their outer coat forms a tight barrier underwater. On land, penguins relax these muscles, recreating the loft that creates a coat of warm air around their bodies. This coat warms them and protects them from the perpetual winds and freezing waters.

To further adapt to their climate, penguins arrange their feathers evenly over their entire body surface, rather than in tracts like most birds do. Even the structure of the feathers themselves is different as they are shorter and stiffer than most, and are separated into an outer "pennaceous" or "vane" region, as well as an inner "after feather". Gentoo penguins, native to the harsh regions of Antarctica, exemplify this trait perfectly: the outer vane region of each feather overlaps other feathers which is responsible for the creation of the shielding effect the coat has. The inner after feather is however much more complex as they are comprised of even smaller components that create tiny air spaces, trapped within the structure of the feather itself. Each of the Gentoo's after-feathers, has approximately 47 barbs, each of which have up to 1250 barbules, which each finally have tiny extensions called "cilia". These cilia attach to nearby barbules which allows them to move only in one way through a "slip stick" system of sorts. This causes the barbules return to a uniform arrangement when the penguin relaxes is muscles on land, creating a coat of air of uniform thickness and division. The uniformity of this coat creates optimal insulation against the harsh winds of the Antarctic, and is thus essential in the survival of this species.

Temperature of the outside

Temperature of the penguin

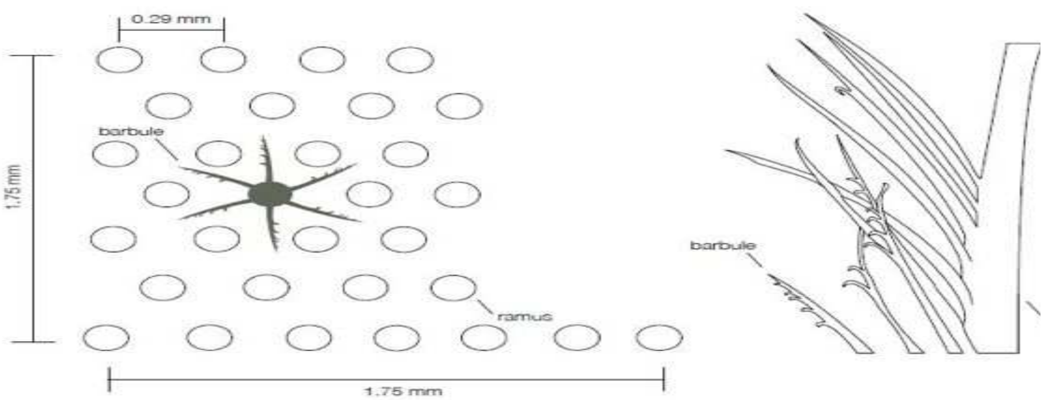
The temperature of the penguin is clearly 10-15 degrees higher than the outside.

Mechanism

The unique feathers on the Gentoo penguin are fantastic at maintaining heat and creating a wind barrier

Design principal.

A coat or layer on a space suit, space ship, or habitat designed to insulate the inhabitants as well as create a barrier from wind storms.



Application idea

- Create a space suit or habitat that is a great insulator and works as a protection from strong winds

Key life principals

- Staying warm can be just as important as eating or sleeping
- Replicate strategies that have already been proven to work.

References

D. Attenborough, "Feathers trap air to provide warmth - AskNature", AskNature, 2016. [Online]. Available: https://asknature.org/strategy/feathers-trap-air-to-provide-warmth/. [Accessed: 10- Oct- 2016].

M. Mayntz, "Gentoo Penguin Fact Sheet", About.com Home, 2016. [Online]. Available: http://birding.about.com/od/Penguins/fl/Gentoo-Penguin.htm. [Accessed: 10- Oct- 2016].

Images

http://birding.about.com/od/Penguins/fl/Gentoo-Penguin.htm

Function

Block out harmful UV light.

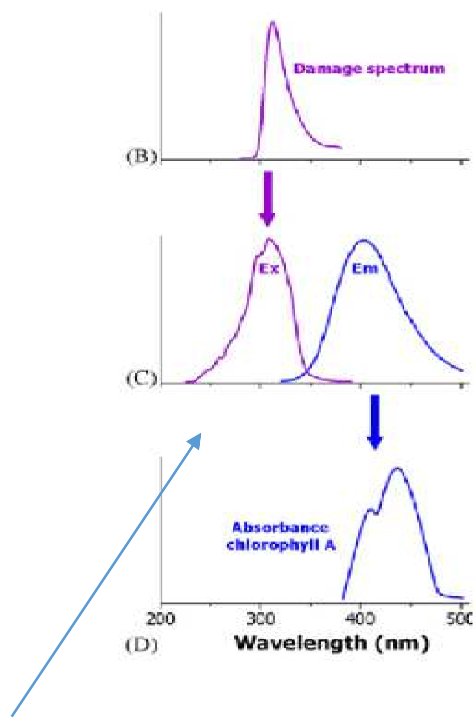
Organism

Pinus mugo Dwarf mountain pine

Biology strategy

The Dwarf mountain pine has its habitat in some parts of northern Europe and Australia (usually high altitudes), where is it exposed to the sun constantly. Any organism that is constantly exposed to the sun's UV rays would have a difficult time surviving without some sort of protection. The dwarf mountain pine has developed a wax to protect itself. This biological coating contains chromophores that absorbs UV radiation in such a way that it removes the most harmful UV-B and UV-A from the solar spectrum. External flavonoid aglycones which is shown to be in the chromophores which absorb the harmful UV light (280-400nm) are found on the outside of the dwarf mountain pine. This fluorescent cuticular wax removes the most dangerous part of the UV radiation for the Dwarf mountain pine, only leaving harmless blue light.

This sort of wax is found in other plants of the same family with a few variations, like reducing the uptake of solar radiation by reflection rather than absorption.



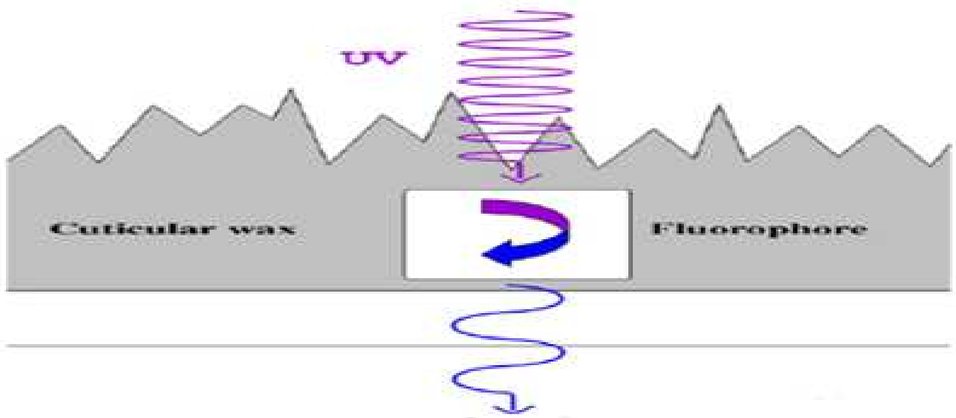
The damaging UV light being absorbed and leaving only blue light

Mechanism

Cuticular wax on the mountain pine absorbs or reflects the most dangerous UV rays and leaves only the harmless ones.

Design principal.

A wax or plastic material that either absorbs or deflects harmful solar radiation and leaves only the harmless radiation composed of chromophores like fluorophore.



References

F. Jacobs, "Chromophores protect from harmful UV", AskNature, 2016. [Online]. Available: https://asknature.org/strategy/chromophores-protect-from-harmful-uv/#.V_LDKOArKM8. [Accessed: 03- Oct- 2016].

J. Jacobs, "Fig. 4. Mechanism of protection by cuticular wax from P. mugo subsp....", *Researchgate.net*, 2016. [Online]. Available: https://www.researchgate.net/figure/223216814_fig2_Fig-4-Mechanism-of-protection-by-cuticular-wax-from-P-mugo-subsp-mugo-found-in-the. [Accessed: 03- Oct- 2016].

B. Bhushan, *Springer handbook of nanotechnology*. Berlin: Springer, 2007.

Application idea

- Place a wax or film over a space ship or astronauts suit in order to limit radiation from reaching the astronauts

Key life principals

- Problems that occur in space can also occur on earth to a smaller scale
- Learn from what nature has already done

Function

Provide shelter from harmful solar radiation and from extreme heat.

Organism

Sphincterochila boissieri

Biology strategy

This live specimens of this snail, mostly withdrawn in the shell and dormant, can be found on the desert surface of Egypt and Israel in mid-summer, fully exposed to sun and heat. The surface temperature of these deserts may reach 70 °C and more than a year may pass between rains.

The maximum air temperature, reached at noon, was 42.6 °C, and the maximum soil surface temperature in the sun was 65.3 °C. Under the snail, in the space between the soil surface and the smooth shell, the maximum temperature was 60.1 °C. Yet the snail does not heat up to the same temperature as the soil surface. The reason lies in the shells high reflectivity in combination with the slow conduction of heat from the substrate. Within the visible part of the solar spectrum (which contains about one-half of the total incident solar radiant energy) the reflectance of these snails is about 90%. In the infrared, up to 1350 nm, the reflectance is similar to that of magnesium oxide and is estimated to be 95%. In the total range of the solar spectrum, therefore, we can say that the snails reflect well over 90% of the incident radiant energy. Like many other shells, this shell is composed mostly of calcium carbonate, it is the shape and attributes of the shell that help the snail so much. The shell of Sphincterochila boissieri is, thick, irregularly streaked, somewhat effulgent, and colored white. It has 5 slightly convex whorls. The last whorl is deflected anteriorly. The bottom has a thick lip, keeping most of the shell off the ground.

Also heat flow is impeded by two important circumstances. Firstly, the snail shell is in direct contact with the rough soil surface only in a few spots, and a layer of still air separates much of its bottom surface from the ground, forming an insulating air cushion.

5 Whorls

Most of the shell is off the ground therefore not touching the hot surface

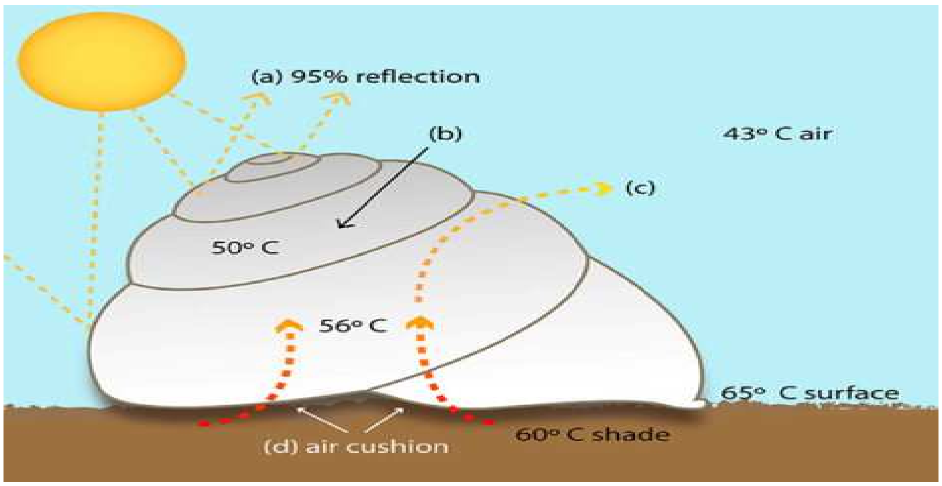
Air bubble

Mechanism

The unique shape of the shell on the *Sphincterochila boissieri* protects it from the harsh sun and droughts of the desert.

Design principal.

A shelter or space craft designed to minimize heat and radiation from the sun by shaping is in a way where it can reflect heat and maintain temperatures on the inside constant.



Application idea

- Shape the space ship and habitat on Mars in a way that will deflect harmful radiation from the sun and also protect from extreme heat that may occur on Mars.

Key life principals

- Organisms that are protecting themselves from heat are also protecting themselves from solar radiation
- Sometimes the shape of the product is much more important than the material

References

D. Mierzwa, "CHEMICAL COMPOSITION AND STRUCTURE OF THE SHELL", Foliamalacologica.com, 2016. [Online]. Available: http://www.foliamalacologica.com/download.php?ma_id=494. [Accessed: 10- Oct- 2016].

P. Gutenberg, "Sphincterochila boissieri | Project Gutenberg Self-Publishing - eBooks | Read eBooks online", Self.gutenberg.org, 2016. [Online]. Available: http://self.gutenberg.org/articles/sphincterochila_boissieri. [Accessed: 10- Oct- 2016].

Images

https://asknature.org/strategy/shell-protects-from-heat/#.V_vS9uArKM8

http://flickrhivemind.net/Tags/sphincterochila/Timeline

Function

Produce an adhesive "glue" in order to hold something in place under a great amount of force.

Organism

The Caulobacter crescentus cells

Biology strategy

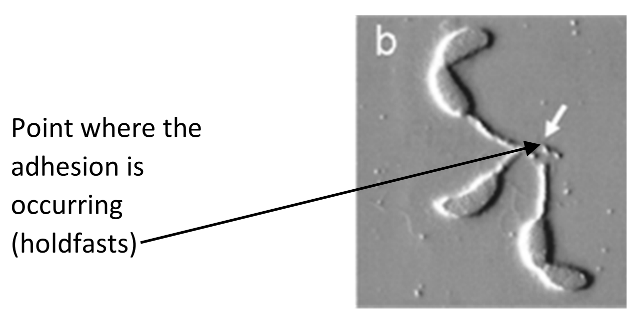
The Caulobacter crescentus cells of the live in many diverse aquatic settings. In one of their two forms, they grow stalks littered with a foot-like structure known as a holdfast.

In order to be able to send off spores to reproduce these cells need to permanently attach to a surface while under water. It is here where the cells produce an adhesive substance, based in part on polysaccharides of N-acetylglucosamine, which enables the cell to stick to surfaces. Once in place, the cells bud off a series of mobile cells (swarmer cells) that seek out their own little dots of land, to which they stick by growing their own buds and holdfasts.

A quarter-size patch of this cohesive substance could conceivably suspend a 5 ton elephant. A quarter-size patch could conceivably suspend a 5-ton elephant. The sticking power of the bacterium's adhesive approaches 70 Newton/mm2, reports Brun, Brown University biophysicist Jay X. Tang

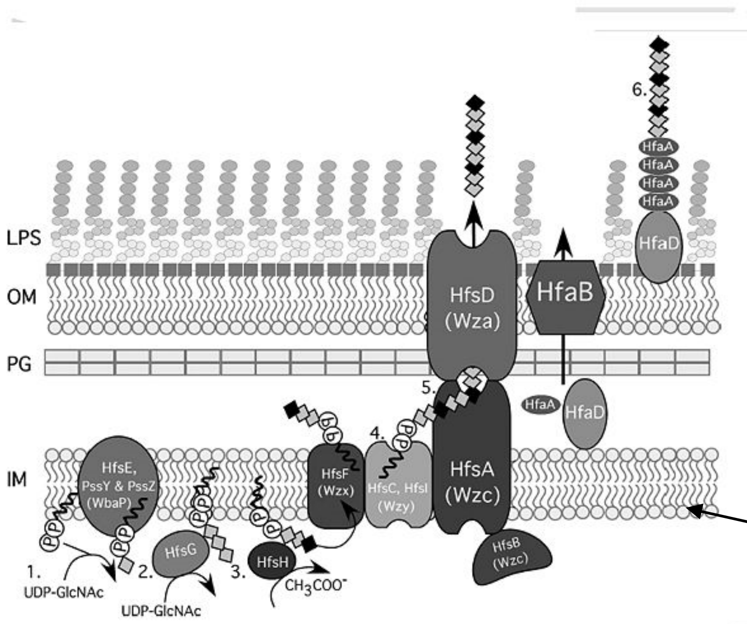
Mechanism

The bacterium's adhesive is an incredibly strong adhesive which can withstand a lot of force.



Design Principal

An adhesive substance that could keep a structure grounded no matter what the conditions outside are.



The holdfast polysaccharide is transferred across the outer membrane by HfsA, HfsB and HfsD proteins. Hfa proteins mediate the polysaccharide attachment to the cell. The products of the 3 adjacent hfsD hfsA and hfsB genes are involved in the holdfast export.

Application idea

- Create an adhesive that can keep a human habitat on Mars grounded even during insane wind storms.

Key life principals

- Things that seem so simple could turn out to be very challenging in hostile environments
- Simple things like attaching to surfaces can be much more complicated then they seem

References

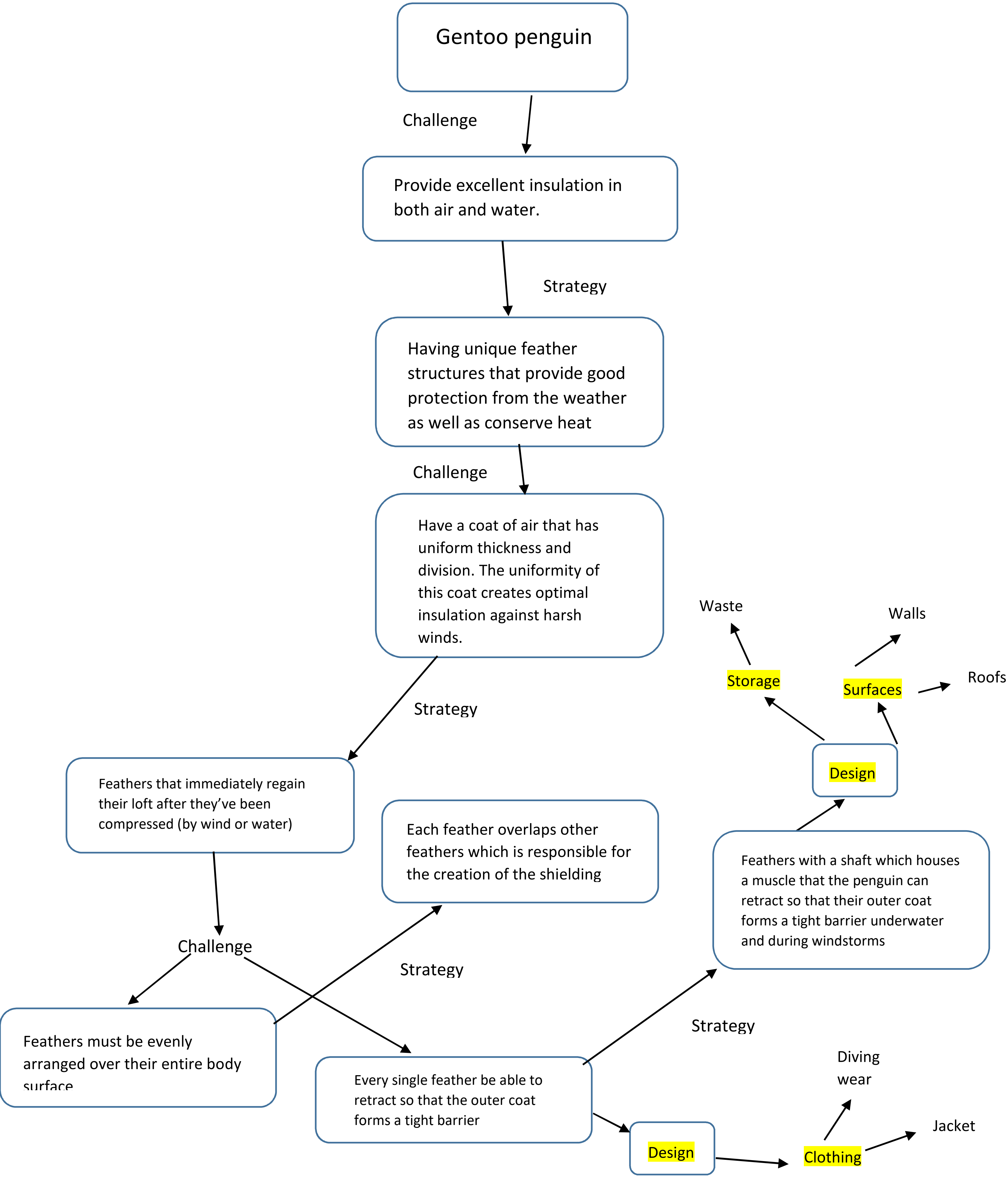
[1]"Team:ULB-Brussels/Project/Introduction - 2009.igem.org", 2009.igem.org, 2016. [Online]. Available: http://2009.igem.org/Team:ULB-Brussels/Project/Introduction. [Accessed: 08- Nov- 2016].

[2] Amato, "Adhesive works under water : Caulobacter crescentus - AskNature", AskNature, 2016. [Online]. Available: https://asknature.org/strategy/adhesive-works-under-water/#.WCEWZvkrKM8. [Accessed: 08- Nov- 2016].

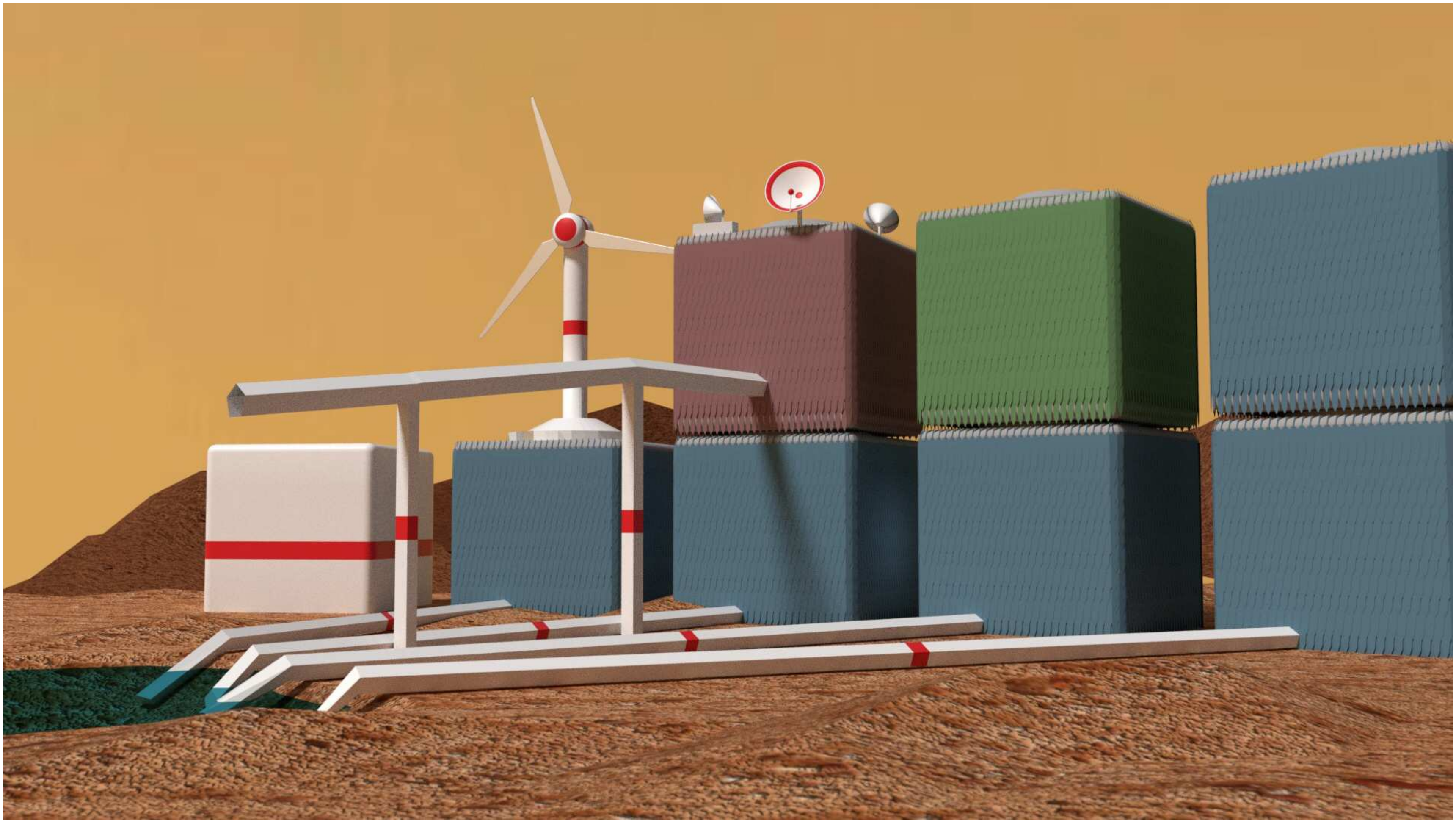
Images

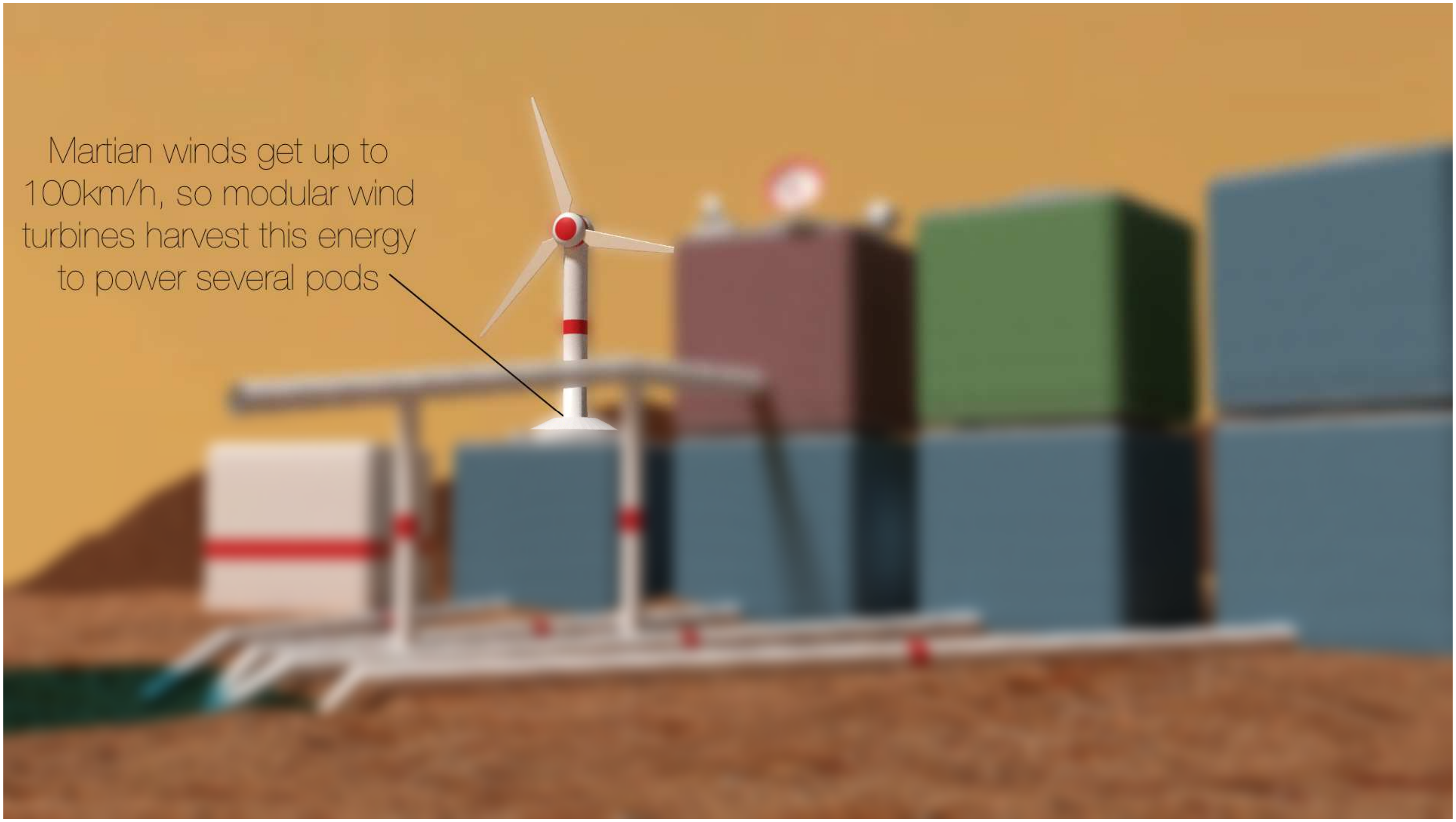
https://asknature.org/strategy/adhesive-works-under-water/#.WCEWZvkrKM8

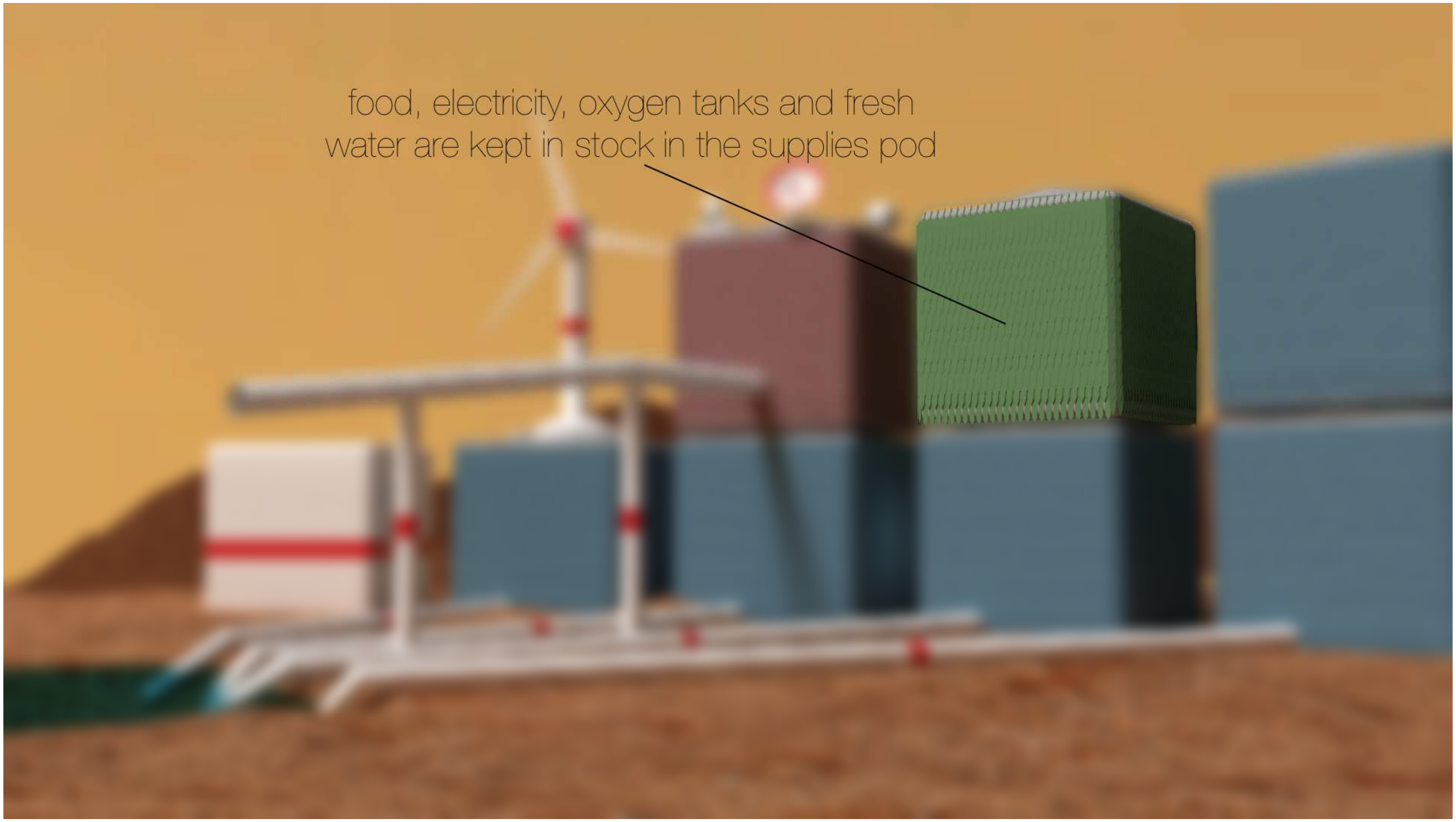
http://2009.igem.org/Team:ULB-Brussels/Project/Introduction

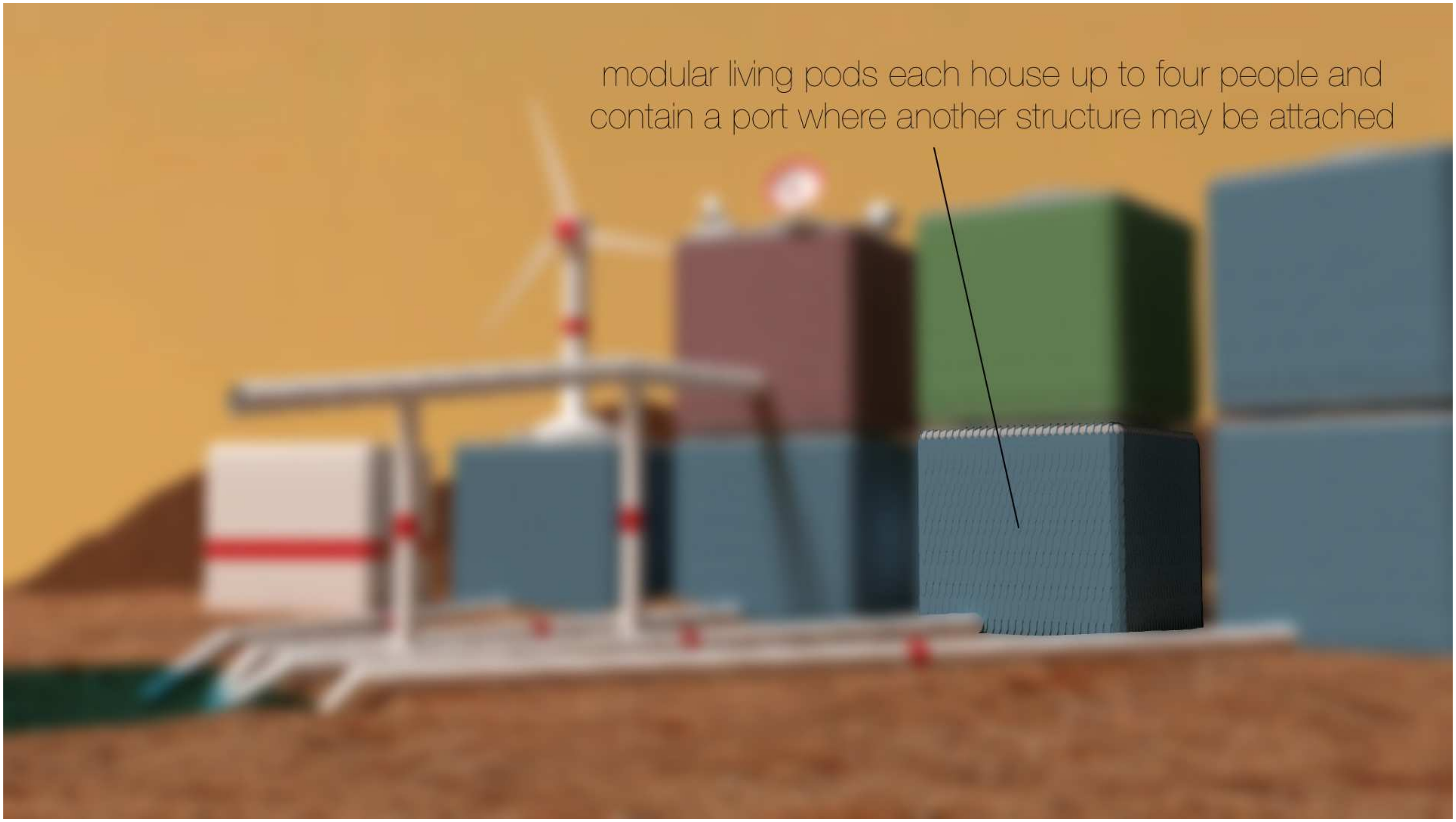

Gentoo penguin
Challenge
Provide excellent insulation in both air and water.
Strategy
Having unique feather structures that provide good protection from the weather as well as conserve heat
Challenge
Have a coat of air that has uniform thickness and division. The uniformity of this coat creates optimal insulation against harsh winds.
Strategy
Feathers that immediately regain their loft after they've been compressed (by wind or water)
Challenge
Feathers must be evenly arranged over their entire body surface
Strategy
Each feather overlaps other feathers which is responsible for the creation of the shielding
Every single feather be able to retract so that the outer coat forms a tight barrier
Strategy
Feathers with a shaft which houses a muscle that the penguin can retract so that their outer coat forms a tight barrier underwater and during windstorms
Design
Storage
Surfaces
Waste
Walls
Roofs
Design
Clothing
Diving wear
Jacket

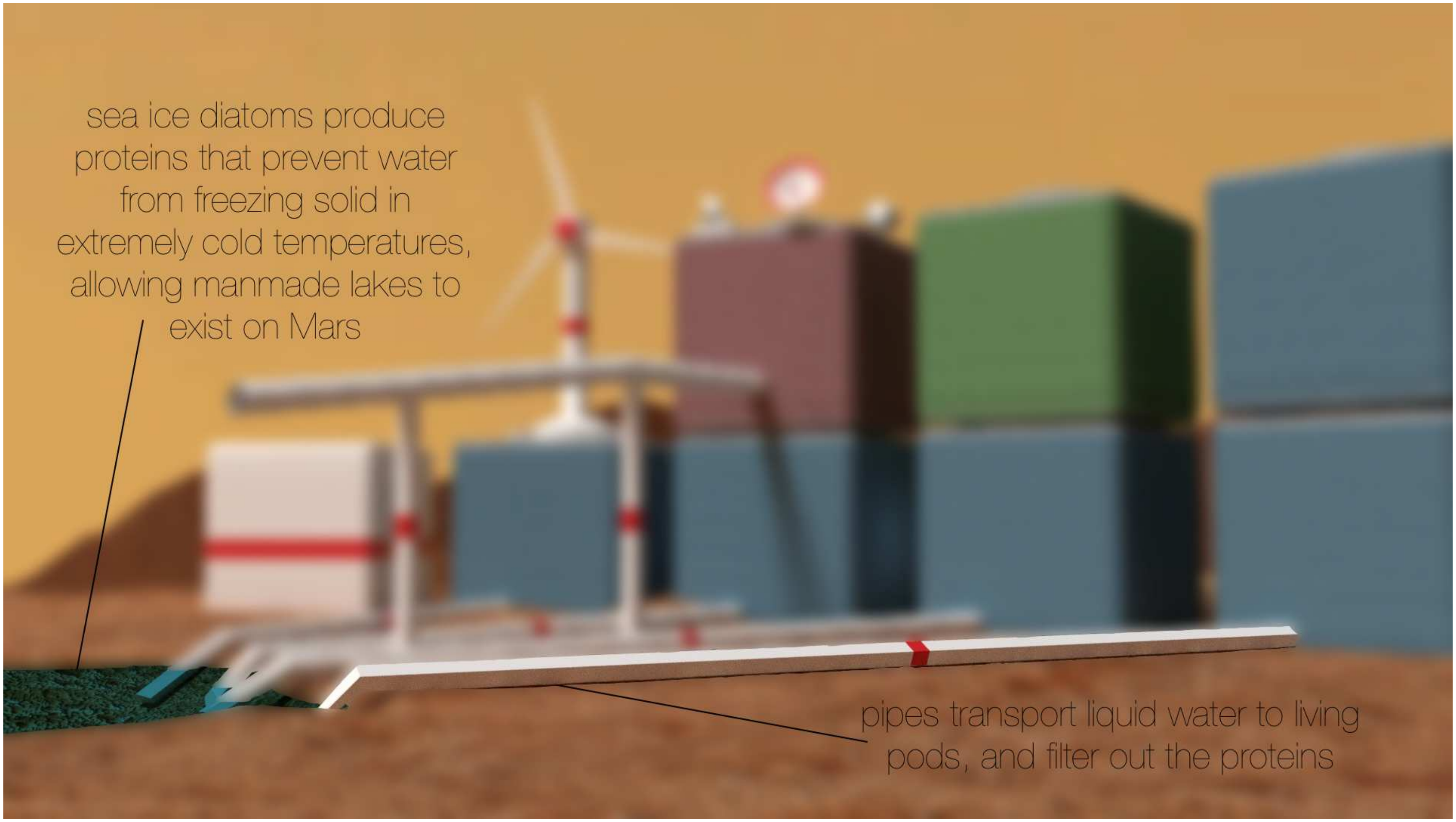
Robert Dumitru

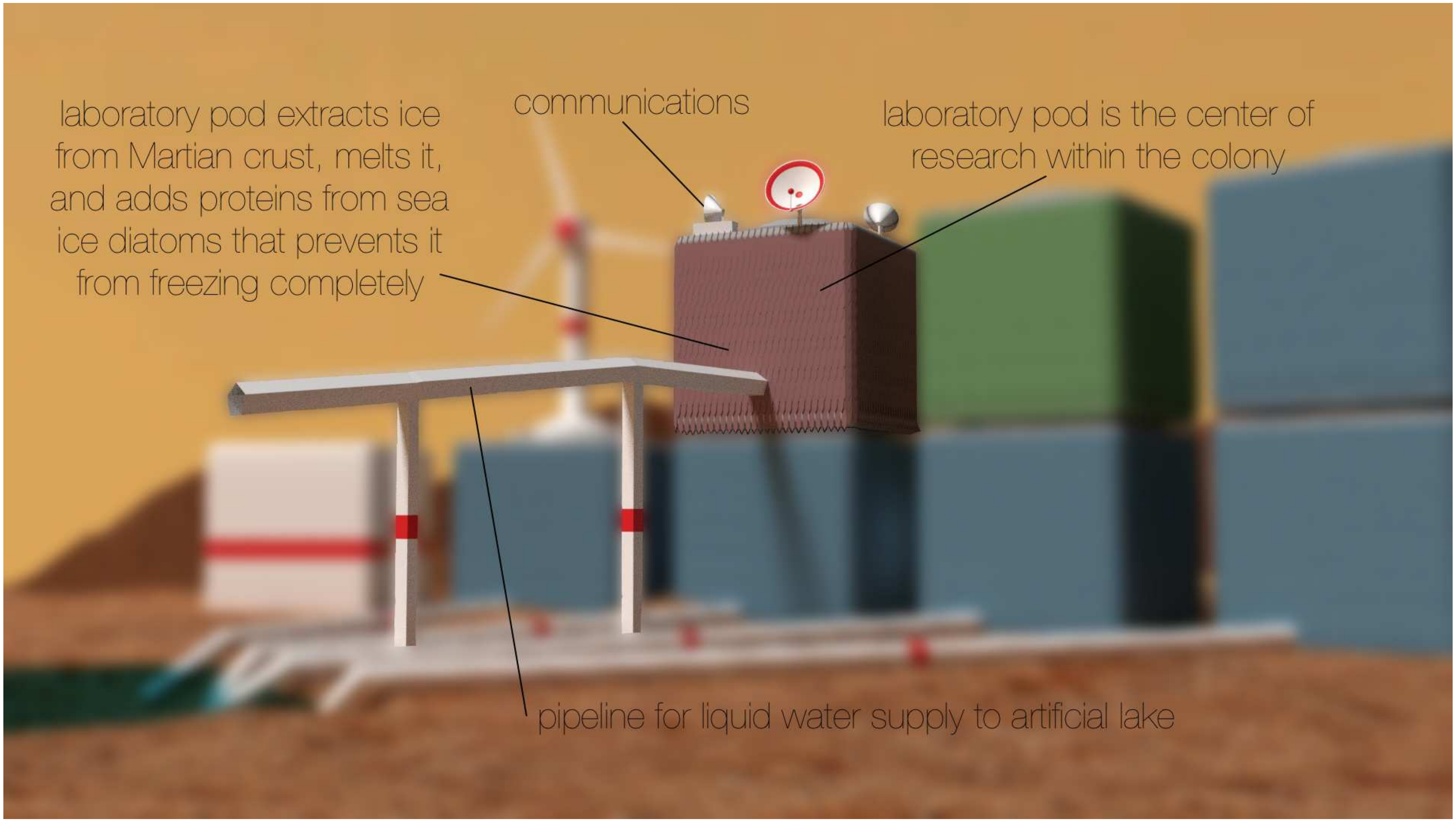


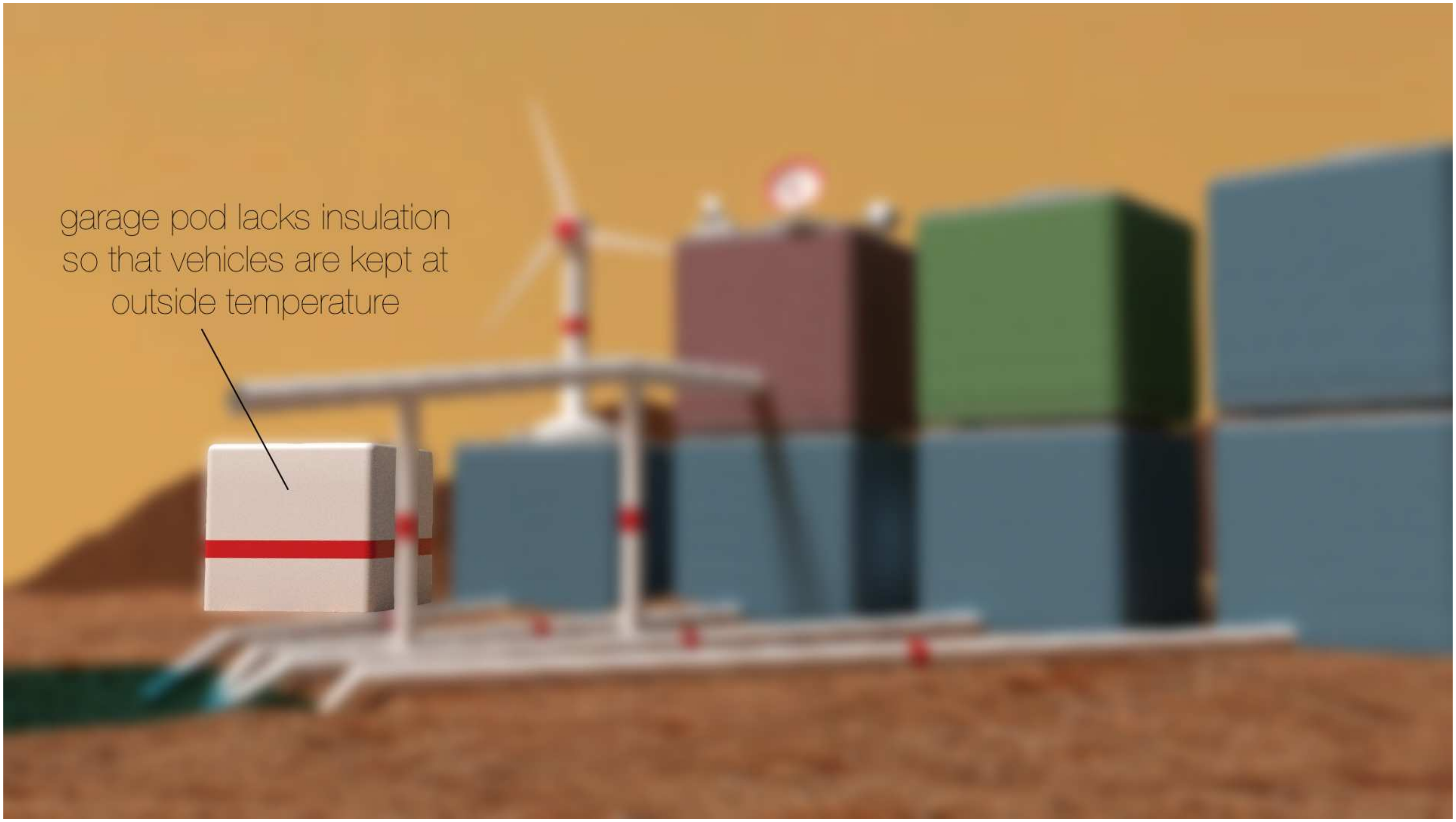

Martian winds get up to 100km/h, so modular wind turbines harvest this energy to power several pods

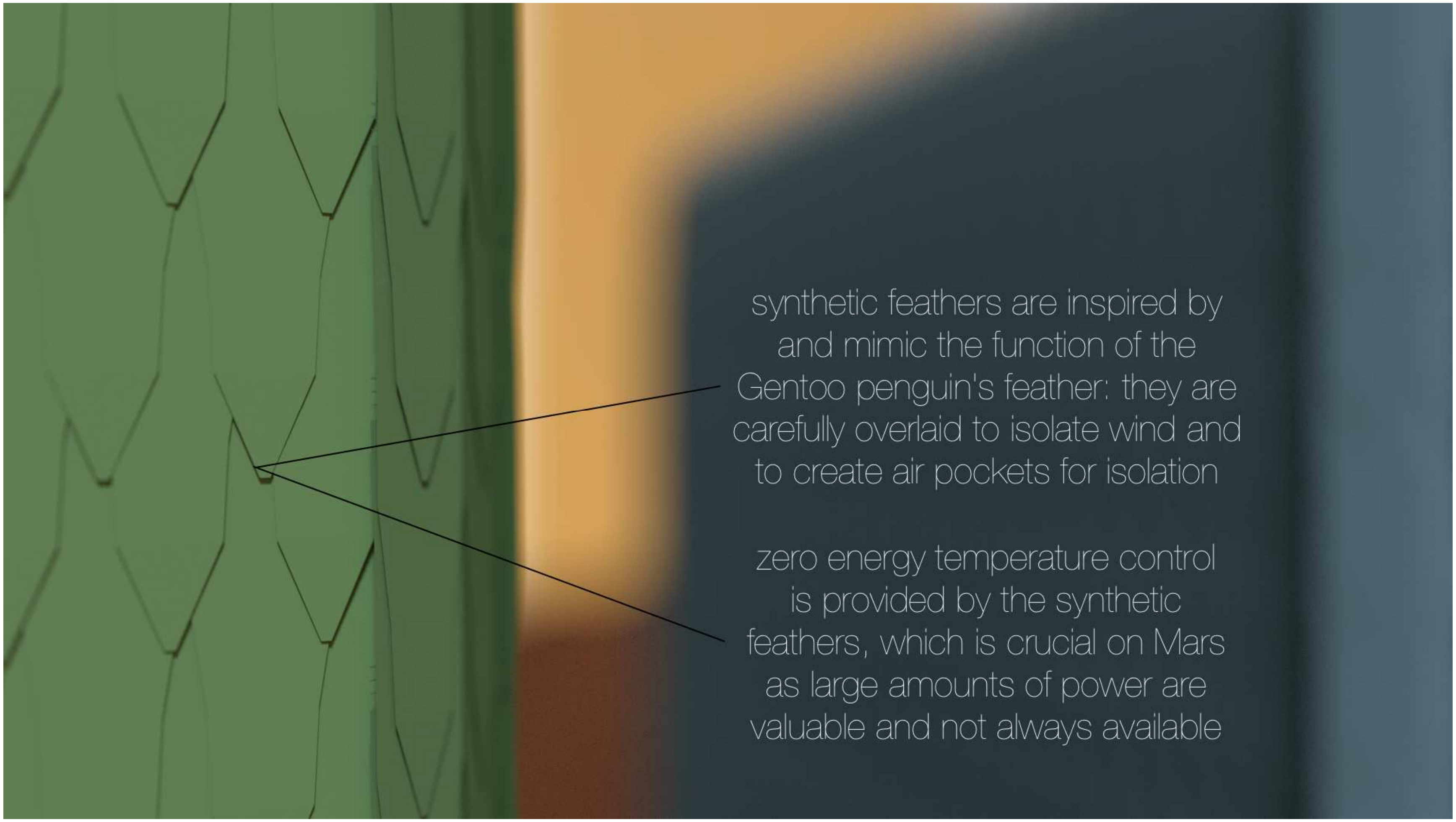

food, electricity, oxygen tanks and fresh
water are kept in stock in the supplies pod

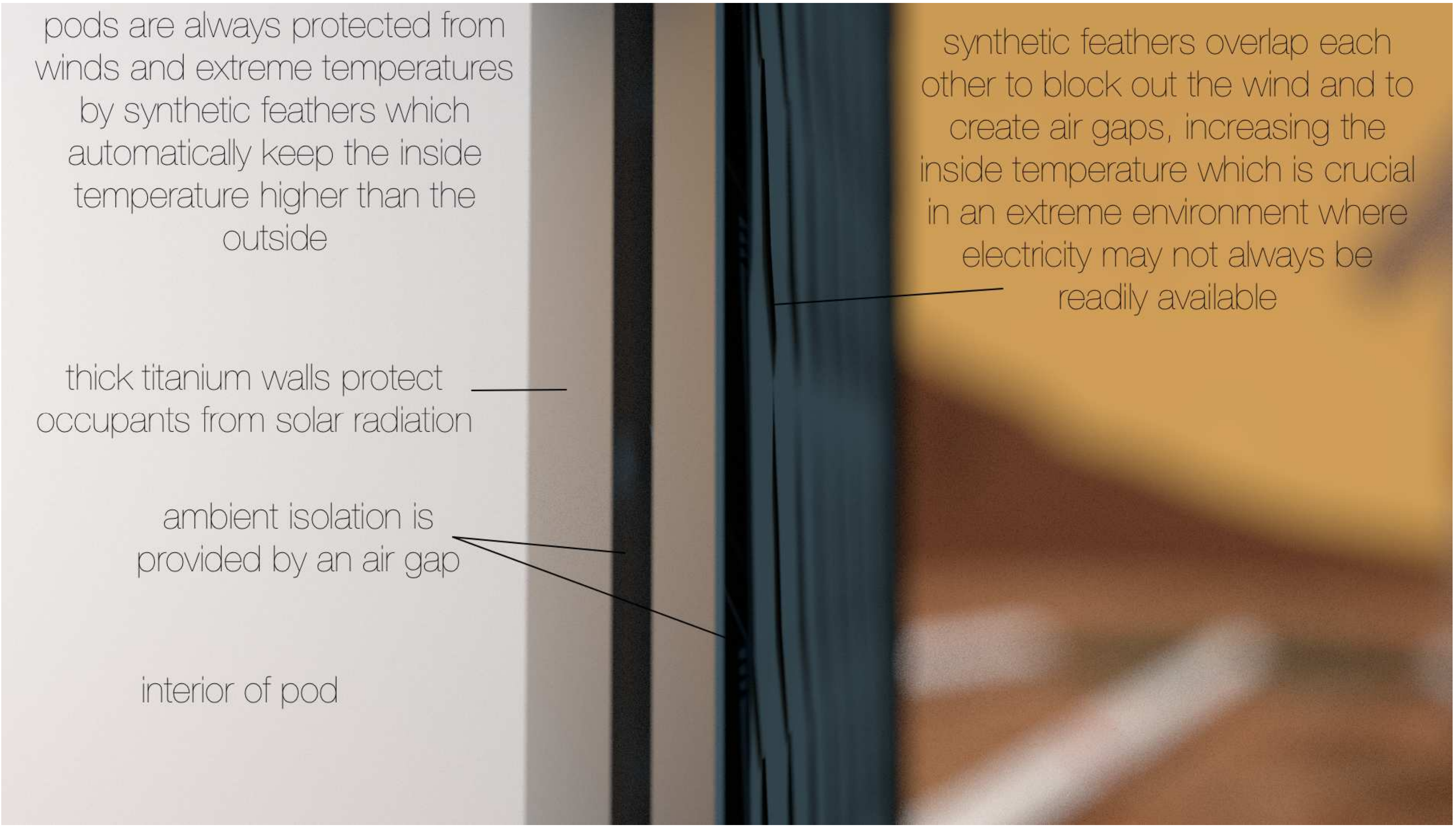

modular living pods each house up to four people and
contain a port where another structure may be attached


sea ice diatoms produce proteins that prevent water from freezing solid in extremely cold temperatures, allowing manmade lakes to exist on Mars
pipes transport liquid water to living pods, and filter out the proteins


laboratory pod extracts ice from Martian crust, melts it, and adds proteins from sea ice diatoms that prevents it from freezing completely
communications
laboratory pod is the center of research within the colony
pipeline for liquid water supply to artificial lake


garage pod lacks insulation so that vehicles are kept at outside temperature


synthetic feathers are inspired by
and mimic the function of the
Gentoo penguin's feather: they are
carefully overlaid to isolate wind and
to create air pockets for isolation
zero energy temperature control
is provided by the synthetic
feathers, which is crucial on Mars
as large amounts of power are
valuable and not always available


pods are always protected from winds and extreme temperatures by synthetic feathers which automatically keep the inside temperature higher than the outside
synthetic feathers overlap each other to block out the wind and to create air gaps, increasing the inside temperature which is crucial in an extreme environment where electricity may not always be readily available
thick titanium walls protect occupants from solar radiation
ambient isolation is provided by an air gap
interior of pod