Hypothetical Challenges of Engineering Biosynthetic Martian Autotrophs for the Terraformation of the Planet

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Introduction

Biotechnologically modified autotrophs growing on Mars, will eventually lead to the Terraformation of the Planet. Chances for the success of modified Earth life to move to the planet Mars highly depends on their abilities to:

✓ Metabolize minerals presented within Martian ground, brines and Atmosphere;

✓ Tolerate radiation/pressure/temperature variations of the Martian Surface, using evolutionary preserved and/or artificially provided adaptation mechanisms.

These highlight the most important steps for the maintenance of extremely complex tasks required for Genetic Modifications – creation of Chimeras, adapted to Martian conditions.

Objectives

Main objectives are the conduction of the experiments, which will provide the answers to some very basic questions:

1. Based on modern scientific achievements and advanced technologies, how far could we possibly get with genetic modifications until synthetic organisms become and remain self-maintaining?
2. Which organisms, among so many species, are most suitable both for the subtraction and insertion of the desired genetic material?
3. As single gene usually determines more than one specific biological property, how can we derive all genes/plasmids/vectors and, at the same time, manipulate with desirable traits in a way that none of these combinations will result in a failure of main biochemical processes?
4. How can we incorporate so many desired genetic materials to the organism without changing sharply its initial identity? What are the chances for their survival and reproduction on Mars with each trait or their combination?

Methods

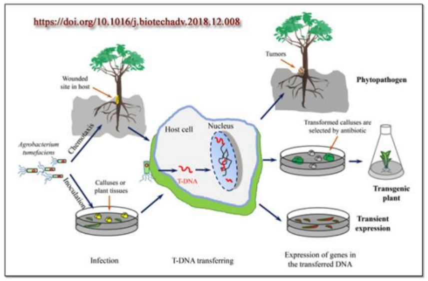
Exact scenario of the introduction of genetically modified autotrophs, as well as the level of their bioengineering, depends on the stage of planetary engineering:

1. Mars as it is today: experiments have shown many Earth extremophiles are already capable of surviving harsh Martian conditions - improvement & modification of these organisms may be needed to accelerate bioremediation processes [1];

2. Atmospheric pressure at the surface of Mars is between 90 – 150 mbar: Genetically modified mosses and lichens can be introduced; Extensively bioengineered Martian chimeras may survive;

3. Ecopoesis: Atmospheric pressure at the surface of Mars is above 150 mbar: Highly lignified grasses, shrubs and Trees with additional empowering traits can survive [2].

Figure. 1. Horizontal gene transfer using *Agrobacterium*: genes can be transferred from the microbe to the plant or from the plant to plant [3].



Desired Genes:
1. Lignification Genes (increased resistance to low pressure and gravity, transpiration);
2. Antifreeze production (adapting to the low temperature);
3. External hair (low temperature, transpiration, sunken stomata);
4. Antracene, Tocopherols, Tocotrienols (Radiation Resistance);
5. Motoric genes (movement to avoid intolerable environmental conditions).

Results

Figure. 2. Symbiotic cyanobacteria and lichens living on the tree-bark or under transparent layers, may provide natural UV protection to Martian plats and also assist in Photosynthesis:

Figure. 3. Selective polarization by biosynthetically engineered double layer of the waxy cuticle provides UV protection by the polarization of the harmful waves:

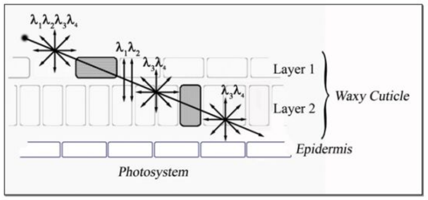
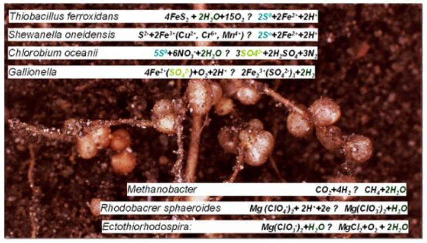
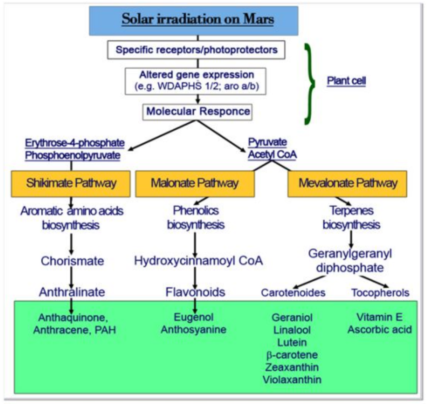


Figure. 4. Symbiotic bacteria in the root nodules transforming insoluble minerals in the Martian ground (bioremediation) into substances acquirable by plants.



Discussion

Reciprocal interactions have to be investigated that can shape genes, genomes, organisms, and species variety of future Martian organisms. We have to experiment with the genetic circuitries to reveal existing extreme adaptations, and ensure their stable integration into more complex biological entities, such as whole cells and organisms, thus creating the life adapted to Martian environment. Along with the other engineering tools, bioremediation of Martian Ground and Atmosphere could well be accelerated with the creation of organisms like lichens and plants genetically modified for the survival on Mars [4, 5].



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