Mars is a disappointing hellhole lacking
practically everything we need to stay

alive. It looks like we'll only ever have small
crews spend a miserable time hidden underground.

Except, we could terraform it into a green
new world. But to solve the planet's problems,

we first need to make it worse and turn it
into oceans of lava with gigantic lasers.

This isn't a far-fetched science fiction tale.
Terraforming Mars is possible, on the kind of

time scale our ancestors built great monuments
in. If humanity solves some of its pressing

problems and ventures into space to expand into
the solar system, this may not be that far off.

Ok. So how do we terraform Mars
quickly? Well, It's complicated.

Mars is dry and has no soil to grow anything. Its
atmosphere is too thin to breathe or protect from

radiation, giving you a high risk of cancer.
So to turn it into a new home for humanity,

we have to give it a proper atmosphere, similar
to Earth's. It should be made of 21% oxygen,

79% nitrogen and a tiny bit of CO_2, at an average
temperature of 14°C and under 1 bar of pressure.

We have to create oceans and rivers and then the
ground has to be weathered into fertile soil to

host living things. Then we need to install
a biosphere on the surface and prevent it all

from being undone by installing protective
measures that can stand the test of time.

It's difficult. But a big
laser makes it a lot easier.

Challenge 1: The Atmosphere

Some 4 billion years ago Mars had a nice
oxygen-rich atmosphere and was home to vast

oceans and rivers. It held onto it for
several hundred million years before it

got blown away. Ultraviolet rays broke down
the atmospheric gases and then the oceans,

until they were swept away by solar wind.

Today Mars is a dry, barren wasteland.

Luckily a sizable portion of the water is frozen
in deep reservoirs and in the polar ice caps,

enough to create a very shallow ocean.
And enormous amounts of oxygen are bound

as minerals in the Martian rocks,
like the oxygen in the iron oxides

that give the planet its rust-red colour,
as well as carbon dioxide in carbonates.

To free these gases, we need to
reverse the reactions that lock

them away by using thermolysis,
which occurs at temperatures as

high as on the surface of the Sun. In
short, we want to melt Mars' surface.

The best way to do that would be to put lasers
in orbit aiming their beams down on Mars.

The most powerful laser today is the ELI-NP,

able to produce beams of 10 Petawatts
of power, for a trillionth second.

To melt Mars we need a laser twice as powerful,
that runs continuously. The easiest way is to use

a solar-pumped laser that can be powered directly
with sunlight: At its core are metal-infused glass

rods that absorb energy and release it as a laser
beam. If we build an array of mirrors in space,

about 11 times the size of the United States, we
can focus enough sunlight onto them to melt Mars.

Let's do it!

As the lasers hit the surface, about 750
kg of oxygen and some carbon dioxide emerge

from every cubic meter of rock melted. If
we are efficient our lasers only need to

melt through the top 8 meters of
the surface to get enough oxygen.

It would look terrifying. The
skies would be shrouded in storms,

while the ground would glow red-hot,
criss-crossed by currents of lava.

Tireless laser beams sweep over the landscape, leaving trails too bright to look at. After they

pass, the ground cools quickly. A strange
snow falls: the ashes from all the elements

that solidify as they cool down, like silicon and
iron. Mars is still a cold planet at this point.

A happy side effect of this inferno is that
all the water in the polar ice caps and even

deep underground rises into the sky as hot
steam, forming clouds that rain down over

the entire planet. They would wash out
the nastier gases from the atmosphere,

like chlorine, and carry away harmful elements
that accumulated on the surface. In the end, they

would form shallow oceans, saltier than on Earth.
We might need to do an extra clean-up afterwards.

It would take about 50 years of continuous
lasering to create our oxygen atmosphere. We

could use this opportunity to dig deeper in some
places to create the basins for salty oceans or

rivers and spare some landmark features
like Mons Olympus and Valles Marineris.

We’re not done though.

The resulting atmosphere is nearly 100%
oxygen and only 0.2 bar. It’s hard to

breathe and very flammable. To make
it similar to earth and a lot safer,

we need to add a lot of nitrogen, which
Mars is lacking sadly. We have to import it.

The ideal source is Titan, a large moon of Saturn,
covered in a thick atmosphere that’s almost

entirely nitrogen. We just have to move 3000
trillion tons from the outer solar system to Mars.

While that’s not easy, it is doable. To
process that much of Titan’s atmosphere,

we have to construct giant automated factories,
on its surface powered by our lasers to suck in

the atmosphere and compress it into a liquid.
This gets pumped into bullet-shaped tanks,

which a mass driver shoots all the way to
the red planet, where they explode and mix

with the oxygen. We've already been able to send
individual missions to Saturn in just a few years.

With enough resources, it should be possible
to complete the task within 2 generations.

Of course it would be much more
convenient to have nitrogen left

over from terraforming Venus on the side: we
explained this in detail in another video.

So, about a century after the
start of the terraforming process,

we have a breathable atmosphere that has
the right gases. If the liberated CO2

isn't enough to warm it up to temperatures we
can stand, we just add some super greenhouse

gases. Mars at this point resembles a
black marble from all the cooling lava,

spotted with growing oceans and red patches
where the old surface remains untouched. It's

still a wasteland, no better than a desert
on Earth. We need to fill it with life.

Challenge 2: Biosphere

Installing a biosphere on a new planet is
very difficult. Unexpected interactions

between species or sudden diseases can
destabilise it to the point of collapse.

We would probably begin by seeding our young
oceans with phytoplankton. Without competition,

it would bloom rapidly, filling up the oceans
to become the bottom of an aquatic food chain.

They can be followed by tiny zooplankton,

then by fish. Maybe even sharks and whales. If
things go well, life in the oceans will thrive.

Life on land is harder. Plants need
nutrient-filled ground to sink their roots

into. But most of the surface is the congealed
remains of lava and ashes. We could wait for

thousands of years for water and wind to grind it
down into finer sands or try to do it manually.

But we want to be quick. And we have a
big laser. Turning the beam on and off

in rapid succession would cause the ground to
quickly heat up and contract, which breaks it

into smaller and smaller pieces. Add a bit
of water, and you get a sort of dark mud.

Into this mud, we can mix fungi and
nitrogen-fixing bacteria. They're

able to absorb nitrogen and convert it
into nitrate compounds to feed plants.

The first plants we want to bring are
native to volcanic islands on Earth,

since they are perfectly suited to
the laser-blasted Martian landscape.

Eventually, the enriched mud becomes the
foundation for grasslands and forests. In

Mars' lower gravity, trees can become very tall
very fast. Their roots gather the nutrients

they need and then dig deeper to turn more rocks
into soil, forming a self-sustaining ecosystem.

At this point we can slowly introduce more plant
varieties, insects and animals. Not mosquitoes

though. The new biosphere needs to be maintained
to prevent it from falling out of balance. If

plants grow too quickly and absorb too much
carbon dioxide, the planet cools down too much.

If key species die out, we could see populations
collapse faster than they could recover. On Earth,

other species would move in to fill the void,
but our Martian biosphere is not as flexible.

It takes hundreds if not thousands of years
before Mars becomes a stable environment.

But eventually the planet will have the potential
to sustain large human colonies. With air,

water and food available, we
can finally call Mars – black,

blue and green – our home. A
giant, volcanic island in space.

Will it last though?

Challenge 3: The long-term future

There is a problem we haven't addressed: Mars'
core does not produce a magnetic field, so it does

not have enough protection from solar radiation
or cosmic rays. This becomes dangerous for the

long term health of Martian populations. So as a
final step, we need an artificial magnetic field.

It doesn’t have to be huge like Earth’s. It

just needs to deflect the solar wind
enough so that it doesn’t touch Mars.

The easiest way is to construct a magnetic
umbrella far ahead of Mars that splashes the solar

wind to the sides. A big, superconducting ring
powered by nuclear facilities is all it takes.

It would orbit at the Mars-Sun L1
point, keeping it constantly in

between the Sun and Mars and protect
the new atmosphere. And that’s it!

Terraforming Mars would take some work,
hefty resources and probably a century or

ten but it would be the first time
we’ve lived in a home designed and

shaped solely by us and for us. A first
step towards our future among the stars.

The first step we can already take
down on Earth is learning more about

the physics and biology needed for such a project.

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