

**18 OCTOBER 2019 - 23 FEBRUARY 2020**

### **TEACHER NOTES**

These teacher notes are extracted from the exhibition text. The introduction, section headers and captions are as found in Moving to Mars. The exhibition is split into six sections within which sub sections focus on key groups of objects such as 'Pressure suits and spacesuits' and 'Eating in Space'. These sections are represented in these notes but the expanded text can be found in the exhibition. A few exhibits from each category have been selected to enable you to guide your students' journey around the exhibition and point of some exhibits of interest as you go. If you would like a more in-depth look around the exhibition, then you may be a free preliminary visit once you have made your group booking. We do not run tours of our galleries but our visitor experience assistants who are based in the galleries are knowledgeable on much of the content.

Photography and cinematography is permitted in the gallery without the use of a flash. Dry sketching is allowed. No food or drink is allowed in the gallery. Please do not touch any objects unless instructed to do so in gallery signage.

## **1. IMAGANING MARS**

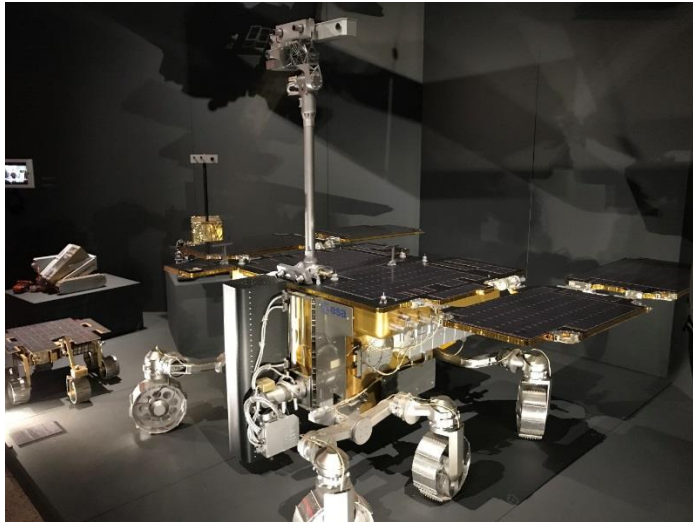
Mars is the most striking planet in the night sky. Its reddish glow and wandering motion fascinated ancient astronomers. Mars promised fire, destruction and war. From early maps to Hollywood film posters, the ways we have represented the Red Planet reflect our shifting understanding of it.

As telescopes developed, astronomers could read Mars more deeply. The father of observational astronomy, Galileo tracked its orbit while the 17th Century scientist Huygens could make out landmarks and calculate the Martian day. British-German astronomer William Herschel saw ice at the poles. He thought that Mars had an atmosphere and, perhaps, inhabitants. By the 1870s many astronomers were convinced there were channels, or canals, on the surface, perhaps made by Martians to bring water from the poles to their parched planet.

In 1897, fiction took this further when H. G. Wells published The War of the Worlds, the first of many Mars novels. By the 1950s a golden age of science fiction populated Mars with living beings, Earth settlers, and even Martian ghosts. The Mars of imagination surely provoked a hunger to see the real thing.

### **Scale model of the Rosalind Franklin ExoMars Rover**

European Space Agency (ESA) and the Russian space agency (Roscosmos), 2019



ExoMars is a joint endeavour between the European and Russian space agencies. The ExoMars rover, due to launch in 2020 and land in 2021, is named Rosalind Franklin after the notable scientist whose X-ray images led to the discovery of the structure of DNA.

The ExoMars rover is a complex mobile laboratory with nine different scientific instruments from research groups in the partner countries studying the geology, mineral composition, and possible biology of Mars.

Even if Mars had sustained life in the past, the harsh conditions today, with high radiation levels and little water, are likely to have sterilised the surface. This rover will drill down two metres into the surface to sample and analyse more protected soil, and look for evidence of past or even of present life buried underground.

Scale: 1:1

### **Seven-foot reflecting telescope with eyepieces and mounts William Herschel, 1770-90**



William Herschel was originally a musician and composer from Hanover, Germany. By 1766, he had become a well-known organist and concert director in Bath. He was joined there by his sister Caroline (thought to be the first professional female scientist) and the two became increasingly absorbed in astronomy. They discovered thousands of new astronomical objects and also made astronomical telescopes for sale.

William Herschel used a telescope similar to this to study Mars. In 1784, he reported, 'I have seen the white poles retreat and expand in yearly cycles like the seasonal melting and freezing of ice at the poles of the Earth. I conclude that Mars has summers and winters like ours'.

## Mars in Popular Culture



'No one would have believed in the last years of the 19<sup>th</sup> century that this world was being watched keenly and closely by intelligences greater than man's'. So began *The War of the Worlds*, arguably the single most influential example of Martian science fiction. H.G. Wells was intensely interested in all scientific topics and was aware of Percival Lowell's theories about canals and life on Mars. As the canal craze took hold of the scientific community, the idea of intelligent life on Mars seeped into popular culture, becoming a recurring topic in films, novels and magazine articles.

Images of the Red Planet continued to reflect to the scientific discoveries. In the postwar era, science fiction magazines and cartoons saw Mars conquered by space-suited explorers with shiny rockets. Space adventures and real science futures seemed to collide as authors like Robert A. Heinlein, Isaac Asimov and Arthur C. Clarke bridged the gap, moving between science fiction, science education, and direct involvement in promoting space exploration. Images of intelligent beings on Mars proliferated, but they were now joined by human adventurers in rockets and spacesuits. Today, Mars fuels the imaginations of video game designers, writers, and film makers.

## 2. ON MARS TODAY

What's it like on the surface?

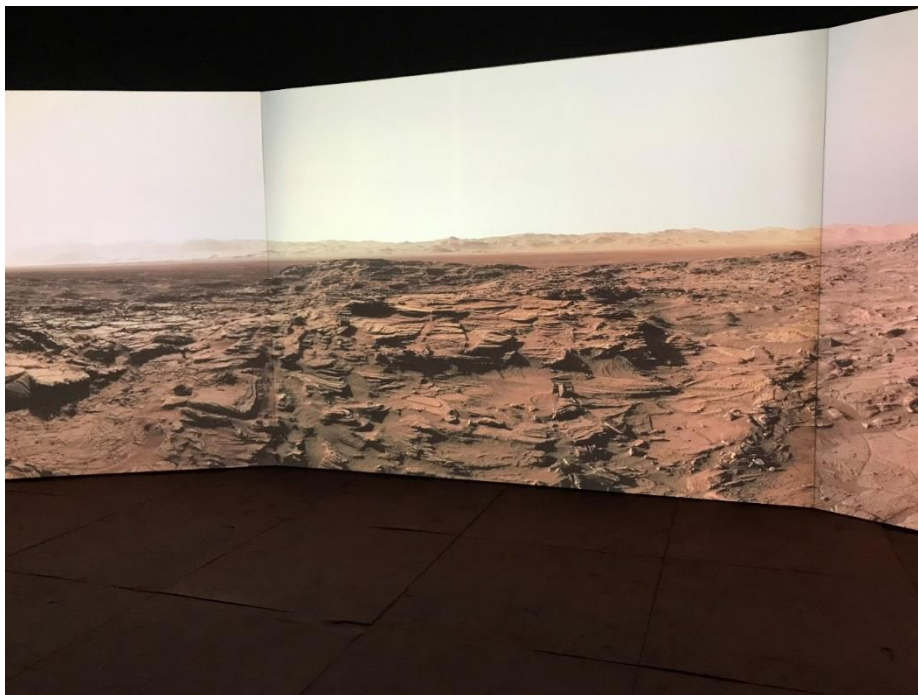
In 1965 the Mariner 4 spacecraft took the first flyby photographs of Mars. There were no canals and no traces of complex lifeforms. But more recently the Mars rover missions have brought us images of astonishing clarity. The pictures show a planet tortured by geological forces, ancient floods and meteor collisions.

Today our knowledge of Mars has been transformed by data from unmanned missions. Its canyons, craters and volcanoes dwarf anything on Earth.

This is a place where no one has ever stepped before. And it is deeply inhospitable. Freezing temperatures, unbreathable air, solar and cosmic radiation all make a lethal environment for humans. But we still imagine, one day, standing on those red plains ourselves.

### **Utopia Planitia: What might Mars smell like?**

Immersive experience



Nicolas Bonneville, a French perfumer from the fragrance company Firmenich, asked himself this mysterious question.

He used four words from NASA as a starting point: earthy, mineral, volcanic, metallic. He then began to imagine the smell of the Red Planet.

Come and stand on the replicated surface of Mars and smell the 'smell of the red planet'.

### 3. THE VOYAGE

Can we stay safe and sane on the way to Mars?

The journey to Mars will be the most challenging ever attempted. Apollo flights took just three days to reach Moon orbit. The Mars outbound voyage will take seven or more months. The dangers are many and personal space minimal. Privacy will be hard to find. And how will you spend all that time? Astronaut and Mars enthusiast Buzz Aldrin says 'it will be a good time to finish War and Peace'.

In zero gravity, every daily ritual has to be rethought. The way the astronauts eat, wash and sleep is designed for the challenging conditions. They must exercise at least two hours a day just to avoid losing bone and muscle mass.

Meanwhile, the view of Earth will shrink to a tiny dot. What will be the effect of this profound separation from home? NASA ranks psychological issues among the major risks to the mission. A people-focused design of the craft and all its equipment will be crucial for their wellbeing.

#### *Wernher von Braun- The original rocket man*

*From Nazi scientist to American citizen. Von Braun was the chief scientist behind the race into space.*

**Chesley Bonestell, space artist**



Chesley Bonestell was one of the main artists for the space editions of Collier's magazine but also worked extensively for science fiction magazines and books.

Bonestell had worked as an architect and also as an illustrator in the film business. This experience, combined with a passion for astronomy, gave Bonestell the ability to draw unseen worlds which look utterly convincing.

Some credit him, along with von Braun, with kickstarting America's space programme and inspiring thousands of young Americans to make a career in aerospace engineering.

### *Public or private space?*

*Space was traditionally reserved for rich nations. With half the world's wealth currently owned by just 80 people, it is now the focus of the super-rich.*

### **SpaceX and Mars**



Elon Musk achieved his first business success at age 12, selling a computer game called Blaster. Later, he dropped out of academic physics and founded an internet payment company that became PayPal. In 2002 Musk launched SpaceX, a company that aimed to slash the cost of space launches and space exploration by applying commercial engineering principles to rocket design.

As part of the commitment to reduce costs, SpaceX has pioneered reusable launch systems, demonstrating the successful landing and recovery of booster rockets on land or on barges at sea.

Musk is also committed to the human exploration and settlement of Mars saying, 'I believe we have a duty to expand to other planets to preserve life against a natural or man-made calamity. With SpaceX, I'm hoping I can do as much as possible to further that goal'.

### *Designing for micro-gravity*

*From eating and drinking to taking a shower, microgravity presents problems that designers and scientists need to solve.*

#### **Materials researched for the construction of TransHab**

Various Manufacturers, 1997



### *Pressure suits and spacesuits*

*Keeping humans safe in space requires a specialist pressure suits and spacesuits to provide heating, cooling and pressurisation whilst also allowing freedom of movement.*

#### **Sokol Spacesuit and Soyuz capsule chair**

Zvezda, 2002



*This Soyuz Kazbek seat is thought to have been used by the Belgian Cosmonaut Frank De Winne in his 2002 flight to the International Space Station. It has a shock-absorbing design and knee pads. The seats are designed to load the body as evenly as possible during the g forces of the rocket launch.*

### **Eating in space**

*From the food in toothpaste tubes at the state of human space flight through the modern oven made meals, space food have come on since the first human spaceflight in 1961.*

### **Coffee cup for drinking espresso in space**

Mark Weislogel and Andrew Wollman with John Graf and Donald Pettit/NASA Johnson Space Centre, 2015



The cup is partly sealed, using surface tension and capillary action to hold the fluid in place. No liquid flows until an astronaut starts to suck it out.

## **4. SURVIVAL**

What does home look like? And what's for dinner?

The first Mars missions will send small survey crews that rely on equipment from Earth. But a true long-term Mars settlement must find its own materials and energy sources. The techniques to locate and create what's needed are being studied on Earth - but they still need to be proved on Mars where everything is new and different.

Shelter from the atmosphere and from radiation will be crucial to survival. Architects have imagined different ways of building habitats on Mars, using robotic diggers, 3D printers and other techniques. Despite the high-tech construction, Martian homes will be far more primitive than on Earth – but less wasteful.

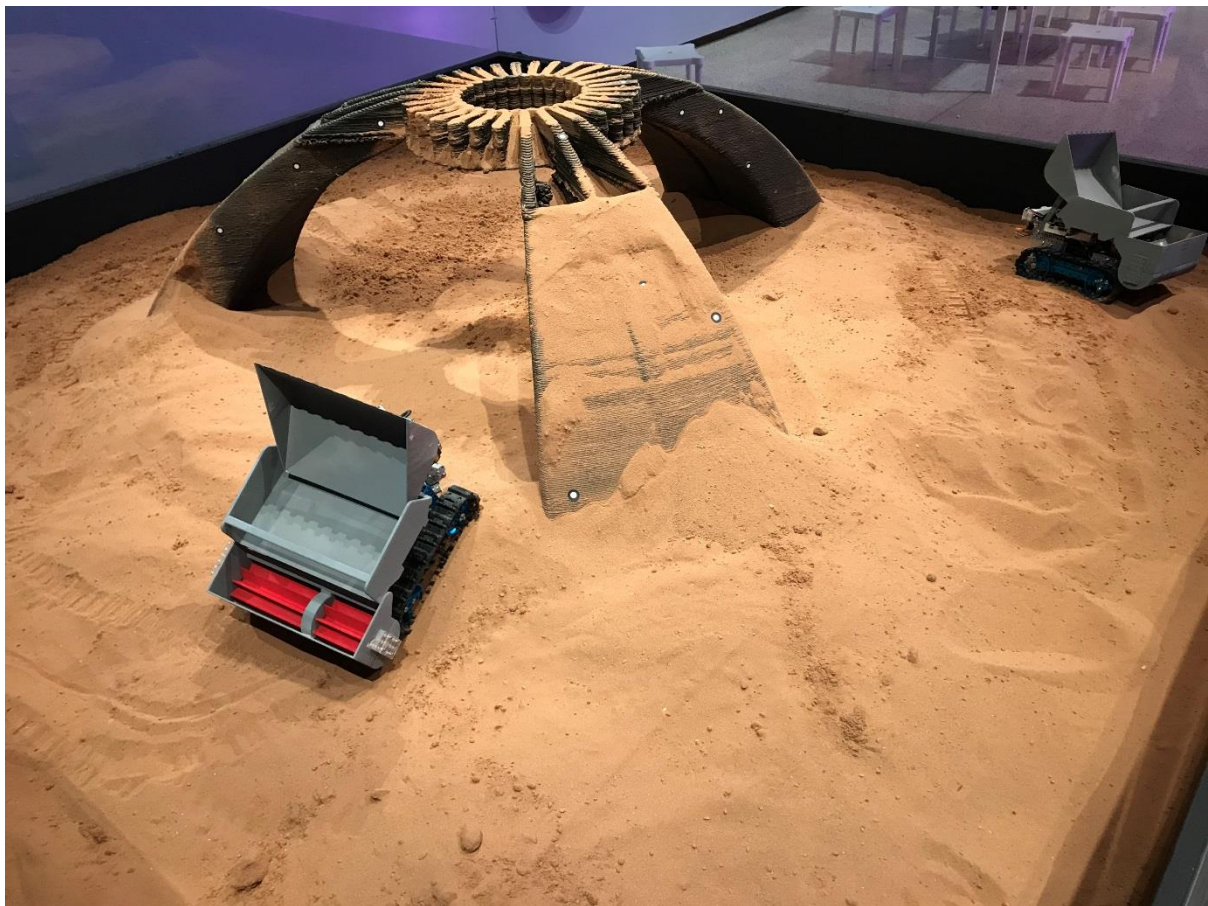
Long-term human survival will demand new levels of sustainability. We will need to perfect self-sufficient closed ecosystems that recycle all waste and carbon dioxide. A mix of plants and micro-organisms will provide food, oxygen and clean water. Some Mars farming will look familiar – using pressurised greenhouses – while other processes will look more like chemistry labs.

### *Building on Mars*

*Construction on Mars will have to use the native materials to create buildings that counteract the harsh Martian atmosphere.*

#### **Mars robot builders**

Foster + Partners, 2015



There are three types of robot builder specialised for one of three jobs: ‘dig, move, or melt’. Foster + Partners believe that the process gets greater reliability from using simple single-task machines rather than one type of multifunctional smart robot builder.

The larger digging robots pile up loose regolith for the medium-sized mover robots to pile on top of the inflatable modules in rough layers. Then, once a layer of regolith is in place, the smallest robots - the melters - fuse patches of the regolith into a hard crystalline state which gradually stitch the developing domes together.

The aim of the three-part robot construction process is to cover each inflatable living module with a thick layer of stabilised regolith. This is needed to reinforce the pressurised modules, but also to block radiation and retain heat.

### *Mars farming*

*Farming on Mars will need to be as closed a loop as possible when it comes to farming food and resources.*

### **Hydroponics**

**Growstack, 2019**



Hydroponic cultivation lets plants grow in a solution of nutrients mixed with water. On Earth, the system is used increasingly for quick-growing crops. Almost anything can be grown hydroponically if the nutrient mix is right. Leafy greens like spinach and salads grow well, as do herbs, peppers and strawberries.

The advantages include faster growth, bigger yields and less space needed, since the plants do not develop extensive root systems. Moreover, the plants only use the water they need.

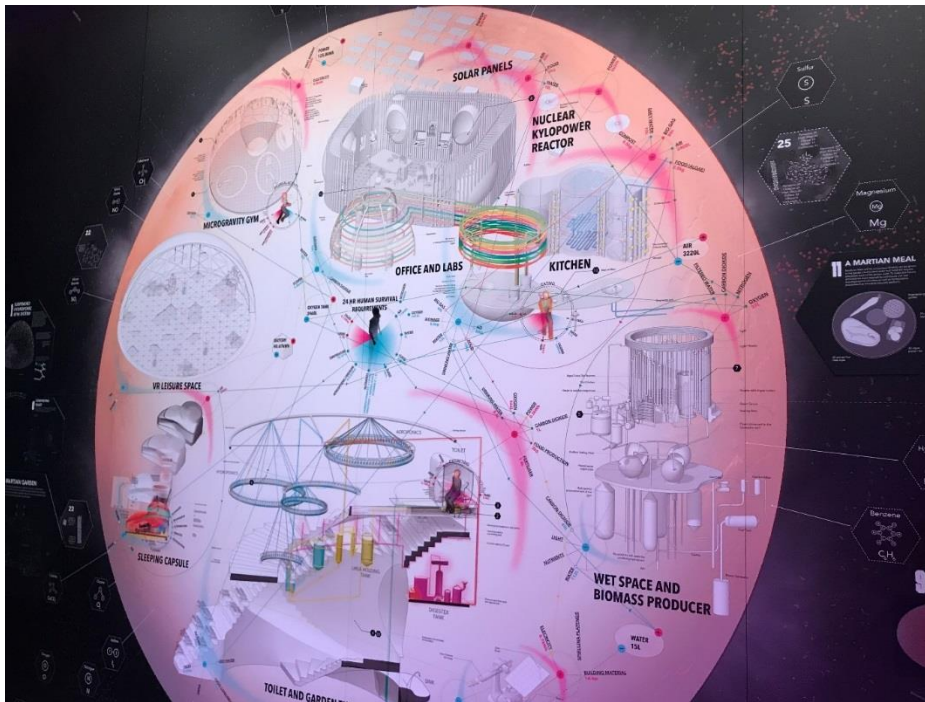
All these points suggest that the system would be good for Mars settlers. However, it will need enclosures or greenhouses with atmosphere under pressure to feed plants the carbon dioxide they need, as well as heating and artificial light.

### *At home on Mars*

*What will it be like to live on Mars? International architecture practice Hassell was shortlisted in the NASA/Bradley University competition to design the first human home on Mars.*

## Life on Mars

*This graphic is an attempt to design the engineering flow chart of a Martian colony as a lifeform in itself.*



## 5. MARS FUTURES

Is Mars a lifeboat for humans?

Are we set to become a spacefaring species? Physicist Stephen Hawking argued that humankind should commit to space as insurance against nuclear war or global warming. Elon Musk speaks about preserving 'a seed of human civilisation' in space.

Right now, the technology, the know-how, and the public enthusiasm seem ready for the venture to Mars. There are even notions of 'terraforming', or greening, Mars to make it fit for human life. But do we have the right to 'colonise' this planet? Some feel that it is too invasive an approach.

But Mars is not the only destination. Space enthusiasts also promote artificial settlements – vast floating structures engineered for life and survival. In this imagined future, humanity would spread through the solar system both to Mars and beyond it.

## Mars 2100 Expedition

This film takes you on the emotional journey of a future astronaut. Please wait for countdown before entering the screening room.

## Space colonies

In 1929 JD Bernal published 'The World, the Flight and the Devil' in which he proposed space stations as giant spheres with people on the inside.

## Stanford Torus, interior view

Rick Guidice, 1975



'I realized this was a very important opportunity to really do something special' recalled Rick Guidice in 2017. His favourite painting was the first he developed - the double cylinder space colony.

## *The Wilding of Mars*

The Wilding of Mars is both a thought experiment and a work of art exploring an alternative future in which we might colonise Mars with bacteria and plants, but do not settle on the planet ourselves.

## Pioneers and Descendants

Alexandra Daisy Gainsberg, 2019



In each simulation, sixteen extremophile Earth life-forms colonise Mars, seeded in stages. The first 'pioneers' are the hardest cyanobacteria and lichens. They help make the planetary conditions more tolerable, contributing to a programmed ecosystem determined by water, temperature. And nutrient levels.

New subspecies evolve that are better adapted to the harsh Martian conditions. Not all survive, but every 'subspecies' existence is documented and named by the system. This display shows the sixteen pioneers and some of their thousands of decedents that were generated in the two simulations.

## 6. DOWN TO EARTH

Should we go, and what could we learn?

The Apollo Moon missions of the 1960s brought us CAT scans, computer microchips, memory foam and joysticks, but it also transformed our thinking. The 'whole Earth' photographs revealed a fragile, blue planet floating in the void. It brought a new sense of our precious environment. We glimpsed then that you can't throw anything away. There is no 'away'.

Like the Moon landings, shooting for Mars promises to fuel high-tech research for generations. On Mars, materials are precious and scarce, energy is hard to find. Mars living may show us a new environmental path inspired by the ultimate economical, lean design.

Could we achieve this without the cost and danger of going to Mars? Or does the rigour of an actual mission make it more likely that we will develop the efficient systems and thinking required to preserve life on Earth? Beyond technique, perhaps we need a whole new point of view.



### EXHIBITION GUIDANCE

Objects in the exhibition are on open display rather than in cases. Care should be taken when moving around the exhibition and most objects should not be touched. Any objects

that can be touched will be clearly signed. Please ask staff if you are unsure. We would be grateful if you could brief your students accordingly.

Depending on your group and your itinerary for the visit, we would recommend that you set aside approximately 45 minutes to explore this exhibition.

Photography is permitted in this exhibition without the use of a flash.

Please ensure that you read our school visit Terms and Conditions document before making your visit.

**Design Museum, 224-238 Kensington High Street, London, W8 6AG**

**Daily 10am – 5.45pm**

**+44 20 3862 5900**

**[learning@designmuseum.org](mailto:learning@designmuseum.org)**